The role of voluntary reformulation policy in reducing population consumption of sugar

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Declaration of own work

I Rachel Clark, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Abstract

Excess sugar consumption has been associated with adverse health outcomes and recommendations have been made globally to reduce intake of free sugars across all ages. Despite this, sugar consumption in England remains high and in 2016 government introduced a voluntary reformulation policy aiming to reduce the sugar content of certain products. The aim of this DrPH thesis was to examine the potential role of voluntary reformulation policy in reducing population consumption of sugar, and I examined this using three discrete studies.

I conducted a systematic review of empirical evidence examining the impacts of sugar reformulation policy. I identified five studies of voluntary policies, three of which focused on England's policy. Studies showed small reductions in the sugar content of products overall and the volume of sugar purchased (or sold), however the certainty of evidence was assessed as very low. Greater reductions were reported for certain product categories, although most sugar reduction targets had not been met and reductions were still modest. No studies had examined the effects of reformulation policy on sugar consumption.

I conducted a qualitative case study of England's voluntary salt reformulation policy, using existing evidence to examine implementation factors relevant to policy effectiveness. Evidence suggested that population salt intake was reduced when the policy was implemented alongside food labelling and consumer awareness policies, with clear reformulation targets, and monitoring of progress using soft regulation. Gradual reduction of salt in products was considered technically feasible and acceptable to consumers. Leadership external to (yet backed by) government, resourcing for policy implementation, transparency in implementation and governance were also important.

I conducted a quantitative study using Kantar FMCG consumer panel data to explore changes in sugar content, portion sizes and purchases of breakfast cereals, sweet and chocolate confectionary between 2015 and 2018. I saw evidence of a reduction in the sugar content of breakfast cereal products only. Changes in sugar content of products were due to a combination of reformulation and product renewal. There was no evidence of reductions in portion sizes of single serve products or in the total volume of sugar purchased.

Limited evidence suggests that voluntary sugar reformulation policy might lead to modest reductions in the sugar content of certain products and the volume of sugar purchased, although the potential impact of reductions on population sugar consumption is unknown. The lack of any comprehensive, independent evaluation of England's sugar reformulation policy is a missed opportunity to generate new empirical evidence based on policy implementation. Application of the regulatory approaches used by the Food Standards Agency during the initial phase of England's salt reformulation policy should be considered to enhance the potential impacts of voluntary reformulation policy for sugar. Voluntary reformulation policy will have the greatest impact when implemented alongside other policies focused on reformulation.

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Abbreviations

ALB	Arms-length body
CASH	Consensus Action on Salt and Health group
COMA	Committee on Medical Aspects of Food and Nutrition Policy
DH	Department of Health
DHSC	Department of Health and Social Care
FSA	Food Standards Agency
GRADE	Grading of Recommendations Assessment, Development and Evaluation
HFSS	High in fat, salt and sugar
NDNS	National Diet and Nutrition Survey
OHID	Office for Health Improvement and Disparities
PHE	Public Health England
RD	Responsibility Deal
RP	Research project
SACN	Scientific Advisory Committee for Nutrition
SDIL	Soft drinks industry levy
SRP	Sugar reduction programme
SSB	Sugar sweetened beverages
SWM	Sales weighted mean
TFA	Trans-fatty acids
US	United States
WHO	World Health Organization

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1. Introduction

This DrPH thesis explores the potential role of voluntary reformulation policy in tackling excess population consumption of sugar. This has been a major policy priority in England over the last decade, however, there remains a lack of evidence on the implementation and effectiveness of such policies. In this thesis I will synthesise existing evidence examining the impact of reformulation policy on the sugar content of products, purchase or consumption of sugar; explore implementation factors that may contribute to successful voluntary sugar reformulation policy drawing on lessons from previous salt reformulation policy in England; and analyse changes in the sugar content, portion size and sugar purchases of products that have occurred following initiation of the voluntary sugar reformulation policy in England.

This introductory chapter describes the links between sugar consumption and health, the excess consumption of sugar in England, nutrition policies available to tackle this and the role of artificial sweeteners in reformulation. It defines voluntary reformulation policy, considers the role of industry in health and describes the extent to which this type of policy is being implemented globally. The existing evidence surrounding the effectiveness of sugar reduction policies is set out with a view to highlighting the need for an updated systematic review focused on sugar reformulation policy. I close on the rationale for my DrPH research and the structure of this thesis.

1.1 The issue of sugar consumption and public health

There is a growing body of evidence linking excessive sugar consumption to adverse health outcomes. Increased or decreased sugar consumption have been associated with increased or decreased body weight respectively in both children and adults (1, 2). Further evidence suggests that consumption of sugar-sweetened beverages (from herein, SSBs) is associated with overweight and obesity in children (1, 3) and adults (3), type 2 diabetes (2), cardiovascular disease (4, 5) and some cancers (6). Sugar intake has been associated with blood pressure and serum lipids (independent of its effect on body weight) (7) and with dental caries in children and adults (8). An overview of the breadth of health harms associated with excess consumption of sugar is also available in a recent umbrella review based on 73 meta-analyses of 83 potential harms from more than 8000 articles, which concludes that excess consumption is negatively associated with multiple health issues (9).

Sugar is a type of carbohydrate. It is found naturally in some food and drinks, for example 'fructose' in fruit and 'lactose' in milk but may also be added to food and drinks either as table sugar or during the manufacturing (10, 11). In 2015, the World Health Organization (WHO) issued guidelines around the intake of sugar for adults and children recommending a reduced intake of 'free sugars' across the life-course (12). Free sugars are defined as those added to products (whether added by the consumer or during manufacturing processes) and those that are naturally occurring in fruit and vegetable juices and juice concentrates, syrups and honey, but excluding naturally occurring fructose in fruits and vegetables or lactose in milk-based products (2). I have adopted this definition for the purpose of this thesis and from herein the term 'sugar' will refer to 'free sugars'. In England, the Scientific Advisory Committee for Nutrition (SACN) released guidelines recommending that intake of sugar for adults and children aged two years and above should be less than 5% of total dietary energy intake, and that the consumption of SSBs should be reduced (2).

Despite these guidelines, most recent data from the National Diet and Nutrition Survey (NDNS) suggest that all ages of the population within England are exceeding recommended sugar intakes. Between 2016 and 2019 sugar intake was greater than the recommended 5% of total dietary energy intake in all age groups, contributing to as much as 12.5% and 12.4% of total dietary intake in girls aged 11 to 18 years and boys aged 4 to 10 years respectively (13). The biggest contributors to sugar intake across all ages included cereal and cereal products, non-alcoholic drinks (which includes fruit juices and soft drinks), and sugar, preserves and confectionary products (14). The percentage contribution of these food and drink categories to sugar intake varied by age categories but ranged between 21% and 33% (see Table 1).

Table 1. Top three contributors to sugar intake, % by age according to NDNS analysis (14**)**

	Age Groups Percentage contribution to sugar intake			
	1.5 to 3 yrs	*4 to 10 yrs*	*11 to 18 yrs*	*19 to 64 yrs*
Cereal and cereal products	31%	33%	29%	24%
Non-alcoholic drinks	21%	22%	33%	21%
Sugar, preserves & confectionary	20%	23%	21%	25%

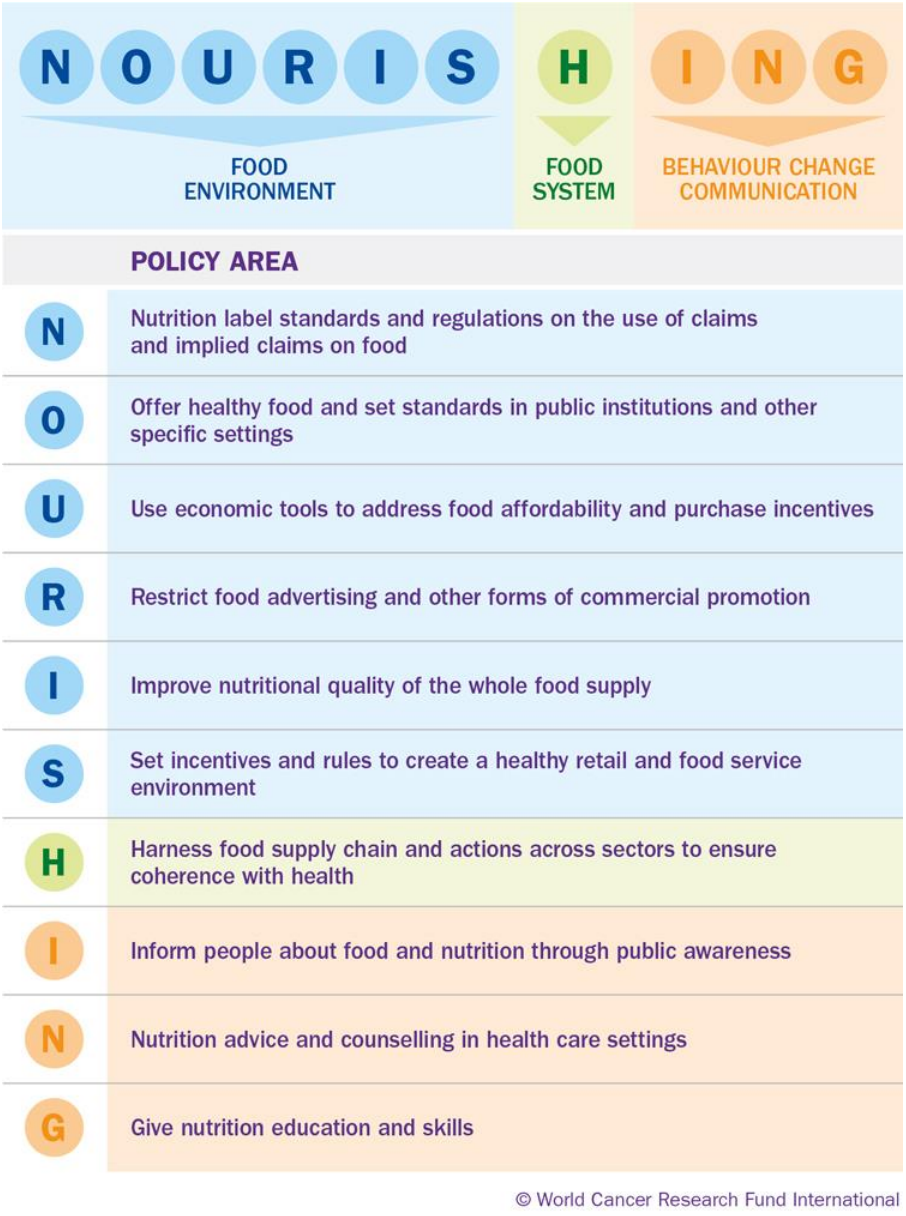
Evidence on the associations between excess sugar consumption and health issues, accompanied by the over-consumption of sugar, have contributed to an increased interest in policies to reduce population-level consumption in England (15-17).

1.2 Policies for reducing the consumption of sugar and the role of reformulation policy

Influences on diet are broad and complex. They include individual-level factors such as income, food preferences and cooking skills; socio-cultural factors such as cultural norms or social support; and community environments, for example, availability of certain products in schools and other community setting or proximity of local supermarkets (18, 19). Diet is also influenced by agricultural practices and industry behaviours (for example, marketing of certain products), government (for example, its structures and political priorities), and global issues (for example, food distribution) (18, 19). The potential for interventions to improve diet reflects this, including individual or group-based education and behaviour change interventions, awareness raising campaigns, adjustments to the availability and affordability of healthy or less healthy food options, and legislative approaches amongst other approaches (20). Whilst individually focused interventions can have an important role in improving diet, if implemented alone they are unlikely to bring about lasting population changes as wider issues can overpower attempts to change behaviour. The importance of environmental and policy approaches has therefore been emphasised for sustained and equitable improvements in diet (21, 22).

A range of policy options exist for improving nutrition and these have been described and categorised in multiple frameworks or typologies. Policies are typically grouped as those that target the food environment or food supply (for example, food labelling policies, settings-based policies or pricing policies) and policies targeting individual behaviour change (for example, through nutrition education or marketing campaigns) (23-27). The NOURISHING framework (displayed in Figure 1 below) (23, 27) was developed based on a review of policy frameworks, national policies and effectiveness evidence (23). This framework describes policies promoting healthy eating to prevent obesity and diet-related non-communicable diseases. It features ten policy actions across three domains: i) the food environment (6 policy actions), ii) the food system (1 policy action) and iii) behaviour change communication (3 policy actions). Together, the food environment and food system make

up seven of the ten potential policy actions, emphasising the importance of these compared with policies targeting individual behaviour change which have a lesser role to play in dietary change. The 'food environment' category under 'I – improve nutritional quality of the food supply' includes reformulation. Whilst described as 'product' (25) or 'food composition' (24, 26) policies within other frameworks, I have adopted the term 'reformulation policy' for the purpose of this thesis.



This material has been reproduced from the World Cancer Research Fund International NOURISHING framework https://www.wcrf.org/int/policy/policy-databases/nourishing-framework

Figure 1. The NOURISHING policy framework for promoting a healthy diet (WCRFI, 2020) (27)

Efforts to improvement population nutrition can adopt different approaches (28). Regulatory approaches are driven by government and regulated either by government or some other public body. They are more likely to be effective than other approaches (28, 29), although this will vary depending on the type of policy, and there may be industry opposition to regulation which can impact on political support (28). Voluntary approaches are led and implemented entirely by industry or the private sector. Voluntary approaches enable industry to work autonomously using their preferred approach, targets and timeline but in turn, can lack specificity and transparency. Evidence suggests that voluntary approaches are for the most part ineffective, and may even lead to adverse outcomes (28). Policies implemented as 'public-private partnerships' involve collaboration across sectors to implement and regulate interventions (28). As with voluntary approaches, evidence suggests that partnership approaches have limited effectiveness across a range of policies and outcomes (28). The focus of this thesis is on regulatory approaches (albeit with voluntary rather than mandatory involvement from industry) and this evidence is considered more fully in Chapter 3, Section 3.2.

Under the stewardship model, government has responsibility for ensuring that the appropriate conditions are in place for individuals to live a healthy life should they want to, but without placing unnecessary restrictions on individual choices (30). The Nuffield intervention ladder proposes that where a policy is more intrusive (in terms of taking control over individual choices) a greater justification is needed for the policy compared with less intrusive approaches (30). Reformulation policy sits almost at the top of the ladder, restricting choice through the reduction or removal of 'unhealthy' ingredients in products (30) although a ban on a particular ingredient would sit at the top of the ladder as the most intrusive policy option (elimination of choice). With this in mind, it is important to ensure justification is sufficient to warrant implementation.

Policy approaches that target whole populations and work to create a healthier food environment are essential for tackling health inequalities. It is well established that individually focused 'downstream' interventions may exacerbate inequalities whereas 'upstream' policies or interventions targeting the environment are more likely to reduce them (31). This is certainly apparent in nutrition policy, with evidence suggesting that

pricing policies targeting the food environment in certain settings can reduce health inequalities whereby interventions targeting individual behaviour change (namely dietary counselling) can widen them (32). There is limited evidence on the potential impacts of reformulation policy on health inequalities, however two studies (focused on salt and trans fats) suggest no impact either way (33). It is important to understand the potential role of reformulation policy more fully from an inequalities perspective.

Industry reformulates products for a variety of reasons, for example to improve the taste of a product or to reduce its production costs (34). Reformulation of products for health purposes involves changing the composition of a product to reduce the content of a particular nutrient or to enhance its nutritional profile (34, 35). From a public health perspective, reformulation should involve gradual changes to existing products that are either unnoticed by, or acceptable to, consumers (36). Taking this perspective, reformulation should lead to reductions in the amount of a nutrient purchased and subsequent dietary improvements without requiring behaviour change among individuals who consume the products. Technical approaches to achieving this vary, but may involve the replacement of a nutrient with an alternative ingredient. This was the primary approach in the reduction of trans fats for example (37), but not for salt reformulation (38). Reformulation can also involve changes to portion sizes which changes the availability of a nutrient, and it has been acknowledged that manufacturers may respond to reformulation targets through reducing portion sizes of products as opposed to changes in nutritional content (39). Alternatively, industry may respond to reformulation policy with the creation of new alternative products that are lower in a given nutrient and therefore alter the food supply. This requires consumers to change their purchasing behaviour in order to benefit (40). The approach to reformulation could affect its impact on diet and ultimately health as consumers may respond differently to different approaches. This is described more fully in Chapter 3, Section 3.1.

Sugar reformulation can involve gradual sugar reduction or replacement with artificial sweeteners, the latter being a common approach meaning that artificial sweeteners are now widely available in food and drink products (41). The potential health risks associated with consumption of artificial sweeteners therefore warrant consideration. The WHO have conducted a robust systematic review examining evidence on the health effects (both

positive and negative) of artificial sweeteners (42). Whilst evidence from RCTs suggests that increased consumption of artificial sweeteners can lead to a reduction in intake of calories and sugar as well as weight loss, evidence from longer term prospective cohort studies suggests an association between increased consumption of artificial sweeteners and increased risk of a range of health issues in the longer term including obesity, type 2 diabetes and stroke. Overall, the evidence was assessed as low certainty however the WHO has made a conditional recommendation that artificial sweeteners should not be used for weight management or to reduce noncommunicable disease risk (42). Despite this, and perhaps perpetuated by low certainty of evidence from observational studies, there remain mixed views in relation to the risks versus benefits of artificial sweeteners (41) and a perception of risk among the general public (43) that could potentially be used (and amplified) by industry in order to push back on sugar reformulation activity.

Reformulation policies can be voluntary or mandatory and typically involve the use of average targets or upper limits on nutrients, energy density or portion sizes, or elimination of a nutrient (23). Voluntary reformulation policy is used (most typically by government) to incentivise voluntary action by industry, for example, with the issuing of voluntary guidelines or targets for industry to work towards. Mandatory reformulation policy uses legislation to set limits on the amount of a nutrient in foods. This could involve a mandatory upper limit of a nutrient or an outright ban with the intention of eliminating a particular nutrient. Mandatory approaches have primarily been used to reduce trans-fats as it was considered feasible and achievable to eliminate these from manufactured foods entirely using replacement strategies (35) although voluntary approaches have also been used. Mandatory and voluntary reformulation policies have most typically been implemented in relation to salt reduction where the approach has focused on making gradual reductions in the salt content of manufactured foods (38). The use of these policies for targeting sugar is still novel and no single approach has been proposed.

1.3 Commercial determinants of health

Industry and the private sector can have a major influence on health and health-related behaviours. Commercial influences have been described and defined in different ways over the last decade, but are commonly referred to as the commercial determinants of health

defined by the WHO as *"…the conditions, actions and omissions by commercial actors that affect health"* (44). Whilst industry influences on health can be both positive and negative, it has been suggested that benefits are typically outweighed by harms (45). Commercial determinants of health operate at multiple levels and are largely driven by power (44-46). Industry uses power to influence political decision making, as well as other wider social factors such as trade agreements and social narratives for example, around a health issue or government policies (46). Different groups and sectors are targeted by industry in different ways, for example marketing to children or other vulnerable population groups, lobbying, or through funding not-for-profit organisations and political parties (46).

The food industry exerts a powerful influence on diet in multiple ways including the marketing of unhealthy products, pricing (making unhealthy products attractive through low costs), controlling the availability of products, use of labelling to mislead the public, and the use of large portion sizes to encourage purchasing of unhealthy products (47) (48). Large companies have taken control of supply chains which broadens their influence and increases power (48) and are working to shape social norms and opinions about products, dietary issues and government policies (49). The power held be industry needs to be recognised within public health and tackled (45), perhaps even more so in policies such as reformulation policy that rely on industry engagement and action for social good.

1.4 Implementation of reformulation policy globally and in England

Implementation of reformulation policy is commonplace. A study of 23 nutrition policies in high income countries in 2013 reported that reformulation policy was included in more than two thirds (68%) of all policies, with most focusing on salt reduction using a voluntary approach (50). A recent policy brief prepared by the WHO (35) reported that 111 countries had a reformulation policy or plan in place. More than half (n=70) of these countries were using a mandatory approach and whilst these mainly targeted trans-fats (n=61 countries) 20 countries were also using mandatory limits for salt (sodium). Some countries were implementing voluntary approaches alongside mandatory approaches and only five countries were implementing solely voluntary approaches. manifest

Several countries were described by the WHO as having reformulation policies in place targeting sugar including Australia, France and England. Australia was implementing a

Healthy Food Partnership, with voluntary targets set for sugar alongside salt and saturated fats. The policy was initiated in 2021, and maximum sugar targets were set for several food and drink food product categories to be achieved by 2026 (51). France had in place 'voluntary food industry commitment charters' with targets for sugar (as well as fat and salt), and progress monitoring by government (reference not available). The NOURISHING database[1] (as of 9th November 2023) describes a further 12 countries with sugar reformulation policies in place, this is more than double the number identified in 2021 (52). The brief policy descriptions provided show that all are taking voluntary approaches using either guidelines, maximum targets or industry pledges to target certain product categories, and most of the policies target sugar alongside other nutrients. For example, in Singapore seven manufacturers have made pledges to reduce the sugar content of SSBs to 12% or less as part of wider efforts to prevent diabetes (53). In Portugal, voluntary targets have been set through negotiation with industry to reduce the sugar content of five product categories by 7% (fruit juices) and 10% (chocolate milks, yoghurts, SSBs and breakfast cereals) (54). Some target deadlines have passed, others are still underway but only one in Norway referred to an evaluation report including data on sugar. The results of this are described in Chapter 3, Section 3.2.2 of this thesis.

The sugar reformulation policy in England was described as the first of its kind worldwide (55). It was formally announced within the governments Childhood Obesity Plan in 2016 (15) although it was one in a suite of recommendations made within a package of evidence published in October 2015 (56). The Sugar Reduction Programme (from herein, the SRP) is a voluntary reformulation policy which uses sugar reduction targets, progress monitoring and industry engagement to encourage gradual reductions in the sugar content of products that contribute to the greatest intake of sugar in children (57). A full description of this policy and its place in the wider nutrition policy landscape in England is provided in Chapter 2, Section 2.2 of this thesis and the results of progress monitoring reports are summarised in Chapter 6, Section 6.1.

[1] The NOURISHING database is a collection of nutrition policies being implemented by governments around the world. It is held by the World Cancer Research Foundation and can be accessed here: World Cancer Research Fund (wcrf.org)

England has over 20 years of experience implementing voluntary reformulation policy for salt reduction, and it has been argued that this provides important lessons for English sugar reformulation policy (58). The salt reformulation policy was first initiated in 2003 as part of a salt reduction programme, following publication of a SACN report highlighting the links between salt and health (59) and population salt consumption being considerably higher than the recommended 6g per day for adults and 1g – 6g per day for children [2] (60). The programme was described as successful based on evidence suggesting that the salt content of products had reduced (61, 62) without being obvious to consumers (63), and that concomitant reductions in population salt intake had been observed (61, 64). Guides to successful salt reduction have been produced based on this initial approach within England (65, 66), although the approach in England has evolved and changed over time. In 2011, the salt policy was integrated into the Responsibility Deal (from herein, RD): a public-private partnership between government, industry and non-government organisations, which included a focus on salt reduction alongside other public health issues (67). The RD was heavily criticised as government stepping away from their obligations (68-71); although an evidence review of voluntary policies (worldwide) similar to the RD suggested that such interventions can be effective if implemented well and properly monitored (29). The policy was later (in 2017) absorbed into a wider reformulation programme led by Public Health England (PHE) where salt reduction targets were again published and monitored, although the most recent reports showed that whilst progress has been made, many industry salt targets were still not being met (72). This suggests that voluntary policies can only go so far, or that certain implementation factors are necessary for ongoing success.

1.5 Evidence examining the effectiveness of sugar reduction policies targeting the food environment

There is a considerable evidence base examining the effectiveness of policies aiming to reduce sugar consumption. Recent scoping reviews identified 25 unique systematic reviews examining the effectiveness of policies across a range of outcomes (52, 73). Initially systematic reviews focused entirely on policies targeting SSBs (73), however more recently

[2] Recommended salt intake for children is as follows: 0-6 months - < 1g per day, 7-12 months – 1g per day, 1-3 years – 2g per day, 4-6 years – 3g per day, 7-10 years – 5g per day, 11-14 years – 6g per day.

reviews have also examined sugar reduction policies targeting other food and drink products (52). Multiple systematic reviews have examined the impact of taxes ('U') on the sale and consumption of sugar-sweetened beverages (74-76), food products (77, 78) or both (79). Reviews consistently reported that taxes on sugar are effective in reducing the purchase or sale of SSBs with the level of change dependent on the level of price increase (74-76, 79, 80). Whilst early reviews relied on modelling studies which simulated possible policy impacts, the most recent review included a larger number of studies comprising real-world SSB taxation interventions and experimental studies (76). Limited studies have suggested that taxes on high sugar food products may also be effective in reducing the purchase or consumption of sugar (78, 79, 81).

A recent Cochrane review examined the effectiveness of interventions focused on the food environment ('NOURIS', excluding taxes but including other pricing policies) in relation to SSB sales and consumption. Based on the results of 58 empirical studies, positive outcomes were reported from multiple interventions (82). For example, two interrupted times series studies showed a reduction in the sale of SSBs labelled as red in a hospital setting following the use of traffic light food labels ('N') and five controlled before and after studies were reported showing a reduction in SSB sales or intake when availability was reduced in schools ('O'). This review was focused on interventions, as opposed to nutrition policies.

Two systematic reviews have examined the effectiveness of reformulation ('I') in reducing sugar consumption either as a primary focus (83) or as one a range of dietary outcomes (39). Based on small, experimental studies and modelling studies Hashem et al. concluded that reformulation may be effective in reducing the consumption of sugar (84) but highlighted a need for empirical studies based on real-world implementation of reformulation. Gressier et al. (2021) included three empirical studies examining the effectiveness of sugar reformulation policy reporting a positive outcome from one of the studies in relation to the sales weighted sugar content in products (39). A more detailed summary of these two systematic reviews is provided in Chapter 3, Section 3.2.1 of this thesis.

1.6 Rationale for this thesis

Given the continued implementation of voluntary reformulation policies, and their prominence in tackling excess consumption of sugar in England, there is a need to better understand the potential for this type of policy to have an impact on sugar consumption and this is the goal of my DrPH thesis.

An **up-to-date synthesis of global evidence** is needed to determine the impacts that have been achieved following implementation of reformulation policies in real world settings in relation to sugar content of products, volume of sugar purchased and consumption of sugar. With the most recent systematic review searches by Gressier et al (39) completed five years ago it is known that more studies have been conducted. Focusing explicitly on evidence of policies targeting sugar will enable a clearer understanding of impacts unique to sugar.

An **analysis of the implementation of previous reformulation policy** is needed to understand what implementation factors are important for its success (or otherwise). The SRP in England follows a similar approach to English salt reformulation policy. This policy has been widely considered as a success based on reductions in population salt intake that were reported following its implementation, and understanding of its implementation approaches were used to inform global guidelines for salt reduction.

A **new in-depth analysis of product changes** in sugar, portion size and purchasing in England following implementation of the SRP is needed to examine the impacts of individual levers that were proposed for policy implementation. An in-depth analysis of three exemplar food product categories allows for more detailed insights to be gathered, therefore building on available progress monitoring reports. It also enables a closer look at industry approach to reformulation, in relation to reformulation of existing products or the creation of new products and the breadth of reformulation that occurred.

1.7 Overview of thesis

The remainder of my thesis is structured as follows:

- Chapter 2 provides a detailed description of the policy context in England in relation to sugar reduction and the sugar reformulation policy (SRP),
- Chapter 3 examines three theoretical frameworks that focus on reformulation and existing research evidence underpinning sugar reformulation policy,

- Chapter 4 sets out the aims, objectives and research questions for this thesis,
- Chapter 5 describes the detailed methodology used for the three studies included in this thesis and the results are presented in Chapters 6, 7 and 8,
- Chapter 9 provides a discussion and interpretation of the combined results of the three studies, sets out the strengths and limitations of my research, considerations for sugar reformulation policy and research gaps,
- A brief conclusion is provided in Chapter 10 and my integrating statement is presented in Chapter 11.

2. Policy action to reduce consumption of sugar in England and the Sugar Reduction Programme

This chapter describes the national policy context relating to sugar reduction in England during the initiation and implementation of the sugar reformulation policy. A detailed description of the sugar reformulation policy and its implementation is also provided.

2.1 Policy landscape in England relative to reducing the consumption of sugar

In England, government committed to reducing sugar for the first time as part of its Childhood Obesity Plan published in August 2016 (15). At the time, Health Survey for England data showed that around one in three children were overweight or obese (85) and the Childhood Obesity Plan set out an ambition *"…to significantly reduce England's rate of childhood obesity within the next ten years"* (15). A broad range of strategies were described within the Plan, targeting both nutrition and physical activity, and across a range of settings including early years settings, schools and communities. For example, a re-commitment to fund the Healthy Start Scheme providing vouchers fruit, vegetables and milk to low-income families and a new primary school healthy rating programme to encourage healthy eating and physical activity. Four of the strategies included a focus on sugar. Commitments were made to update school food standards to include new advice on sugar and to revisit food labelling to ensure sugar recommendations were clear. Initial plans were set out for the introduction of a tax on SSBs (the soft drinks industry levy, SDIL, this had already been announced in March 2016 within Budget 2016 (86)) and a voluntary sugar reduction programme for industry (the SRP). The latter two policies were intended to target the sugar content of food and drink products that contributed the most to childhood sugar. The Childhood Obesity Plan also referred to the Change4Life Sugar Smart app which had launched on 4th January 2016 as part of a marketing campaign targeting sugar (87, 88) and committed to further digital innovations for tackling obesity.

A second chapter of the Childhood Obesity Plan was published two years later in June 2018 (16) and showed strengthened political support for action to reduce sugar. This second chapter featured a section exclusively on sugar reduction, alongside four other sections on calorie reduction, advertising and promotions, local areas and schools – all of which

highlighted opportunities for sugar reduction. In the section focused on sugar, commitments were made to consider an expansion of the SDIL to include milk-based drinks and to consider other legislative options for high sugar food products if sufficient voluntary reformulation was not made through the SRP. Further commitments were made to consider whether products targeting babies and young children should be incorporated into the SRP, and to consult on a potential ban on the sale of energy drinks to children before the end of 2018. In other sections of the Childhood Obesity Plan Chapter 2, and in relation to sugar, commitments were made for further consultations regarding a potential ban on price and location promotions of food and drinks high in fat, salt and sugar, and a potential 9pm watershed for advertising products high in fat, salt and sugar on television alongside other limits related to advertising these products online. The need to consider sugar within School Food Standards was reiterated, and consultation regarding continued Healthy Start vouchers was announced.

In July 2020, during the early stages of the COVID-19 pandemic (see Section 2.4 below), a further strategy was published for tackling obesity in children and adults (17). This was driven by the immediate links that were observed between overweight and obesity and risk of a more severe COVID-19 infection. The strategy described more individually targeted action – for example, an online Better Health campaign for individuals and expanded weight management and diabetes prevention services. It also reiterated environmental policy actions from the earlier Childhood Obesity Plans, for example legislation on volume-based price promotions and a ban on advertising foods high in salt, fat and sugar on television after 9pm (policies which had not progressed since having originally been set out in the Childhood Obesity Plan). In a section on next steps, continued commitment was made for the SRP and to further action if insufficient progress was made although no information was provided on what this further action might be.

The two major policies that targeted sugar consumption are the SDIL and the SRP, both of which were initiated soon after the publication of the first Childhood Obesity Plan. The SDIL formally commenced in April 2018 and an independent evaluation of the policy was commissioned via the National Institute for Health and Care Research (89). Industry progress with reducing the sugar content of drinks included in the Levy was also monitored, initially by Public Health England (PHE) and then the Office for Health Improvement and

Disparities (OHID). Further information about the SRP, the policy of interest within this thesis, is provided below in Section 2.3. In addition to these policies, restrictions were placed on the location-based promotion of foods high in fat, salt and sugar as of 1st October 2022 (90) however, the restriction on volume-based price promotions (for example, buy-one-get-one-free offers) and advertising of these products have been postponed until 1st October 2025 (91). Whilst a public consultation was conducted in relation to the ban on sale of energy drinks to children (92) the results of the consultation were not published, and the policy has not been implemented.

2.2 The Sugar Reduction Programme (SRP) in England

The SRP is a voluntary reformulation policy. It is designed to encourage gradual reformulation of products by industry and thereby reduce the consumption of sugar at a population level. Led by Government, responsibility for implementing the policy initially sat with PHE, an arms-length body of the Department of Health and Social Care (DHSC), but it moved to OHID which sits within DHSC following the closure of PHE in September 2021. Whilst the policy does not have a definitive start and finish date, it is described by PHE as having been 'launched' in 2016. Whilst first announced within the Childhood Obesity Plan (15), the recommendation to implement the policy was made by PHE within a sugar evidence package published in October 2015 (93). This report collated multiple forms of evidence to describe the key influencers of sugar consumption, the potential impacts of food supply interventions, and strategies to improve public and professional knowledge of the role of sugar in health (93), and proposed a series of actions that collectively could contribute to reductions in sugar consumption. A timeline around policy initiation and implementation is provided in Table 2.

Implementation of the SRP included the development and publication of sugar reduction guidelines for industry to work towards, open and transparent progress monitoring of industry progress against these guidelines, and a programme of engagement with all sectors of industry and key stakeholders including trade associations and non-government organisations (57). The sugar reduction guidelines were set for all sectors of industry, initially across ten categories of food (see Box 1 below) based on their contribution to sugar intake in children as determined by PHE based on data from the National Diet and Nutrition

Survey and market analysis (57) and with industry consultation (94). The aim was for a minimum of 20% reduction in the sugar content of these products, with a minimum of 5% reduction at the end of the first year. Average and maximum calorie guidelines were also set for single serve products.

Table 2. Timeline of policy events relating to the sugar reformulation policy in England

Date	Event
June 2014	Draft SACN Carbohydrates and Health report out for consultation
June 2014	PHE asked to provide recommendations to government on sugar in the diet by Spring 2015 as part of PHE remit letter
June 2014	PHE publishes Sugar reduction: responding to the challenge detailing how evidence and advice on sugar would be provided to government
July 2015	SACN publishes Carbohydrates and Health report
October 2015	PHE Sugar Evidence Package published
August 2016	Childhood Obesity Plan published
August 2016	SRP 'launched' within the Childhood Obesity Plan
March 2017	SRP Guidelines published by PHE
May 2018	Year 1 Progress Monitoring Report (2015 – 2017) published by PHE
May 2019	Year 2 Progress Monitoring Report (2015 – 2018) published by PHE
May 2021	Year 3 Progress Monitoring Report (2015 – 2019) published by PHE
September 2021	PHE closes
October 2021	OHID starts, SRP moves to OHID
December 2022	Final Progress Monitoring Report (2015 – 2020) published by OHID

The policy was later extended to include milk-based drinks and juices from May 2018 (yoghurt drinks were initially excluded, but later incorporated into the milk-based drinks category from January 2019) as these products had been excluded from the SDIL. For milk-based drinks, ambitions were set for an initial 10% reduction in the sugar content of products by 2019 and 20% reduction by 2021 (95). For juices, an ambition was set for a 5% reduction in the sugar content of blended juices and for no increase in the sugar content of mono juices (95). The specific metrics used to set guidelines varied depending on product category but included mean or sales weighted mean (SWM) sugar content (g/100g) and

average and maximum calories per 100g of single serve products (defined by PHE as products that are likely to be eaten in a single occasion) (57). A table of guidelines set for each product category is provided in Appendix 1. The original intention had been to set all guidelines based SWM, to *"…help businesses to focus their reformulation efforts on the top selling products"* (57) however due to data limitations, this was only feasible for the in home sector. Mean sugar content was used to create guidelines for, and monitor progress within, the out of home sector.

PHE defined industry sectors as either 'in home' or 'out of home'. The in home sector comprised retailer own brand and manufacturer branded products intended for consumption at home. The out of home sector included pubs, restaurants, fast food restaurants and coffee shops where products were purchased for consumption outside of the home or takeaway and meal delivery services (57).

<table>
<tr><th colspan="2">Box 1: Categories of products included in the SRP</th></tr>
<tr>
<td>From 2016 onwards, ten food product categories:
• Biscuits
• Breakfast cereals
• Cakes
• Chocolate confectionary
• Ice-cream, lollies and sorbets
• Morning goods
• Puddings
• Sweet spreads and sauces
• Sweet confectionary
• Yoghurts and fromage frais</td>
<td>From May 2018: unsweetened juice and sweetened milk-based drinks (yoghurt drinks from January 2019)
<u>In home categories of milk-based drinks and juices:</u>
• Pre-packed milk based drinks
• Pre-packed flavoured milk substitute drinks
• Pre-packed fermented (yogurt) drinks
• Coffee and tea powders, syrups and pods as consumed
• Hot chocolate and malt powders, syrups and pods as consumed
• Milkshake powders, syrups and pods as consumed
• Pre-packed mono juices
• Pre-packed blended juices
<u>Out of home categories of milk-based drinks and juices:</u>
• Open cup milkshakes
• Open cup hot or cold drinks
• Blended juices</td>
</tr>
</table>

Three possible levers for industry to meet the reformulation targets were proposed:

- Lever 1: reformulation of products to reduce the amount of sugar
- Lever 2: reduction in calories and / or portion size of single serve products
- Lever 3: shift consumer purchasing patterns to lower or no added sugar products

The use of three levers was intended to provide flexibility for industry, acknowledging that some products might be easier to reformulate than others (57) and that different approaches may be needed to achieve overall reductions in sugar. PHE's guidelines emphasised the need to reformulate existing products, as opposed to creating new 'lower sugar' products, although it was acknowledged that the latter might still be used by industry as a means of achieving guidelines (96).

Progress was monitored by PHE analysts. Four progress monitoring reports were published on the government website annually (97-100), although there was some variation in timing over recent years most likely due to a combination of COVID-19 and organisational transition. Progress monitoring used the same data and metrics used to set guidelines and included year on year comparisons against a baseline year, examining mean and percentage change over time. Businesses were named in parts of the reports to compare the extent of progress that had been made, where permission had been granted by the business. Businesses were also invited to provide information for use in case studies, to enable them to highlight any successes that may not have been captured in routine progress monitoring.

2.3 Impacts of the Sugar Reduction Programme: progress against guidelines

The final SRP progress monitoring report showed an overall 3.5% reduction in SWM sugar content of food products within the in home sector by 2020 and a 0.25% reduction in the average sugar content of food products within the out of home sector (100). For the in home sector this was less than one quarter of the 20% reduction target set by PHE and almost zero progress for the out of home sector. There was variation in the extent of sugar reductions seen for product categories; for example, between 2015 and 2020 there was a 14.9% reduction in the SWM sugar per 100g in breakfast cereal products compared with a 3.1% reduction in the SWM sugar per 100g in biscuits. No one food product category achieved the 20% reduction target. Drink products were not included in the overall results,

and again category-specific results varied however targets were met or exceeded by five of the drink product categories included.

There was little overall change in the number of calories in food products available as single serve portions (a 0.5% reduction in SWM calories for products from the in home sector) although again, results varied by product category. Calories in drink products reduced across all product categories and three of four categories increased the proportion of products below the guideline for calories in a single serve product. Additional details of the results from progress monitoring reports are presented in Chapter 6, Section 6.1, which reports the results of a systematic review examining the impact of voluntary reformulation policies targeting sugar.

Unlike the SDIL, no formal evaluation of the SRP was commissioned via the National Institute for Health and Care Research (NIHR). A review conducted by Action on Sugar suggested that limited progress had been made as a result of the SRP, and that the considerable variability in sugar content of products suggested further reformulation was feasible (101). Monitoring of progress against guidelines by PHE / OHID aimed to capture progress against all three levers via one metric (the SWM), and progress against individual levers has not been examined. Nor has the breadth of reformulation of products (how many products have been reformulated) or the approach to reformulation (i.e. the reformulation of existing products versus the creation of new lower sugar products) been explored. Further analysis would therefore be useful to understand how industry has responded to the voluntary guidelines and to what extent.

2.4 Wider political context of relevance to this thesis

PHE's early work on sugar was complemented by an anti-sugar campaign led by Jamie Oliver, featuring a television documentary 'Sugar Rush' which highlighted the impacts of sugar on health. In his manifesto, Jamie Oliver supported the public health actions recommended by PHE (102) although advocated for a mandatory reformulation policy rather than voluntary (103). The evidence linking sugar consumption and health was first considered in the late 1950s when British nutritionist John Yudkin suggested that increases in heart disease were associated with increased consumption of sugar (104). Over subsequent decades this notion was heavily discredited by a prominent American

nutritionist Ancel Keys and his supporters, who were pushing their evidence an excess consumption of saturated fat was responsible for increased heart disease (not sugar), and by the food industry who had responded through lower fat (and therefore higher sugar) products (104, 105).

It is also important to note the wider context within which this thesis was conducted, and in particular which impacted on the final year of SRP implementation and subsequent policy decisions. Firstly, there have been multiple UK Prime Ministers since the SRP was first initiated in 2016 although, always with a Conservative government in power (see Box 2). There have also been multiple changes in the Secretary of State for Health and Social care (five different people held this role between 2021 and 2022) who has responsibility for the work of DHSC.

Box 2. UK Prime Ministers, 2015 onwards	
2015 – 2016	David Cameron
2016 – 2019	Theresa May
2019 – 2022	Boris Johnson
2022	Liz Truss (September – October)
2022 onwards	Rishi Sunak

In January 2020, the first case of COVID-19 was recorded in the UK and there were various restrictions in place between March 2020 and December 2021 that impacted on all parts of society. PHE played a major role within the national COVID-19 response and maintained this through to its closure on 30th September 2021. From 1st October 2021 public health responsibilities were split between the UK Health Security Agency (another arms-length body) and the Office for Health Improvement and Disparities (OHID) which was embedded within DHSC. Whilst this context may not have impacted implementation of the SRP between 2015 and 2019, it may have impacted on policy implementation (and ongoing commitment towards the policy) from 2020 onwards. This is considered further in the Discussion chapter of this thesis (Chapter 9, Section 9.4.4).

3. Reformulation policy: Theoretical frameworks and existing evidence

In this chapter I will describe three existing theoretical frameworks that can be used to analyse reformulation policy. As no one framework has focused on all aspects of reformulation policy and its implementation, multiple frameworks were needed and will be drawn upon throughout the three studies within this thesis. This chapter also includes an overview of previous studies that contribute to understanding of the potential role of voluntary sugar reformulation policy, with a view to highlighting a need for the research conducted as part of this thesis.

3.1 Theoretical frameworks to examine the potential impacts and implementation of reformulation policy

In Chapter 1 of this thesis, I introduced the NOURISHING framework as a tool to enable the classification of nutrition policies and to define the policy of interest (reformulation policy): *"I – Improve nutritional quality of the whole food supply"*. The NOURISHING framework is useful for understanding the breadth of policy options available, and previous studies have used it as a tool to categorise and monitor the implementation of policy actions globally (23, 27, 28, 50). However, it stops short of describing policy actions such as the tools, processes and structures required to support policy development and implementation (50).

Policy actions are captured in the similar Food-EPI framework, 'Healthy Food Environment Policy Index' for government, which has a narrower focus on only the food environment (24) but describes both the policies and infrastructure support needed in policy delivery. The framework was developed through a review of policy documents and consultation with experts, and as with the NOURISHING framework it has since been used to examine policy implementation (106, 107). The policy components broadly reflect the seven 'NOURISH' policy actions described previously, and descriptions and statements of good practice are provided alongside each policy (see Table 3) (24). For reformulation policy, referred to by Swinburn et al. (2013) as 'food composition', the statements of good practice relate to having targets for population intake of the nutrient of interest and strategies to achieve these, government targets for nutrient content of particular foods, a government led plan to

achieve improvements and systems to monitor progress (see Table 3 below). These statements provide a useful starting point for examining the implementation of reformulation policy.

Table 3. Food-EPI framework, statements of good practice for reformulation policy (Swinburn et al. 2013) (24)

Domain	Proposed good practice	Proposed good practice statements
Food composition	There are government systems implemented to ensure that, where practicable, processed foods minimize the energy density and the unhealthy nutrients of concern (e.g. salt, saturated and trans-fats, and added sugars) and maximize the healthy components (e.g. whole grains, fruit and vegetables)	• Clear population intake targets, with appropriate strategies, have been established for the unhealthy nutrients of concern (usually salt, saturated and trans-fat, and/or added sugar) to meet the World Health Organization and national recommended daily intake levels • Food composition targets / standards have been established by the government for the content of unhealthy nutrients of concern (usually salt, saturated and trans-fat, and/or added sugar) in certain foods or food groups if they are major contributors to population intakes of these nutrients (e.g. trans-fats in processed foods, salt in bread, saturated fat in commercial frying fats) • There is a transparent implementation plan, led by the government, to achieve improvements in energy density of the diet, food composition and population nutrient intakes for the specified nutrients of concern • Monitoring systems are in place to regularly check progress on improving food composition towards food composition guidelines/standards and population intakes towards specified intake targets or recommended daily intake levels

The Food-EPI framework also describes the infrastructure support needed for implementation of nutrition policies targeting the food environment. Based on the WHO

health systems building blocks (108), infrastructure support includes leadership, governance, monitoring and intelligence, funding and resources, platforms for interaction, workforce development and health in all policies (24). Again, statements describing good practice are provided against each one, however these are focused on the broader application of nutrition policy and whilst elements may have relevance, as they are not uniquely applicable to reformulation policy their role in its successful implementation need to be determined.

I have identified two different frameworks that focus exclusively on product reformulation. One of the frameworks sets out core domains that need to come together for industry reformulation to occur (109, 110), the other describes how product reformulation can be implemented and the expected impacts of this (40).

Van de Velde et al. (2016) (109) proposed the integration of four disciplines as a prerequisite for industry reformulation: i) nutrition and health, ii) legislation, iii) food technology and iv) consumer perspectives (see Figure 2, taken from Van de Velde et al. 2016). The nutrition and health component recognises the need to understand the health issues related to consumption of a particular nutrient, levels of consumption of a nutrient, the contribution of certain products to nutrient intake and established goals for reducing the availability and consumption of a nutrient. This aligns with the best practice statements described by Swinburn et al. (2013) in relation to reformulation policy (24) as well as commonly used nutrition risk assessment processes (111) (112). The legislation component recognises the importance of government led policy to drive reformulation. It highlights a range of policy actions that could be implemented in order for reformulation to occur, for example reformulation targets, labelling and pricing policies. The consumer perspectives component highlights the importance of consumer views on aspects of a product such as cost, the product itself (perceptions about taste of a reformulated product for example) or responses to marketing of a product. The food technology component acknowledges the importance of the technical aspects of product reformulation, such as taste and texture and the ability to replace a nutrient with something else.

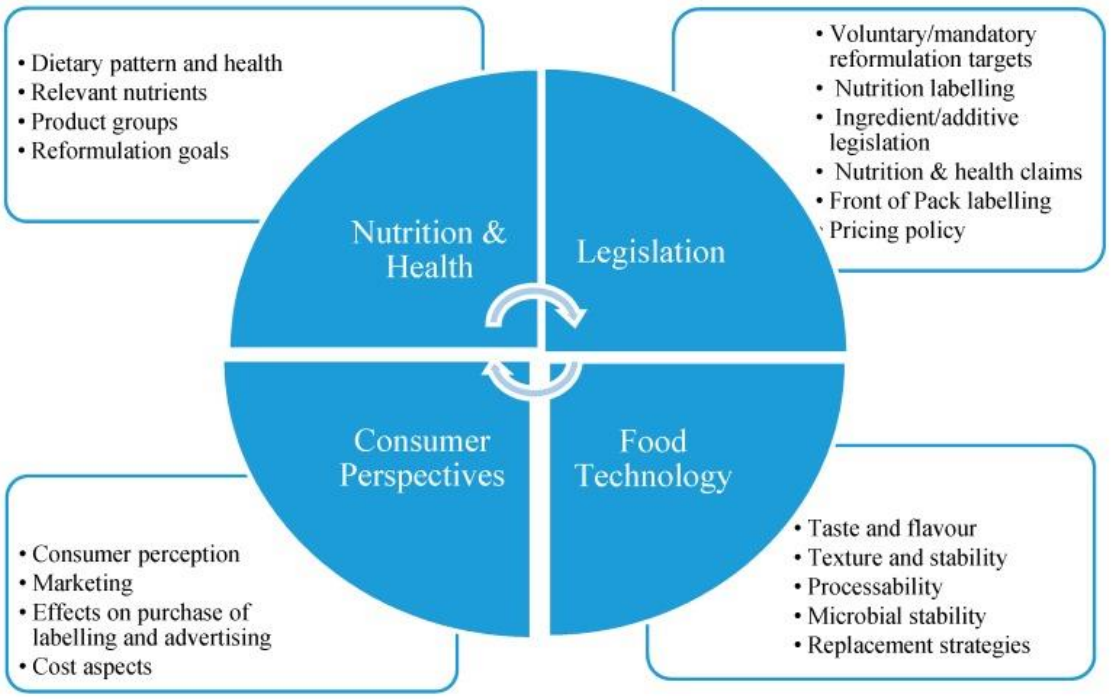


Figure 2. Framework for product reformulation to occur (Van de Velde et al, 2016) (109**,** 110**)**

Whilst the focus of the Van de Velde paper describing the framework was on meat and bakery products (based on their contribution to a range of nutrients in the diet within Europe) there is no reason why it should not apply to other types of products. The initial framework was published in 'New Food', an industry magazine, and appears to be based on a small sample of published literature although no methods are provided to explain how this was sourced (109). The framework was tested via a qualitative study with small to medium food companies which confirmed that the integration of these four disciplines was important for reformulation from the perspective of food companies (110) but also acknowledged additional challenges to reformulation from an industry perspective. For example, whilst aspects of health are important to industry, so is reducing the extent of additives (e.g. E numbers) and a focus on this could detract from nutrient reformulation efforts, particularly where additives enable reformulation. Study participants also suggested that some products or product groups are easier to reformulate than others and that salt reduction is easier to reformulate than other nutrients although no reasons for this were provided. The study suggested 'retailers' could be considered as a fifth component of the framework as they are known to drive the production of unbranded products as well as the

products on offer in supermarkets and can therefore be influential in relation to reformulation efforts.

Gressier et al. (2020) proposed a framework to describe how product reformulation can lead to dietary improvement and subsequent health outcomes (see Figure 3 below) based on different approaches to reformulation that might be adopted by industry (40). The framework is based on published literature, although only a brief method is provided noting the search databases and that literature reviews were sought and used as both a direct source and a source of primary studies. The studies described are mainly focused on reformulation of salt and trans-fats due to availability of evidence at the time. The framework includes a central 'expected' pathway, where a food product is reformulated, there is no change in the marketing of the product, consumers continue to choose that product, and this leads to dietary improvement and an impact on health. The pathway also highlights alternative actions or consequences that could lead to either no improvement or indeed a worsening of the diet. If a 'new' reformulated product is added to the market, rather than replacing an existing product, it may not be selected by the consumer in which case there would be no change in diet.

Any framework needs to consider the importance of consumer perspectives on food technology changes. If an existing product is reformulated but consumers change the way in which they're consuming it – either through consuming more of it due to a promotion or switching to another product due to change in taste for example – again, there may be no change in diet. The framework also suggests that a consumer may, when continuing to select the reformulated product, compensate for the changes, for example, through consuming more of this or another product if they're aware that it has been reformulated. Many public health advocates have stated the importance of understanding how industry approaches food reformulation in practice, as this will have implications for policy impact on intake.

The frameworks described in this chapter are complementary and when used together can help to examine the implementation and impacts of reformulation policy. These frameworks will be drawn upon throughout this thesis. In particular, the Gressier et al. framework will be used to identify expected impacts of reformulation policy, and to consider the extent to which industry reformulation follows expected or alternative routes (24, 39, 109). The Van

de Velde et al. (109) and Food-EPI (24) frameworks will be used to examine implementation of reformulation policy.

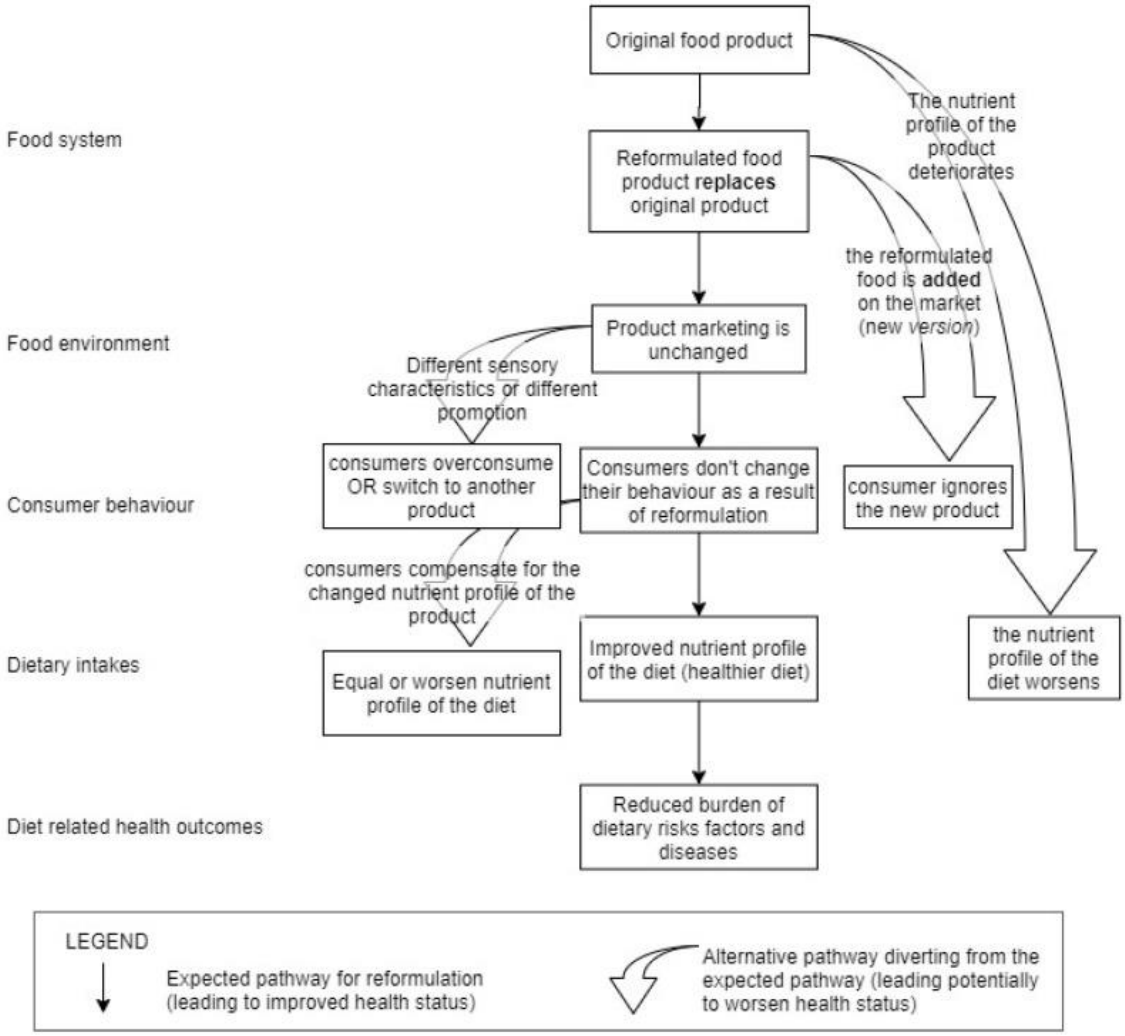


Figure 3. Framework for product reformulation (Gressier et al, 2020) (40**)**

3.2 Existing evidence on the implementation and effectiveness of sugar reformulation policy

3.2.1 What is known about the effectiveness of voluntary sugar reformulation policy?

Implementation of reformulation policy in relation to sugar reduction is still a relatively new concept, although as noted in Chapter 1 of this thesis (Section 1.3) it is gaining momentum globally and there is evidence underpinning this approach. Hashem et al. (2019) conducted a systematic review examining the effectiveness of reformulation in changing sugar intake

and health outcomes (83). This systematic review included studies published between 1990 and early 2016. Risk of bias in included studies was assessed using the Cochrane tool for randomised controlled trials and an adapted version of this for observational studies. The intention was to include evaluations of policy interventions as well as studies assessing the efficacy of product reformulation in changing intake under controlled conditions and modelling studies, however only one study evaluating a real-world reformulation policy was identified. This is not surprising, given the SRP in England was just starting at the time the search for studies was conducted and it is understood to be the first policy intervention of its kind (55).

The Hashem et al. (2019) review included 16 studies overall. Three were randomised controlled trials examining the impact of reformulation after 8 – 10 weeks under controlled, experimental conditions, six were modelling (simulation) studies estimating the effect of reformulation on population level sugar consumption or health outcomes, and six scenario-based simulation studies. The randomised controlled trials examined the effectiveness of reformulation rather than the effectiveness of a policy, for example through providing lower sugar products in place of usual products to a group of participants in an intervention group and comparing certain outcomes to a control group. Total sample sizes ranged between n=23 adults and n=49 adults with interventions lasting eight or ten weeks. Meta-analysis showed pooled reductions in sugar intake of -11.18% (95%CI: -19.95 to -2.41, $p<0.0001$, n = 123), suggesting that when individuals consume sugar reformulated products their intake of sugar reduces. These results were assessed using GRADE (the Grading of Recommendations Assessment, Development and Evaluation) as very low certainty due to high risk of bias in included studies, concerns over heterogeneity of the results, the small sample sizes and the fact that the RCTs did not closely resemble a population-level intervention.

The modelling studies that examined the potential impacts of reformulation either simulated specific levels of sugar reformulation in products or simulated the likely impact of particular reformulation interventions and their potential effects under different scenarios. Estimated reduction in sugar intake ranged between 0.2g/day to 62.1g/day (based on the results of eight studies) depending on the extent of reformulation modelled. For example, in an analysis that fed into the development of the SRP, Tedstone et al. (2015) reported that a 50% reduction in the sugar content of eight categories of food products could reduce intake

of sugar by between 17g/day and 26g/day depending on age (113). Modelling studies also estimated reductions in overweight and obesity, type 2 diabetes, dental caries in children and deaths being averted following sugar reformulation, although the extent of this varied depending on the scenario assessed (83). One of the scenario-based studies also included a retrospective observational component (the one 'real-world' policy). This observational study evaluated industry-led reformulation in Ireland, showing a 14% reduction in sugar content of reformulated products between 2005 and 2012 (the equivalent in grams was not reported). Data on reformulated products only were provided by industry for analysis, and the measure of intake is not reported. There is limited information provided on the methods or intervention by Hashem et al. (2019) and I have been unable to locate the original report, however the study was assessed as high risk of bias due to a range of methodological issues.

Risk of bias in modelling studies was not assessed, although Hashem et al. acknowledged certain methodological limitations inherent to the studies for example, the use of national survey data and potential measurement issues involved in the collection of nutritional information that was used in the modelling (83). Whilst modelling or simulation studies have a role in setting out impacts that could be achieved if a certain amount of reformulation were to occur, they can only estimate potential effects of reformulation, and are unable to take account of the range of factors that may impact on implementation in the real-world.

A second systematic review conducted by Gressier et al. (2021) examined the effectiveness of reformulation policy focused on any nutrient and targeting packaged food and drinks or food sold in restaurants, using only empirical studies of policy interventions (39). The Gressier et al. (2021) review builds upon the results of the Hashem et al. (2019) study as it collates and examines studies evaluating real-world sugar reformulation policy interventions published up to December 2018. Studies were included by Gressier et al. (2021) if they examined changes in sales or purchases of a reformulated product, change in market-share weighted average of nutrient, change in intake of a nutrient or in health. Studies assessing change in the nutrient content of products only were excluded, as were simulation or modelling studies.

Gressier et al. (2021) identified three studies evaluating the impacts of sugar reformulation policy (39). One was the year 1 PHE progress report for the SRP and two evaluated voluntary

reformulation policy in France. All three of the studies measured change in either purchases, sales or market-share weighted average sugar content, and only the results of the year 1 PHE progress report for the SRP were reported as positive (114). No further details on the results of these studies are provided by Gressier et al. (2021), and differences in results were not examined. The lack of reporting on sugar is largely due to the broad nature of the review which covered multiple nutrients, although I was able to go to the original studies for more details and these are reported here. The Spiteri et al. study (115) was scored as having a relatively low risk of bias (a score of 6 out of 7 using the Newcastle Ottawa Score, with 7 being lowest risk of bias) whereas Tedstone et al. and Oqali et al. had higher risk of bias with scores of 3 out of 7 (114, 116).

Spiteri et al. (115) examined change in sugar and other micronutrients of breakfast cereals, crisps, biscuits and cakes, and SSBs between 2008 and 2013. In relation to sugar the study reported 1% increases in the sales weighted mean sugar content of breakfast cereals and biscuits, and a 0.1% reduction in sales weighted mean sugar content of sugar-sweetened beverages. It is worth noting that the study did not describe any specific policy intervention in place at the time, only that some voluntary commitments had been made by industry. Tedstone et al. (2018) in their year 1 progress review of the SRP (114) reported a 2% reduction (between 2015 and 2017) in the sales weighted mean sugar content of food products included in the policy within the in home sector with variation across different product categories ranging from -6% in yoghurts and fromage frais to a 1% increase in puddings. I have been unable to consider results of the Oqali study (116) as it is reported in French.

Evidence from reformulation policies targeting other nutrients can also be drawn upon to consider the potential effectiveness of policies targeting sugar, and there is a large body of evidence examining the effectiveness of reformulation policies targeting trans-fats and salt. Studies have examined the impacts of both voluntary and mandatory policies on the nutrient content of products, nutrient purchasing or sales, and nutrient intake. Systematic reviews, based on empirical studies, have reported that reformulation policies are effective in reducing the content of trans-fat in foods (117), including when weighted by sales (39), trans-fat consumption (39, 117, 118) and improving health (39). Studies suggest that trans-fat bans are the most effective type of policy for reducing the content of trans-fats in food,

resulting in an almost complete removal of trans-fats from the food supply (117), and that multi-faceted interventions which included a ban on trans-fats in products are likely to be the most effective approach for reducing intake (118). A systematic review examining the effectiveness of salt reduction policies quantified the comparative effectiveness of different interventions, reporting modest effect sizes from voluntary reformulation policies compared with mandatory, fiscal and multi-faceted policies . Although only modelling studies had examined the effects of mandatory approaches (119).(119). A more recent review of empirical studies did not identify any studies examining the impacts of mandatory reformulation policy on change in market-share weighted average of salt or intake (39). More broadly, studies examining the effectiveness of voluntary, mandatory and partnership approaches to nutrition policy suggest that whilst mandatory policies are consistently reported to be effective the evidence for voluntary policies is mixed (28).

The definition of reformulation has varied in previous studies and systematic reviews. For example, some have considered food labelling or a tax as a reformulation policy. As a result, it is not always possible to determine the impacts of reformulation policy explicitly as defined within my thesis. This is particularly challenging when considering evidence from systematic reviews, as the results of different type of policy are combined. In addition, as reformulation policy has often been examined as one of a series of approaches, it is difficult to isolate the impacts of that particular policy. There may also be differences in impact depending on the nutrient of interest, and product categories. For example, in their systematic review of empirical studies of reformulation policy targeting any nutrient, Gressier et al. (2021) reported greater reductions of trans-fats in products (80 – 100% reduction) compared with sugar (2 – 3% reduction) and greater reductions in salt in certain product categories (breakfast cereal for example) (39). There is a need to comprehensively examine the impacts of reformulation policy on the sugar content in products, sugar purchased and sugar intake.

3.2.2 What is known about the implementation of sugar reformulation policy?

There is little evidence exploring implementation of sugar reformulation policy. The reports published by PHE and OHID to monitor industry progress within the SRP have focused on industry progress against guidelines based on single metrics. These analyses have not explored the ways in which industry have approached reformulation or implementation

factors that may have contributed to industry progress (or lack thereof). An evaluation of a voluntary reformulation policy in Norway examined its implementation, but not impacts (120). The policy involved a partnership whereby health authorities and the food industry signed a 'Letter of Intent' committing to work to improve diet between December 2016 and December 2021, including 'reduction of added sugar in foods' alongside other options for dietary improvement. Reformulation of existing products was only one of eight possible approaches to sugar reduction. Creation of new products and changes to packaging or portions were two additional options, but industry could also choose to alter placement or marketing of products. Data on the approaches implemented by industry was gathered using self-report questionnaires (response rate 61% to 79%) and industry views on the agreement were collected using qualitative interviews.

In Norway, no companies signed up to reduce the added sugar in foods until 2020, due to an increase in excise duty on certain high sugar products which led industry to cease any action on sugar. In 2020 and 2021, 45 and 46 companies respectively had signed up to reduce added sugar in foods and 31 of these provided data in 2020 and 2021. The most frequent approach reported by industry participants was the creation of new products, followed by reformulation and marketing of existing products (120). Businesses who engaged in the policy were motivated by social responsibility and the opportunity to improve the sale of their healthier products. Industry collaboration and shared responsibility were viewed as a benefit of involvement. Companies valued the focus on multiple areas of dietary improvement which helped ensure a coordinated approach and expressed a preference to work in collaboration with government than in a regulatory manner. The need to ensure consumers purchase healthier products was highlighted as an implementation challenge and it was noted that gradual changes had a limit whereby there would be technical implications. Whilst this study did not assess the impact of the policy in relation to the sugar content of products, the amount of sugar purchased or on intake; it does provide some useful insights into company views and preferred approaches to sugar reformulation. In light of the 'pathways to impact' set out by Gressier et al. (2020), and described within Chapter 3, Section 3.1 of this thesis, there would be value in better understanding industry approach to reformulation of sugar in England.

Reduction in portion sizes has been described as a potential means for reformulation of nutrients (39) and is a key mechanism within the SRP for reducing the sugar content of single serve products (96). There is consistent and robust evidence that increased portion size increases energy consumption (121, 122) and interventions to reduce portion sizes, including for single serve products, have been highlighted as one of a range of policy options (123) for tackling obesity. However, no previous studies have reported on changes in portion size as an approach to implementing reformulation policy (39) and there remains a lack of evidence examining the effects of reducing portion sizes of products in relation to consumer purchasing, or consumption of any nutrient in this respect. SRP progress monitoring reports suggest that no changes have been made to the calorie content of these products (100, 114, 124, 125). These results are presented in full in Chapter 6, Section 6.1, of this thesis.

Implementation of reformulation policy for salt and trans-fat has been underway for much longer than sugar, and the approach to sugar reformulation policy in England was at least in part informed by prior experience on salt. A short case study included in the package of evidence published by PHE prior to policy initiation described the "collaborative but authoritative approach" as being important in the success of the salt reduction policy, and consultation with industry around targets. Other key components described included the robust evidence base underpinning the need for salt reduction, the analytical approach for identifying where reformulation was needed and the clear and transparent monitoring of progress against salt reduction targets (113). Political commitment has been described as important in the implementation of voluntary reformulation policy for trans-fats, although in considering mandatory policy this could be obstructed by industry resistance (117). Descriptions of successful implementation of salt reformulation policy, in particular based on implementation of the policy in England, have highlighted the importance of a range of factors including data to set and monitor targets for salt reduction, implementation of food labelling and consumer awareness campaigns alongside work with industry on reformulation, and leadership and advocacy for salt reduction (38, 66).

3.3 Chapter summary

In this chapter I have described three theoretical frameworks that will be drawn upon throughout this thesis. There is no one framework underpinning reformulation policy, however these frameworks collectively can help to understand the potential impacts of reformulation policy and the expected pathway to achieving this (40), and core components of reformulation policy and implementation factors that are likely to be important (24, 109). I have also summarised the existing evidence underpinning sugar reformulation policy. Studies suggest that voluntary reformulation policy can achieve modest reductions in nutrient content of products, purchasing or intake of target nutrients, although most of the empirical studies have focused on salt and trans-fats and the evidence suggests that mandatory policies are more effective than voluntary policies. Recent systematic reviews have examined the potential impacts of sugar reformulation policy, but with the initiation of sugar reformulation policies globally it is likely that new evidence is now available. I have briefly described the available evidence on the implementation of sugar reformulation policy, which is very limited despite new policies being in place, and highlighted the potential to learn from the prior implementation of salt reformulation policy in England.

4. Aim and objectives

The overall aim of this research project was to critically examine the role of voluntary reformulation policy in reducing the sugar content of products, sugar purchased and consumption of sugar.

The objectives were as follows:

i) To provide an updated synthesis of the global empirical evidence on the effectiveness of reformulation policy for reducing the sugar content of products, purchase and consumption of sugar,

ii) To analyse implementation of voluntary salt reformulation policy in England to understand aspects of implementation contributing to its successes and pitfalls, and

iii) To examine product changes in sugar content of products, portion sizes and volume of sugar purchased using three exemplar food product categories following implementation of the SRP in England.

5. Methodology

This chapter describes the research methods used within this thesis. I conducted three discrete research studies, drawing on different research designs and methods, and these are described individually here. Theoretical frameworks described in Chapter 3 were drawn upon in conducting the studies (24, 40, 109). Collectively, the studies build an understanding of the potential role of voluntary reformulation policy in achieving sugar-related outcomes. Ethical approval was granted by the LSHTM ethics committee in November 2018 (LSHTM Ethics Reference: 17765). A data management plan was prepared prior to commencing this research and is provided in Appendix 2.

5.1 Study 1: Systematic review of studies assessing the effectiveness of voluntary sugar reformulation policy

5.1.1 Aim and research questions (Study 1)

The overall aim of this systematic review was to provide an updated synthesis of empirical evidence on the effectiveness of reformulation policies in reducing the sugar content of products, purchase or consumption of sugar. The research questions addressed are as follows:

i) To what extent have reformulation policies reduced the sugar content of products, sugar purchases or consumption of sugar?
ii) Are there differences in effectiveness for different types of reformulation policy or for different product categories?
iii) What is the quality of the evidence?
iv) What are the remaining evidence gaps?

5.1.2 Design

I conducted this research using a systematic review methodology, using a systematic search, screening, risk of bias assessment, narrative synthesis and evidence grading. The methodology (i.e., review protocol) set out here was developed *a priori* and the review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement as much as appropriate (126). Whilst a second reviewer was not

initially involved, all key stages of the review are currently being completed in duplicate as per the published protocol and in preparation for publication of results in an academic journal. Prospero: CRD42023465308.

This study is underpinned by the Gressier et al. (2020) framework (40) (Chapter 3, Section 3.1) which describes the expected pathways for reformulation to lead to improved health. In particular, I used this framework to determine the key changes I would expect to occur following implementation of reformulation policy.

5.1.3 Methods

Search methods: identification of studies

One systematic review has already been conducted on the topic of reformulation and sugar (Hashem et al, search dates: 1990 to early 2016) (83). To ensure that I was building on (rather than duplicating) existing research, I have focused on identifying new studies since this review was completed. I have drawn upon the methods used by Hashem et al. (2019) (83) but with some methodological adjustments described throughout this section. I had anticipated using the Hashem et al. review as a source of primary studies, however none of the 16 included studies were eligible for inclusion (see 'Inclusion / Exclusion Criteria below) due to study design (16 modelling studies) and intervention type (one study included an observational component, but evaluated industry led reformulation).

A comprehensive search was undertaken using multiple methods to identify both published and grey literature published between 1st January 2014 until 5th September 2023 (search date 5th September 2023). It is understood that England's Sugar Reduction Programme (SRP) was the first sugar reformulation policy of its kind, and this commenced in 2016. Searching from January 2014 provided additional assurance that any studies of policies that may have emerged around the same time as the SRP would be captured.

Electronic searches were conducted using MEDLINE, EMBASE, Scopus and the Cochrane Library, as per the protocol followed by Hashem et al. (2016) (84). Key words were specified for each component of PICOT, including for example 'sugar', 'reformulation' and 'reduction', based on search strategies used by Hashem et al. (2016). Searches were adapted to fit with each database, and Boolean operators were used to combine terms enabling a focused search. The search strategy developed for EMBASE (Ovid) is provided in Appendix 3.

Reference lists were scanned of primary studies meeting the inclusion criteria for this review, and of reviews identified either via my search or through work on other parts of this thesis.

Grey literature was sought via key word searches on Google and webpages of key public health organisations: the Office for Health Improvement and Disparities, the Centre for Disease Control, the NOURISHING database and the World Health Organization. If additional reviews were identified at this stage, the reference lists were manually screened to check for additional studies.

Inclusion / exclusion criteria

The criteria for studies to be included in this review are described below in Table 4 on the basis of population, intervention, comparison, outcome and study type (PICOT). Studies were excluded if they did not meet the inclusion criteria set out below, and if they were not English language due to limited capacity to undertake translation. This differs from the Hashem review in two important ways. In relation to outcomes, I expanded the narrow criteria adopted by Hashem et al. (2019) (sugar consumption and health outcomes only) to ensure that studies focused on intermediate outcomes (sugar content of products, sugar purchases or sales) were also included. This was managed through amendments to the search strategy. In relation to type of study, I excluded modelling studies and experiments conducted under controlled or laboratory conditions that did not feature a policy intervention in order to focus on studies examining the impacts of reformulation policies implemented in real world settings. I did not set any limits for 'date' for study inclusion.

Screening

Screening was conducted using the pre-determined inclusion and exclusion criteria. Firstly, titles and abstracts were screened, and a decision was made either to exclude a record or to review the full text. Full texts were gathered and reviewed and reasons for exclusion were documented. Screening was conducted using EPPI-Reviewer 4.

Data extraction

A standard data extraction form was developed using Excel and used to extract key pieces of information regarding the included studies. This included general details of the study (country, publication type, study objectives), information about the intervention (type of policy, target population, duration of policy, policy context, setting), methodological details

of the study (type of study, outcomes and outcome measures, data sources, unit of analysis / participants, comparator, study duration), results (by outcome and any sub-group analyses) and funding source. Any data relevant to inequalities was also extracted if available (for example, if changes in sugar intake for population sub-groups is explored).

Risk of bias assessment

The Quality Criteria Checklist (QCC) tool was used to assess risk of bias in included studies (127). This tool (provided in Appendix 4) was developed for the assessment of nutritional studies, although has also been used in public health rapid reviews (128), and is designed for use in reviews that include a mixture of different study designs. I adopted a different approach to Hashem et al. (2019) due to a lack of information about their approach to assessing risk of bias, unexplained inconsistencies in their protocol, and the value of using one tool for multiple study types if necessary. No exclusions were made on the basis of quality assessment scores, however any biases identified were used in interpretation and synthesis of studies.

Synthesis of results

A narrative synthesis was conducted, themed by outcome and with studies focused on the SRP prioritised in reporting due to their direct relevance to the research question. A meta-analysis was not attempted due to heterogeneity and the small number of studies. Sub-group analyses were also reported, in relation to product categories and inequalities.

The overall certainty of evidence was assessed using GRADE (the Grading of Recommendations Assessment, Development and Evaluation); a tool designed to assess the quality of a body of evidence and to enhance the strength of recommendations. GRADE classifies evidence as high, moderate, low or very low certainty on the basis of: i) methodological limitations, ii) indirectness, iii) imprecision, iv) inconsistency and v) likelihood of publication bias (129, 130). All studies started with low certainty due to study design. For each domain, a judgement was made as to whether or not there were any concerns with the studies across these domains, and these concerns were classified as:

- not serious (not important enough to warrant downgrading)
- serious (downgrading the certainty rating by one level)
- very serious (downgrading the certainty rating by two levels)

These concerns were then used to classify the body of evidence for each outcomes as having high certainty, moderate certainty, low certainty, or very low certainty.

Table 4. Criteria for inclusion of studies using PICO

	Inclusion criteria	Exclusion criteria
Population	• Whole populations including children (0 to 17) and adults (18 years and over) from all countries and settings, including where a study targets a particular age group (such as children) or any other population sub-group	• Studies focused on specific clinical groups / those with specific medical conditions
Intervention	• Any policy intervention focused on nutrient reformulation in relation to either food or drink products, defined as per the NOURISHING framework as policies to improve the nutritional quality of the whole food supply ('I') • The reformulation policy may be implemented alone or as part of a package of interventions, provided results specific to the reformulation policy are available	• Any other policy that may lead to reformulation as an outcome, such as food labelling or taxes • Studies conducted without a policy intervention in place • Studies focused on industry-led reformulation
Comparison	• Where studies involving comparison groups are identified, any type of comparison was accepted • A comparison group was not essential for a study to be included although a comparison of two time points was necessary	• Studies with no comparison group
Outcome	• Volume of sugar in products • Volume of sugar purchased, sold or expenditure on sugar • Sales-weighted sugar content of products • Sugar consumption or energy intake through sugar	• Composite nutrition scores using nutrient profiles which include but are not limited to sugar
Type of study	• Studies evaluating policies that had been implemented in the real world • Experimental, quasi-experimental or observational studies	• Modelling studies with simulated interventions or outcomes • Experiments conducted under controlled or laboratory conditions • Systematic, narrative reviews or opinion papers • Qualitative studies

5.2 Study 2: A case study of voluntary salt reformulation policy in England

5.2.1 Aim and research questions (Study 2)

The overall aim of this case study was to critically analyse voluntary salt reformulation policy in England to understand aspects of implementation contributing to its successes and pitfalls. The research questions are as follows:

i) How was the salt reformulation policy implemented and how did this change over time?

ii) What impacts were achieved by the policy and under what circumstances was it more (or less) effective?

5.2.2 Design

A case study approach was adopted. This is known to be a useful method for exploring a particular 'phenomenon' in depth and from multiple angles and perspectives (131). A case study approach also enables descriptive and exploratory research (131), which was important for understanding policy implementation. Salt reduction policy in England was selected as the case of interest, and there are multiple reasons for this. England's salt reduction policy has been described as a success within existing literature having achieved reductions in population salt intake, and there are known to be studies and other published information that describe its implementation and impacts at different time points during its lengthy implementation. The SRP was modelled on the salt reduction programme and therefore has similarities in its approach. I anticipated that the depth of experience gained from long-term implementation of salt reformulation policy would enable an in-depth analysis of policy implementation that could not be achieved through any other method. Essentially, it provided a national policy parallel to focus my analysis and develop an understanding of reformulation policy implementation in a directly relevant context. It was also feasible, as evidence on implementation and impacts of England's salt reformulation policy was already in the public domain.

Often, case study research involves the primary collection and analysis of data. However, there is a wealth of published evidence surrounding the salt reformulation policy in England

and therefore my analysis utilised existing material. I drew upon systematic review methods and qualitative analysis to conduct this case study.

All three theoretical frameworks described in Chapter 3, Section 3.1, were drawn upon within this study. The Van de Velde et al. (109) and Food-EPI (24) frameworks were used to examine policy implementation and the Gressier et al. (40) framework was used for the pathway to reformulation taken by industry (reformulation of existing products versus creation of new products) and policy impacts.

5.2.3 Methods

Data collection: Identification of studies and other published information

Data collection focused on gathering the breadth of evidence available relating to the salt reduction policy in England. Structured electronic searches were supplemented with snowball searching to purposefully identify studies and other published information that provided data relevant to my research questions. Full details of searches are provided in Appendix 5.

Electronic searches were conducted in the first instance using Medline, Embase, PubMed, Social Policy and Practice, and Health Systems Evidence. Key word search terms included 'salt', 'reformulation', 'reduction', 'policy' and searches were conducted using titles and / or abstracts depending on the option available. I screened the titles and abstracts of all records identified from the database searches to determine whether they contained any content relevant to salt reformulation policy in England and any that were clearly not relevant were excluded at this stage.

I used snowball searching to supplement electronic searches to purposefully identify papers or sources that the electronic search might have missed. This involved taking key studies identified via the electronic searches and i) using the 'cited by' and 'similar studies' functions in PubMed to find any additional records of relevance, and ii) scanning reference lists of included studies for additional records.

I searched for grey literature, including for example policy reports and reports published by industry and non-government organisations, using similar key word searches in Google where I screened until no relevant results were produced for three consecutive pages. I also searched government and relevant non-government organisation webpages, including

gov.uk (the UK Department of Health and Social Care webpages), the UK Food Standards Agency, and Consensus Action on Salt and Health (CASH) – all of whom had a direct role in implementing the salt reformulation policy in England. I spent time looking for references in the government archives, and in particular used archived webpages to understand how the policy had previously been implemented and materials used to support implementation.

In addition to studies focused on the salt reformulation policy in England, I looked for review papers (systematic or otherwise) with a broader focus that could be used as a source for primary studies. A number of these have already been summarised in Chapter 3 of this thesis; for example, the systematic review conducted by Gressier et al. (2021) includes four studies that evaluated England's salt reduction programme (39).

Inclusion of studies and information as data

Any study relevant to the case study policy and research questions could be included. No restrictions were placed on study design. Papers without a particular methodology (such as opinion pieces) were drawn upon if they could contribute to answering research questions. The use of studies / information was purposeful, and different perspectives were identified and incorporated (for example of academics, consumers, or policymakers). Reports or webpages were included if they described the policy or its implementation.

Data management and analysis

All studies or information identified were stored in Endnote 20, and I extracted information from relevant records into summary tables in Excel. This included details of the study or information source (title, type of information and date for example), methods (where applicable), relevant results / data, summary notes on how the study had been interpreted in the discussion and my own research notes.

Thematic analysis used in qualitative research was drawn upon to analyse data and this largely followed a deductive approach, however I also drew on inductive analysis to ensure any additional themes that emerged from the data could be captured (132). This was important as the frameworks that underpinned my work have not been widely tested or used for analysing reformulation policy. An initial high level coding framework was developed *a priori* based on the three theoretical frameworks as set out in Section 5.2.2 (see Table 5). Additional themes or sub-themes identified during analysis were added to the coding framework (also Table 5).

Records extracted into excel were organised based on these codes (Table 5). I also coded records by 'perspective' to help elicit different viewpoints using the codes government, non-government organisation, academic or industry. Data extraction and coding were done iteratively rather than sequentially, and additional themes or sub-themes were developed as part of this process. A narrative analysis was produced, organised using the individual theoretical frameworks with a section focused on additional themes. Summary tables and diagrams were used where useful; for example, to present the results of effectiveness studies or to show key policy timeframes. My analysis was also iterative, underpinned by the extraction tables I had produced, however I also went back to the full texts or primary information source during analysis and write up to ensure that appropriate detail was captured. This was particularly important in the larger evidence sources where it was not possible to extract all relevant data.

Table 5. Themes developed and used for data extraction and analysis

Framework	Major theme	Sub-themes
Van de Velde et al. (2016) framework **(**109**)**	Implementation	▪ Government policy ('legislation') ▪ Nutrition and health (intake and reformulation targets) ▪ Food technology ▪ Consumer perspectives
Food-EPI framework **(**24**)**	Implementation	▪ Intake targets ▪ Reformulation targets ▪ Transparent implementation plan ▪ Progress monitoring systems ▪ Government-led[1]
n/a – Leadership, governance and infrastructure[1]	Implementation	▪ Political commitment ▪ Governance ▪ Leadership and team ▪ Lobbying and political pressure ▪ Wider leadership and momentum
Gressier et al. (2020) **(**40**)**		▪ Salt intake and health outcomes ▪ Salt content of products ▪ Consumer behaviour

[1]Additional theme or sub-theme identified during analysis

Throughout data collection and analysis, I looked for both supporting and contrasting evidence, ensuring the use of best available evidence depending on the question (133). For example, when reporting data on effectiveness, I relied firstly on primary research as

opposed to an opinion piece describing the policy as a success (although I have reported on that too). I also considered and described biases in the data based on its source and methodology.

5.3 Study 3: Quantitative analysis of changes in sugar, portion sizes and purchasing in products between 2015 and 2018

5.3.1 Aim and research questions (Study 3)

The overall aim of this quantitative analysis was to examine product-level changes within the three levers of the SRP using three exemplar food categories. The research questions are as follows:

i) **Reformulation:** To what extent has the sugar content of products reduced?
   a. Are there differences between product categories and for branded versus unbranded products?
   b. Have existing products been reformulated or new lower sugar products created?

ii) **Portion sizes:** To what extent have portion sizes reduced?
   a. Are there differences between product categories and for branded versus unbranded products?
   b. Have new products with smaller portion sizes been created?

iii) **Consumer behaviour:** To what extent has consumer behaviour changed?
   a. Has there been a shift in purchasing to lower or no added sugar products?
   b. Are there differences between products categories and for branded versus unbranded products?

5.3.2 Design

This study was observational with a pre-post design, using consumer panel data comprising household purchases between 2015, 2017 and 2018 to track change in specified outcome variables from prior to (baseline, 2015) and during policy implementation. The 2015 dataset was selected for use as baseline data as this was used by Public Health England (PHE) to set SRP guidelines and as a baseline for future monitoring of progress. The 2017 and 2018 data can assess potential impacts for the first two years of the four-year policy. As described in

Chapter 2 Section 2.3, progress monitoring reports show that product changes had occurred within that timeframe (114, 124) and there was therefore value in conducting an in-depth analysis. This study is underpinned by the Gressier et al. (2020) framework (40) (Chapter 3, Section 3.1) which suggests that the initial stage of reformulation involves changes to the sugar content of existing products and highlights that an alternative approach could involve the creation of new, lower sugar products. Changes in portion size are also examined as this was a key lever proposed within the SRP and is a potential approach to reformulation of certain products where lowering sugar content in the recipe is less feasible.

5.3.3 Description of dataset and data collection procedures

Description of the Kantar FMCG dataset

This study utilised aggregated data from Kantar Fast-Moving Consumer Goods (FMCG) panel (formally Kantar Worldpanel), purchased by PHE for use within the SRP and provided to me by PHE for use within this thesis. This particular dataset represents purchases intended for consumption within the home (as opposed to outside of the home). Data from Kantar FMCG have been used for multiple previous studies examining nutrient content of food and beverage products (115, 134, 135) and the dataset was used to set SRP guidelines and for progress monitoring by PHE / OHID (100, 114, 124, 125).

Kantar FMCG data collection procedures

Kantar FMCG purchase and product data are collected continuously from a panel of approximately 30,000 households who have been sampled to reflect the population of Great Britain in relation to key demographics. Households use a scanner to record all purchases of food products intended for consumption within the home. Data are received automatically into the Kantar FMCG database where they are processed and put through a series of quality checks. Nutrition information is collected by fieldworkers who visited major retailers and took pictures of nutrition labels for available products. In 2015 and 2017 two fieldworker visits were conducted during the data collection periods and this was increased to three during 2018 to increase the amount of data available. Nutrition information is then manually added to the dataset. Gaps in nutrition information are filled using third party data sources (BrandBank and MySupermarket) where possible. Data collected via fieldworkers, Brandbank and MySupermarket are defined as 'real' nutrition data. Any remaining gaps in

nutrition information are filled by using nutrition information from similar products ('cloned' data) or imputed values using relevant category averages ('imputed' data).

Description of the Kantar FMCG dataset held by PHE

I used data held by PHE for three time-periods: 2015/16, 2016/17 and 2017/18, each collected over a 52-week time period (see Table 6 below). Whilst each data period crosses over more than one year, the three years of data collection are described within this thesis as '2015', '2017' or '2018' for ease of reporting. The dataset is product-level with unique identifiers assigned to each product. Variables relate to product purchases, product information and nutrition information and are provided in full in Appendix 6. Purchase information includes total volume of a product purchased (kg), total expenditure on a product and the number of products purchased(packs). These variables were weighted by Kantar FMCG to provide estimated purchase volumes that reflect the population of Great Britain. Product information includes product description, brand, product size (in weight), and number of items in a product (if it is a multi-pack). Nutritional information includes overall energy (in kilojoules and kilocalories) and information on specific nutrients (sugar, sodium and saturated fats for example) per 100g, per 100ml and / or per serving and the date the information was last collected is also stored.

Data were provided for products included within all SRP categories (see Box 1, p.29), and the total number of individual products ranged from 17,256 in 2015 to 20,525 in 2018 (Table 6).

Table 6. Data collection time periods

52-week data collection periods		**n products**
Baseline data ('2015')	1st February 2015 – 31st January 2016 *(received by PHE in February 2016)*	17,256
Year 1 data ('2017')	11th September 2016 – 10th September 2017 *(received by PHE on 1st November 2017)*	17,338
Year 2 data ('2018')	11th September 2017 – 10th September 2018 *(received by PHE on 1st November 2018)*	20,525

Each product in the dataset had been classified by a team of PHE nutritionists into one of the SRP categories or excluded. The dataset also included new composite or categorical variables created by PHE, for example to identify single serve products, to identify the weight of one item in a multi-pack product, or to identify the amount of sugar purchased in volume (kg,000s) as opposed to the volume (kg,000s) of products purchased.

5.3.4 Selection of product categories for analysis

To focus the study and enable a detailed investigation of the research questions within the scope of a DrPH thesis, three product categories were selected for analysis: Breakfast cereal, Chocolate confectionary and Sweet confectionary. Selection of product categories was pragmatic based on availability of data (number of products, % real or cloned data), contribution to sugar intake (described in Chapter 1, Section 1.1) and the type of lever most likely used by industry for reformulation. An overview is provided in Table 7. The Breakfast cereal category was selected as it represented an everyday food yet was a major contribution to sugar in diet (14). This category included a sufficient number of products (n ranged between 1417 and 1365), comprised a high proportion of real or cloned nutrition data (between 86% and 91%) and enabled a focused examination of sugar reformulation which was expected to be the primary lever for breakfast cereal products. I also knew that there had been some changes in this category that could be explored (97). Sweet and Chocolate confectionary were selected with a view to examining the use of portion size reformulation to reduce sugar: confectionary products are intended to be sweet so reformulation may be more challenging, and the use of reduction in portion sizes was expected to be more feasible (57).

5.3.5 Data cleaning and preparation

From herein, all statistical work was restricted to the three product categories selected for inclusion within this study. Substantial data checks had already been implemented by Kantar FMCG and PHE analysts, so little additional data cleaning was required for this study. Descriptive statistics, histograms and lists of products with highest and lowest values were used to check for anomalies in the data, check outliers (in particular, extremely high or low values that might have been errors), and to check the distributions of outcome variables to inform statistical tests and to assist with interpretation of results.

Only real or cloned nutrition data were used due to the accuracy required to assess change in nutrition content of specific products, so observations were removed if sugar information was imputed. This aligns with the approach used by PHE. Imputed data are generated by Kantar FMCG based on brand averages of similar products and as this could include lower or higher sugar products within a brand it may disguise any overall changes. Exclusion of imputed data resulted in the exclusion of 23%, 27% and 30% of observations in 2015, 2017 and 2018 respectively (see Table 8).

For variables involving sugar content both the zeros and high values observed were deemed to be plausible (for example, the products were identified as sugar-free chocolate confectionary or sweet confectionary with a very high sugar content) and therefore accurate. Similarly, high values observed in relation to sugar purchase data were considered to be plausible in that they reflected popular products, as were zeros which reflected the purchase of zero sugar products – there were very few of these zeros (2015: n = 6, 2017: n = 8, 2018: n = 16) and purchase data were all higher than 0.

Table 7. Number of products and data issues by product category

	Product category	Number of products (% real or cloned)			Data issues	Relevant SRP lever (57)	Reason for exclusion
		2015 (97)	**2017 (97)**	**2018 (97)**			
Excluded categories							
	Cakes	651 (18%)	686 (22%)	793 (74%)	Nutrition information provided as per serve (not per 100g), gram serving size not provided	Reformulation sugar Reformulation portion size	Very low % real or cloned nutrition data in 2015 and 2017 Low number of products
	Morning goods	244 (20%)	249 (26%)	353 (75%)	Nutrition information not per 100g	Reformulation sugar Reformulation portion size	Very low % real or cloned nutrition data in 2015 and 2017 Low number of products
	Ice-cream, lollies, sorbets	1030 (71%)	1039 (78%)	1077 (71%)	Nutrition information recorded in either ml or g but metric (ml or g) not reported	Reformulation sugar Reformulation portion size	Data issues as described in 'data issues' column of this table
	Puddings	1984 (80%)	1879 (79%)	1999 (72%)	Potential issue with as sold / as consumed conversions	Reformulation sugar Reformulation portion size	Data issues as described 'data issues' column of this table
	Sweet spreads and sauces	320 (84%)	313 (93%)	320 (86%)	Combines three categories due to low numbers	Reformulation sugar	Low number of products
	Yoghurts & fromage frais	1001 (78%)	1099 (80%)	1081 (74%)	n/a	Reformulation sugar Reformulation portion size Consumer behaviour	Products contain natural, so identifying reformulation may be more complex

	Product category	Number of products (% real or cloned)			Data issues	Relevant SRP lever (57)	Reason for exclusion
		2015 (97)	**2017 (97)**	**2018 (97)**			
	Biscuits	2671 (79%)	2532 (78%)	2688 (77%)	n/a	Reformulation sugar Reformulation portion size Consumer behaviour	Not consumed as part of a healthy balanced diet
Selected product categories							
	Breakfast cereals	1417 (91%)	1521 (88%)	1365 (86%)	n/a	Reformulation sugar Consumer behaviour	n/a
	Chocolate confectionary	2608 (96%)	2706 (81%)	2961 (70%)	n/a	Reformulation portion size	n/a
	Sweet confectionary	1828 (61%)	2025 (62%)	2003 (62%)	n/a	Reformulation portion size	n/a

Table 8. Real or cloned or imputed data, n (%), by year, product category, branding, single serve

	2015 n (%)			2017 n (%)			2018 n (%)		
	Total	**Real or cloned**	**Imputed**	**Total**	**Real or cloned**	**Imputed**	**Total**	**Real or cloned**	**Imputed**
All products	7985	6110 (77)	1875 (23)	8839	6412 (73)	2427 (27)	9036	6355 (70)	2681 (30)
Breakfast cereal	1552	1417 (91)	135 (9)	1732	1521 (88)	211 (12)	1588	1367 (86)	211 (14)
Chocolate confectionary	3370	2816 (84)	554 (16)	3875	2872 (74)	1003 (26)	4243	2968 (70)	1275 (30)
Sweet confectionary	3063	1877 (61)	1186 (39)	3231	2018 (62)	1213 (38)	3205	2020 (63)	1185 (37)
Branded	5381	3910 (73)	1471 (27)	5906	4238 (72)	1668 (28)	6072	4265 (70)	1807 (30)
Unbranded	2604	2200 (84)	404 (16)	2933	2174 (74)	759 (26)	2964	2090 (71)	874 (29)
Single serve	2250	1626 (72)	624 (28)	2369	1672 (71)	697 (29)	2353	1619 (69)	734 (31)

In checking the sugar purchase data, initially a larger number of zeros (n=135) were identified in 2015. This was compared with household purchase data, and it was identified that most of these (n=129) were errors - zeros for household purchase data are not possible, as observations are only added to the dataset when a product is purchased. These observations were changed to 'missing' in line with the rest of the dataset (products not available in any given year are automatically flagged as missing). There were no issues with data from 2017 or 2018.

Several new variables were generated either as additional outcome variables (for example, a new categorical variable to identify products that had changed sugar content between two years) or to enable sub-group analysis (for example, a new categorical variable grouping products based on their availability in the dataset each year). These are included in the list of variables provided in Appendix 6.

5.3.6 Statistical analysis

Statistical analysis was conducted using Stata 17. Descriptive statistics were produced to describe the data overall, but also using sub-categories of products. Table 9 shows the outcome variables used to measure changes in each SRP lever. I primarily used available case analysis, whereby any product available within the year of analysis was included, however I also conducted complete case analysis (i.e. products had to be present in all three years) to isolate reformulation effects from effects of changing product portfolios. I examined change in outcomes between 2015 and 2017 and between 2015 and 2018.

The portion size analysis was conducted on single serve products only as it was not possible to determine portion sizes for other products, meaning the Breakfast cereals category was not included in this analysis. I conducted sub-group analyses by the three product categories, whether products were branded or unbranded, and single serve products only. I conducted exploratory analyses to help understand certain results, for example examining the difference in portion size between new and discontinued products, and the extent of g/100g sugar reduction in those products that showed reduced sugar.

Table 9. Overview of main outcome variables by SRP lever

SRP Lever	Outcome variables
Reformulation	• Mean (gram and percentage) change in g/100g sugar content between 2015, 2017 and 2018 • Difference in mean g/100g sugar content for new versus continued products • Change in number or proportion of products available by quantity of sugar (high, medium, low)
Portion size	• Mean (gram and percentage) change in portion size in g/serving between 2015, 2017 and 2018 • Difference in portion size in g/serving for new versus existing products at 2017 and 2018
Consumer behaviour	• Average change in sugar purchasing (kg,000s, weighted to represent GB population) • Difference in category of sugar purchasing (high, medium, low sugar; kg,000s, weighted to represent GB population)

I used statistical tests to test the statistical significance of changes in main outcome variables (as set out in Table 9). In comparing difference between means, I used t-tests (unpaired for available case analyses, paired for the complete case analyses). When comparing proportions, I used proportion tests. I used medians and inter-quartile ranges when data were highly skewed (sugar purchasing data). Further, I used Wilcoxon rank-sum to examine differences between medians for skewed outcomes and where the results were inconsistent with t-test these were discussed as opposed to t-test results.

6. Results of Study 1: A systematic review of studies assessing the effectiveness of voluntary sugar reformulation policy

This chapter presents the results of my systematic review (Study 1) which sought to examine new empirical evidence on the impacts of sugar reformulation policy in reducing the sugar content of products, sugar purchases and sugar intake.

6.1 Study selection

Electronic searches identified 1,477 records, and after removal of duplicates (n = 132) 1,345 were screened for relevance using titles and abstracts. Fifty-two full texts were retrieved for further screening of which four were eligible for inclusion. A further four eligible articles were identified via the grey literature searches and through searching reference lists of existing reviews and relevant primary studies. An overview of the study selection process is provided in Figure 4 and detailed reasons for exclusion at full text screening are provided in Appendix 7. In total, 5 studies (8 reports) were included in this review.

For the purpose of this review the series of four progress monitoring reports published by PHE / OHID in relation to the Sugar Reduction Programme (SRP) are considered to be one study. I have prioritised reporting results of the final analysis published by OHID in 2022 which is based on data from 2020 and described as the fourth and final assessment of industry progress against the voluntary targets (100). Results of earlier reports (114, 124, 125) are drawn upon largely to determine if or how changes evolved over time or to highlight any differences in results between the years, as each year examined changes in outcomes only between two time points.

6.2 Characteristics of included studies

A summary of the characteristics of included studies is provided in Table 10. Three of the studies were from England, one was from Germany, and one was from Slovenia. All studies evaluated the impact of voluntary guidelines for industry for food or drink products using repeat cross-sectional designs, although the study conducted in Germany also included comparison groups. Descriptions of policies are provided in Box 3.

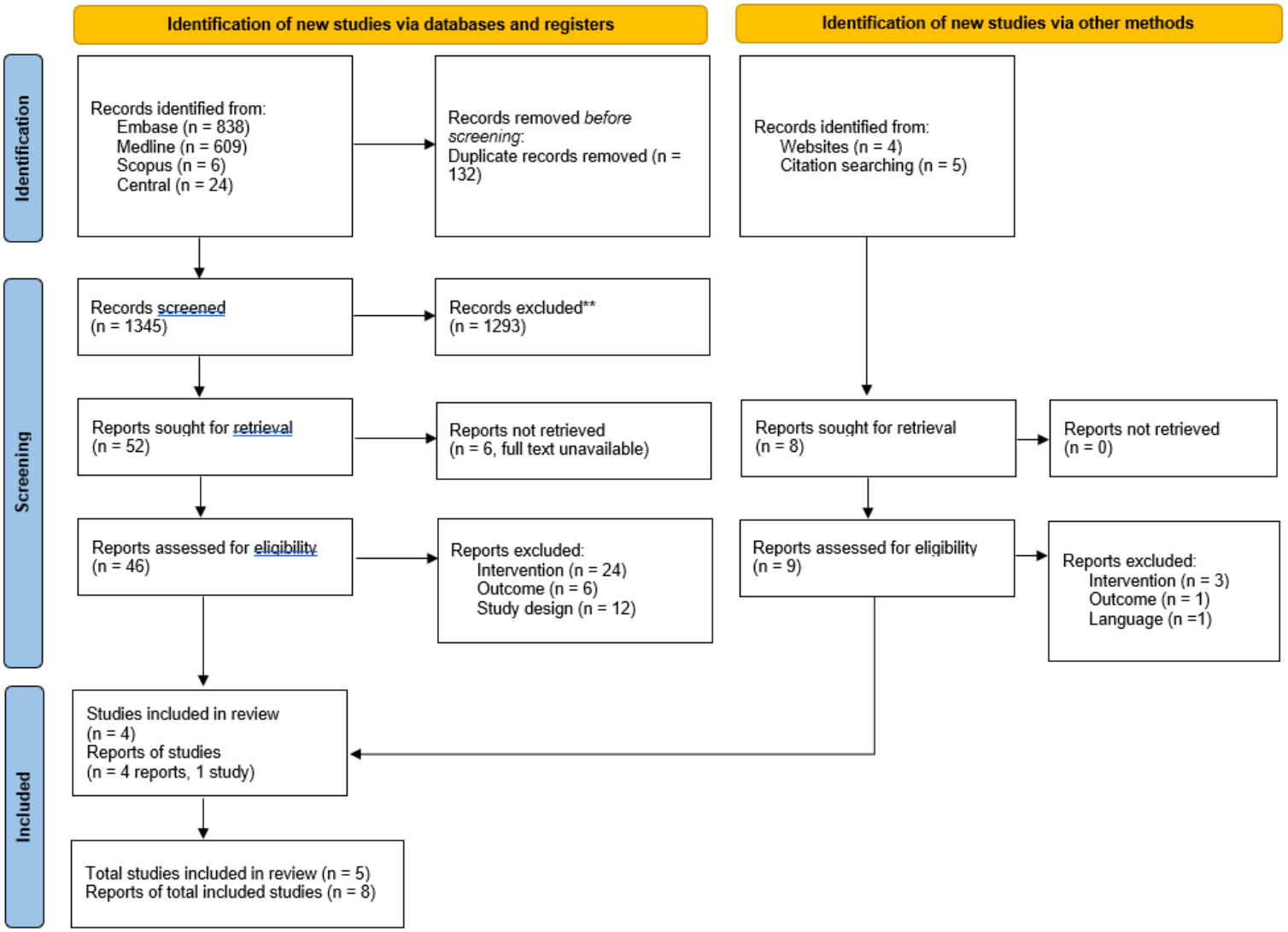


Figure 4. Prisma 2020 flowchart showing results of the study identification and selection process

The three studies (comprising six reports) conducted in England focused on impacts of the SRP (already described in Chapter 2, Section 2.2) over different timeframes and within different settings. One study focused on five categories of food products sold by major restaurant chains (136) between 2015 and 2018 and one study focused on five categories of food products sold within the in home sector (137) between 2017 and 2020. The third study focused on all 10 food and 11 drink product categories included in the policy across all settings and with repeat, annual comparisons between 2015 and 2020 (100, 114, 124, 125). A full list of product categories included in the SRP was provided in Box 1 (Chapter 2, p. 29). The study conducted in Germany focused on sugar-sweetened beverages (SSBs) (as per the focus of the policy) both in retail and out of home settings (138), and the study conducted in Slovenia focused on food and drink products sold in retail settings (139).

In relation to outcomes, two studies examined change in mean sugar content of products (100, 114, 124, 125, 139), one study examined change in median sugar content per portion of products (136), three studies examined change in sales-weighted mean sugar content of products (100, 114, 124, 125, 138, 139) and three studies examined change in sugar purchases or sales (100, 114, 124, 125, 137, 138). None of the studies examined change in intake of sugar as a direct measure of sugar consumption.

6.3 Risk of bias in included studies

An overview of the risk of bias assessment is provided in Table 11. One study was given an overall positive rating (137), three studies were given an overall neutral rating (100, 136, 138) and one study was given an overall weak rating (139). Three of the studies used a commercial data source, which are commonly used however they lack transparency on data collection procedures. Data used in England to examine changes in the sugar content of products in the out of home sector relied heavily on nutrition information provided by businesses which could have biased results. All studies lacked information about the policy, for example in relation to implementation mechanisms or resourcing. Only two studies included statistical tests (136, 137).

The risk of bias assessment considers methodological weaknesses that could introduce bias based on the study design, but it is also important to consider bias inherent to the study design. All of the studies were observational and used repeat cross-sectional designs where

an earlier timepoint formed the main comparison, and only one study included a comparison group (138). This means that it is not possible to determine whether or not changes would have occurred without the policy in place, or the impact of other factors in place at the same time (for example, other policies designed to reduce sugar or changes in volume of purchases overall).

Box 3. Descriptions of sugar reformulation policies

England's sugar reduction programme (SRP), 3 studies (100, 114, 124, 125, 136, 137)
A full description of this policy is provided in Chapter 2, Section 2.2 of this thesis.

Germany's reformulation guidelines for SSBs, 1 study (138)
This policy introduced voluntary reformulation targets to reduce the sugar content of SSBs in Germany by 15% by 2025, set by the German government in collaboration with the food industry. The policy was first announced in 2015 (and this was the baseline year) as part of a national strategy for reducing sugar, salt and fat in processed foods although the targets were published only in 2019. Incremental targets were not set over the ten-year period (2015 – 2025) but the emphasis of the policy was on gradual sugar reductions. No further information is provided in relation to the targets or products included in the policy and as referenced information is in German, I have been unable to utilise this.

Slovenia's sugar reduction targets, 1 study (139)
This policy involved voluntary targets set by the Ministry of Health to reduce the sugar content of packaged products. No information was provided in the paper about the policy including in relation to its start date, what the targets were and when they should be achieved, and which products it focused on. The results section focuses on five particular product categories based on their contribution to sugar intake and 'The Slovenian Resolution on Nutrition and Physical Activity for Health 2015 – 2025 priorities': Yoghurts, Biscuits, Breakfast cereals, Cakes, muffins and pastry, and SSBs. It is likely that these products were the focus of the policy.

Table 10. Characteristics of included studies and key results

Study details	Setting, products	Outcomes	Data source, sample	Key results
Pepper et al. (2023) (136**)** England Repeat cross-sectional design 2017 – 2020 Funder: not reported	Out of home setting: major restaurant chains Five food product categories ('desserts'): ▪ Biscuits ▪ Cakes ▪ Ice-cream ▪ Morning goods ▪ Puddings	**Primary outcome** Progress towards targets: ▪ changes in median grams of sugar per portion **Secondary outcome** ▪ Brand level changes Additional outcomes, not reported here[3] ▪ Change in median energy per portion ▪ % products with calories below maximum target	**Data source:** Nutrition information scraped from business websites or provided by businesses. Use of data collected as part of another study. **Sample (all years):** 78 restaurant chains (2017: n=unknown; 2018: n=71; 2020: n=56; 2018&2020: n=48) 3466 products (2017: n=824; 2018: n=1451; 2020: n=1191)	Overall median sugar/portion: -11% reduction (p=0.001), 30.5g to 27.1g ▪ Ice-cream – Mean 40.5g sugar/portion at baseline reduced to 25.2g sugar/portion in 2020 (−38%, p<0.001) ▪ Cakes – 9% reduction in sugar/portion (grams not reported, p=0.054) ▪ Other categories – no significant changes, results reported as graphs ▪ 4 (of 48) companies had significantly reduced the amount of sugar per portion (-20% to -39% reductions, grams not reported)
Bandy et al. (2021) (137**)** England Repeat cross-sectional design 2015 – 2018 Funder: Oxford University, NIHR	In home setting: retailers and manufacturers Five food product categories ▪ Breakfast cereal ▪ Biscuits and cereal bars ▪ Chocolate confectionary	**Primary outcomes** ▪ SWM sugar content of products (g/100g) ▪ Total volume sugar sales (g/day) **Secondary outcomes** ▪ Variation across companies ▪ Progress against targets	**Data source:** ▪ Nutrition information from Edge by Ascential (prev. Brand View) ▪ Sales data from Euromonitor **Sample:** 2015: 95 companies, 350 brands, 2,515 products 2018: 97 companies, 353 brands, 2,351 products	Overall SWM sugar content reduced from 28.7g/100g in 2015 to 27.2g/100g in 2018 (-1.5g/100g, -5.2%, 95% CI −9.1%, −1.4%, p=0.52) ▪ Breakfast cereal: -2.5g/100g; -13.3%, 95% CI -19.2%, -7.4%; p=0.16 ▪ Biscuits and cereal bars: -1.9g/100g; 95% CI -10.0%, -2.7%; p=0.78 ▪ Chocolate confectionary: -0.5g/100g; −1.0%, 95% CI -3.1%, -1.2%; p=0.91 ▪ Sweet confectionary: -1.5g/100g; -2.4%, 95% CI -4.2%, -0.6%; p=0.92 ▪ Yoghurt: -1.9g/100g; -17.0%, 95% CI -26.8%; -7.1%, p=0.70

Study details	Setting, products	Outcomes	Data source, sample	Key results
	▪ Sweet confectionary ▪ Yoghurts			Total volume sugar sales (g/person/day) reduced from 21.4g to 19.8g (-1.6g, -7.5%): 70% due to reduced mean sugar content of foods, 30% due to reduced volume sales. ▪ Breakfast cereal: −0.5 g/person/day, −16.1% ▪ Biscuits and cereal bars: −0.3g/person/day, −6.1% ▪ Chocolate confectionary: -0.1g/person/day, -1.3% ▪ Sweet confectionary: −0.2 g/person/day, −5.9% ▪ Yoghurt: −0.5 g/person/day, −20.8%
OHID (2022)[1] (100) England Repeat cross-sectional design 2015 – 2020[2] Funded by OHID / DHSC	In home and out of home settings 10 food product categories, 8 milk-based drinks and 3 juice product categories (See Box 1, p.29)	▪ Mean sugar per 100g or ml ▪ SWM sugar per 100g or ml ▪ Total sugar sales[3] *Outcomes varied by sector and product category <u>Additional outcomes, not reported here</u> ▪ Mean and SWM calories per single serve portion ▪ % products below maximum calorie guidelines	**Data sources:** Kantar FMCG and Lumina Intelligence (formerly MCA) **In home, Kantar FMCG only:** Sales data from consumer panel, product information collected by fieldworkers, Brandbank/mysupermarket.com and scraped from some business websites **Sample:**[4] Baseline n = 13,843 2020 n = 15,084 **Out of home:** Sales data collected via consumer survey, nutrition information scraped from websites ▪ baseline (2017), 2018 and 2019 – Lumina Intelligence	**Food products, in home** ▪ SWM g/100g total sugar: -3.5% reduction (from 25.8 to 24.9g/100g), variation across product categories ▪ Mean g/100g total sugar: -2.9% reduction (from 34.1g/100g to 33.1g/100g), variation across product categories ▪ 7.1% increase in sugar sales and 8.1% increase in sales ▪ Variation for retailers and manufacturers **Food products, out of home** ▪ Mean g/100g total sugar: -0.2% reduction (mean 25.7g/100g in 2017 and 2020) **Milk-based drinks and juices, in home** ▪ Mean g/100g sugar content: reduced in 7 of 8 product categories ▪ SWM g/100g sugar content: reduced in 4 of 4 product categories **Milk-based drinks and juices, out of home** ▪ Mean g/100g sugar content: reductions in 2 of 3 product categories

Study details	Setting, products	Outcomes	Data source, sample	Key results
			▪ 2020 data – Kantar FMCG **Sample:**[4] Baseline n = 950 2020 n = 528	
von Philipsborn et al. (2023) (138**)** Germany Repeat cross-sectional design with 3 comparison groups 2011 – 2021 Funded by members of the German Non-Communicable Disease Alliance	In home and out of home settings Sugar-sweetened beverages (non-alcoholic, non-dairy beverages with added sweeteners)	▪ SWM sugar content of products ▪ Mean sugar sales per capita per day ▪ Mean SSB sales per capita per day **Comparison with:** ▪ Targets ▪ UK trends ▪ Baseline	**Data source:** Sales and product information from Euromonitor Passport database **Sample:** No information provided	**Between 2011 and 2021:** <u>Trend in Germany</u> ▪ SWM reduced by -3.2% (5.4g/100 mL to 5.2g/100 mL) ▪ Sugar sales reduced by -9.9% (24g/capita/day to 21.6g/capita/day) ▪ Mean SSB sales reduced by -9.0% (428mL/capita/day to 389mL/capita/day) <u>Trend in UK</u> ▪ SWM reduced by -32.2% (5.6g/100 mL to 3.8g/100 mL) ▪ Sugar sales reduced by -32.9% (22.6g/capita/day to 15.1g/capita/day) ▪ Mean SSB sales increased by 0.2% (289mL/capita/day to 290mL/capita/day) **Between 2015 and 2021:** <u>Trend in Germany (comparison with baseline)</u> ▪ SWM reduced by -2.2% (5.3g/100 mL to 5.2g/100 mL) ▪ Sugar sales reduced by -3.6% (22.4g/capita/day to 21.6g/capita/day) ▪ Mean SSB sales reduced by -3.6% (404mL/capita/day to 389mL/capita/day) <u>Trend in UK</u> ▪ SWM reduced by -28.7% (5.3g/100 mL to 3.8g/100 mL)

Study details	Setting, products	Outcomes	Data source, sample	Key results
				▪ Sugar sales reduced by -28.5% (21.2g/capita/day to 15.1g/capita/day) ▪ Mean SSB sales increased by 0.7% (288mL/capita/day to 290mL/capita/day) <u>Modelled linear German target</u> ▪ SWM reduced by -9% (5.3g/100mL to 4.8g/100mL) **Trends in SWM sugar content before and after the policy:** 2011 – 2015: Compound annual reduction rate of 0.2% 2015 – 2021: Compound annual reduction rate of 0.4%
Zupanic (2019) (139**)** Slovenia 2015 – 2017 Funded by Slovenian Research Agency	Setting not reported, assume in home based on data collected 49 food and drink product categories Some analyses focused on 4 categories of food products and SSBs	▪ SWM total sugar content ▪ SWM free sugar content ▪ On-shelf availability, mean sugar, mean product sales	**Nutrition information:** collected by fieldworkers from major supermarkets (3 in 2015, 5 in 2017) ▪ n=21,115 pre-packaged products scanned and photographed ▪ n=11,425 contained free sugar **Sales:** provided by the two largest retailers in Slovenia ▪ 2015: 8,620 products ▪ 2017: 13,841 products **Matched analysis used for trends:** n not reported	Limited numerical data provided, no statistical tests or confidence intervals. Results mainly presented as graphs, so approximate values are given, and for individual product categories (no overall reductions reported). Some product categories (n=46) showed reductions in SWM sugar content (largest reduction for jelly (approx. 11g/100g), lots of categories increased sugar. Change in product availability and sales reported for 5 product categories, no overall results. Results varied: some increases in availability of low sugar products, increases and decreases in sale of unsweetened products, some increases in sale of low sugar and highest sugar products.

[1]I have summarised the results of the most recent progress monitoring report in this table. Results of earlier reports are included in Appendix 8. [2] Milk-based drinks and juices were included in the policy from 2018 onwards and have a 2018 baseline. Due to issues with 2015 baseline data, a 2017 baseline is used for cakes and morning goods (in home sector), Häagen-Dazs ice cream (in home sector), Aldi and Lidle (in home sector) and all analysis of out-of-home sector food products. [3]Results focused on calories are not reported as these outcomes were not the focus of this study. [4]Number of products included overall, sample size varies (is smaller) in particular analyses.

Table 11: Overview of QCC ratings

Reference	Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8	Q.9	Q.10	Rating
Pepper et al.			n/a		n/a						Neutral
Bandy et al.			n/a		n/a						Positive
von Philipsborn et al.			n/a		n/a						Neutral
Zupanic et al.			n/a		n/a						Weak
OHID			n/a		n/a						Neutral

Key: Green = yes, amber = unclear, red = no

6.4 Synthesis of results

Key results for each study are provided in Table 10. Tables showing annual results with the SRP monitoring reports and category-specific results are provided in Appendix 8. The following narrative summary of results is themed by outcomes, and studies examining change in outcomes based on implementation of the SRP are reported first due to their relevance. An assessment of the certainty of results is provided in Section 6.5 of this chapter using the same outcomes.

6.4.1 Change in sugar content of products (5 studies)

All three studies focused on the SRP reported on change in sugar content of products included in the policy, either through examining change in mean g/100g sugar content of products, sales weighted mean g/100g sugar content of products or median g/100g sugar per portion of products. Outcomes varied depending on sector and this was due to availability of data. Both non-UK studies evaluated change in sugar content of products included in the policy so the results of all five studies are included in this section.

One study – the SRP progress monitoring reports – assessed change in the mean sugar content of products (statistical significance was not tested in these reports). This focused primarily on the out of home sector where data on sales had been considered too unreliable for creating SWM sugar reduction guidelines, although change in mean sugar content of products was also reported for the in home sector to enable comparison between the two sectors. There was no change in mean total sugar (g/100g) content of food products included in the policy in the out of home sector between 2017 and 2020 (100). A -2.9% reduction in mean g/100g sugar was reported for food products in the in home sector over

the same timeframe. Results varied over time (for example, an overall -4.9% reduction in mean sugar content was reported between 2017 and 2018 for the out of home sector compared with a -0.2% reduction in the in home sector, Table A8a and A8c Appendix 8) (124). Different data were used within the two settings, and in some years data from certain product categories were excluded from analysis of out of home data which likely impacted results. Overall change in the mean total sugar (g/100ml) content of drink products included in the policy was not examined.

Results varied for the different product categories included in the policy. For example, in the out of home sector between 2017 and 2020 there was an -8.2% reduction in the mean sugar content of cakes, and between 2017 and 2019 (2020 data not reported) there was a -17.1% reduction in the sugar content of breakfast cereal products and a +10.7% increase in the sugar content of chocolate confectionary. Between 2018 and 2020 mean sugar content reduced in nine of the eleven drink product categories included in the policy across both sectors ranging from -1.7% reduction in pre-packed mono juices to -34.2% in milkshake powders, syrups and pods (both in home sector categories).

A second study assessed change in median sugar content per portion of products. Based on an analysis of five 'dessert' product categories included in the policy between 2015 and 2017, Pepper et al. (2023) (136) reported an overall reduction in median sugar per portion of -11% (from 30.5 g to 27.1 g per portion, $p = 0.001$). This overall reduction was driven largely by a median reduction in sugar per portion of ice-cream products from 40.5g/portion at baseline (2017, n = 250 products) to 25.2 g/portion in 2020 (n = 267 products, $p < 0.001$). There was also weak evidence of a reduction in sugar per portion of cakes (-9% reduction, $p = 0.054$, g/portion value not reported) which is similar to the reduction in mean sugar content (8.2%) reported by OHID (100).

Three studies assessed change in SWM sugar content (g/100g) of products, two of which focused on the SRP, with overall sugar reductions ranging from -2.2% to -5.4% (100, 137, 138). Based on an analysis of five food products categories in the in home sector between 2015 and 2018, Bandy et al. (2021) reported an overall reduction in SWM total sugar content of -5.2% (from 28.7g/100g to 27.2g/100g) which was not statistically significant (137). The overall reduction in SWM reported by OHID for all ten food product categories

included in the policy between 2015 and 2020 was lower at -3.5% from 25.8g to 24.9g (100) with a gradual reduction over the policy timeframe (2019: -3%, 2018: -2.9%, 2017: -2.5%) (114, 124, 125) (statistical significance not tested). The greatest annual reduction in sugar content was reported in 2017 following one year of policy implementation (114). The two studies used different data sources (Euromonitor sales data and Kantar FMCG consumer panel data), and this may have contributed to differences in results, however differences are likely to have been driven by the differences in product categories included in the analysis.

Bandy et al. (2021) reported variability in the extent of change in SWM total sugar content across products categories ranging from -0.5g/100g (-1%, 95% CI -3.1%, -1.2%) in Chocolate confectionary to -2.5g/100g (-13.3%, 95% CI -19.2%, -7.4%) in Breakfast cereal products but again, none of the changes reported reached statistical significance. OHID (2022) reported similar variation (100) with sugar reductions ranging -0.9% in chocolate confectionary to -14.9% in breakfast cereal products between 2015 and 2020. Change in SWM sugar reduced in all four categories examined, ranging from -2.8% in pre-packed blended juices to -29.7% in pre-packed milk-based drinks. In their evaluation of voluntary guidelines to reduce the sugar content of SSBs, Von Philipsborn et al. (2023) reported a -2.2% reduction in SWM g/100ml between 2015 and 2021 from 5.3g/100 ml to 5.2g/100 ml (138) which was less than a quarter of the expected estimated reduction over that timeframe. This reduction in sugar content is lower than the SWM reductions reported for drink product categories by OHID (in home product categories only, n=5) with the exception of yoghurt drinks which reduced by -2.3% (100). The g/100ml sugar content of SSBs was low to start with (5.4ml) compared to product categories included in other studies, and this may have impacted on the extent of reduction reported.

A fourth study analysed change in SWM, however results were presented mainly as graphs and very little numerical data were reported (139). Both reductions and increases in SWM sugar content were reported for some product categories between 2015 and 2017 with largest SWM reductions reported for jelly (approximately 11g/100g), chocolate and sweets (approximately 7g/100g) and breakfast cereals (approximately 5g/100g).

6.4.2 Change in sugar purchases or sales (4 studies)

Three of the five studies reported on change in total volume or per capita volume purchase or sale of sugar. Per capita sales reduced in both studies reporting on this outcome (137, 138), whereas total volume sales increased (100). Bandy et al. (2021) reported a -7.5% reduction in sugar sales from 21.4g/person/day in 2015 to 19.8g in 2018 (no p-values reported), and that 70% of this reduction in sugar sales was due to a reduction in mean sugar content and 30% was due to a reduction in volume sales of products. Von Philipsborn et al. (2023) reported a lower reduction of -3.6% of both sugar sales and SSB sales per capita per day over a longer time frame (138). OHID reported an increase in total volume sugar sales of +7.1% between 2015 and 2020, however this was largely due to an increase in total volume sales of +8.1% over the same timeframe. Small increases in sales and sugar sales were reported in 2018 and 2019, and the reports state that these were partially due to (or could be cancelled out by) increases in the population of Great Britain over the same timeframes (124, 125). There were also changes in the extent to which product categories contributed to overall sales, and this will have affected overall results.

A fourth study examined sales in five product categories included in the policy (139), however results are presented as histograms or line charts and little numerical information is provided. Particular observations were reported in a narrative synthesis describing changes in availability of products and the sale of these. For example, in relation to yoghurts, Zupanic et al. the (2019) reported an increase in the volume of plain yoghurt products but no change in sales of these products, suggesting that the increased volume of lower sugar products would not have impacted on the volume of sugar sold to consumers. On the other hand, there was an increase in both sugar content and sale of fruit yoghurts which would have led to an increase in sugar sales. There was an increase sale of lower sugar breakfast cereals and a reduction in sale of higher sugar breakfast cereal (sugar levels not defined) which would presumably have led to a reduction in sugar sales of these products.

6.4.3 Extent of engagement or implementation by industry

Extent of engagement by industry and extent to which targets had been met were not specified outcomes for inclusion in this systematic review, however in addition to the

variation by product category it provides important context for changes reported. Pepper et al. (2023) reported that only four of 48 businesses had significantly reduced the amount of sugar per portion in their products by between -20% and -39% (change in grams per portion not reported). OHID reported variation in the extent of sugar reductions made by businesses and brands with some showing increases rather than reductions (100). Similarly, based on an analysis of sugar sales for the top ten companies within each product category (50 companies), Bandy et al. (2021) reported variation in the extent of reductions made with some companies showing increased sugar sales.

Bandy et al. (2021) reported that just under half of these 50 companies had achieved the 5% sugar reduction targets by year 2 of the policy (although a 10% target had been set for that timeframe, so this study incorrectly reported on the number of companies achieving the policy targets). Pepper et al. (2023) reported that only one of the five dessert product categories in restaurants had met the sugar reduction targets in England by 2020, although it is worth noting that the target set for businesses was based on SWM rather than per portion changes. Results reported by OHID show that by the end of the policy targets set for year 1 had not been achieved overall, that only three drink product categories had met the 20% reduction target, and very few businesses had achieved this (100). Progress towards the targets for SSBs in Germany was less than one quarter of the expected reduction over the study timeframe (138).

6.4.4 Inequalities

Only one of the included studies considered inequalities in the impact of policies. The most recent progress monitoring report published by OHID (2020) explored differences in outcomes by socio-economic status for the in home setting only (due to data availability) and based on the ten food product categories included in the first iteration of the SRP (100). Percentage changes in SWM sugar content were reported as similar across the five socio-economic groupings for most of the product categories, with certain exceptions. For example, in relation to change in SWM sugar, the percentage reduction for Sweet spreads and sauces was reported to be highest in the most affluent socio-economic group (-13.2% reduction compared with -4.5% in the least affluent group). Other differences in product categories were described, however without product numbers or statistical tests it is difficult to know how meaningful these results are.

6.5 GRADE assessment

Four of the five studies were included in the GRADE assessment as an overall result was needed to enable comparison across studies. The study conducted by Zupanic et al. (139) included category-specific results only so was excluded. The results for drink products in the SRP progress monitoring reports were excluded for the same reason (80, 99, 100). Results of the GRADE assessment are presented in Table 12 and the analysis is provided in Appendix 9.

Table 12. GRADE summary of results

Outcome	Effect	Number of studies	Certainty in the evidence
Mean sugar content (g/100g) of products (100, 114, 124, 125**)**	Reduced by 1.0g/100g (2.9%) for in home setting, no change for out of home setting	1	Very low ⨁◯◯◯ (due to methodological limitations and imprecision)
Median sugar content (g/portion) of products (136**)**	Reduced by 3.4g/portion (-11%, p=0.001), only out of home setting examined.	1	Very low ⨁◯◯◯ (due to methodological limitations and imprecision)
Sales-weighted mean sugar content (g/100g or ml) of products (100, 114, 124, 125, 138**)**	All studies reported a reduction in SWM sugar content ranging from -2.2% to -5.4%.	3	Very low ⨁◯◯◯ (due to methodological limitations, imprecision and inconsistencies in results)
Mean sugar sales per person or per capita per day (100, 114, 124, 125, 137, 138**)**	Reduction in sugar sales ranging from -3.6% to -7.5%.	2	Very low ⨁◯◯◯ (due to methodological limitations, imprecision and inconsistencies in results)
Mean sugar sales – total (100, 114, 124, 125**)**	One study reported different results at different timeframes ranging from a -1% reduction in 2017 to a +7.1% increase in 2020.	1	Very low ⨁◯◯◯ (due to methodological limitations, imprecision and potential inconsistencies in results)
Sugar intake	n/a	0	n/a

High – Very confident that the true effect lies close to that of the estimate of effect. **Moderate** – Moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. **Low** – Confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. **Very low** – Very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of the effect.

There was very low certainty in the results against all outcomes, and this was largely due to methodological limitations, concerns related to imprecision and in some instances, concerns related to lack of consistency in the results. There were particular issues with the lack of information reported on sample sizes and most studies had not included confidence intervals or statistical tests. The number of studies overall was low, and for some outcomes the results of only one study were available. The studies included different product categories, and this is likely to have contributed to inconsistencies in results.

6.6 Chapter summary

In conducting a systematic review to identify new, real-world studies examining the impacts of sugar reformulation policies I identified five new studies. All of the policies evaluated involved voluntary (as opposed to mandatory) action by industry, and three of the studies focused on the SRP in England. The studies assessed change in the sugar content of products (either weighted by sales or not) and change in sugar purchases or sales, but not sugar intake. Overall, some small positive outcomes were observed (see Box 4 below) but there was very low certainty across all results (assessed using GRADE) due to methodological limitations in the studies identified, concerns around imprecision and in some instances concerns around inconsistencies in results.

Box 4. Recap of overall changes by outcome

- **Mean sugar content (g/100g) of products, 1 study (**100**,** 114**,** 124**,** 125**):** Reduced by 1.0g/100g (2.9%) for in home setting between 2015 and 2020. No change reported for the out of home setting.
- **Mean sugar content (g/portion) of products, 1 study (**136**):** Reduced by 3.4g/portion (-11%, p=0.001), only out of home setting examined.
- **Sales-weighted mean sugar content (g/100g or ml) of products, 3 studies (**100**,** 114**,** 124**,** 125**,** 137**,** 138**):** All studies reported a reduction in SWM sugar content ranging from -2.2% to -5.4%.
- **Mean sugar sales per person or per capita per day, 2 studies (**137**,** 138**)**: reduction in sugar sales ranging from -3.6% to -7.5%.
- **Mean total sugar sales, 1 study (**100**):** different results at different timepoints, impacted by other factors

Studies reported differences in results for different product categories. For example, reductions in the SWM sugar content of Breakfast cereal and Yoghurt products were consistently higher than other product categories. Although the changes were not statistically significant in the one study that tested this, despite -13% (Breakfast cereal) and -17% (Yoghurts) reductions in SWM sugar content of products (137). Reductions in sugar were higher for certain drink categories included in the SRP, for example the SWM sugar content of pre-packed milk-based reduced by almost 13% between 2018 and 2020 (100). This was not the case for all drinks included in England's SRP nor for all studies, as a study of voluntary reformulation of SSBs in Germany reported a -2.2% reduction in sugar content of SSBs over a 6-year timeframe.

Studies also reported variation by businesses. For example, Pepper et al. (2023) reported that significant reductions in the sugar content per portion of desserts sold in major restaurant chains were made by only four of 24 businesses included in the analysis (136). The most recent SRP progress monitoring report also highlighted variation in results across businesses by examining the top ten biggest selling products within each product category included in the policy. SWM changes in sugar content of products ranged from a 1% increase in the sugar content of cakes (ASDA, Pladis and Premier Foods) to a -23% reduction in breakfast cereals by Sainsbury's (100). Targets had been met for certain drink product categories only within the English policy (100). No studies reported on industry approach to reformulation, for example in relation to whether new products were created to reduce the availability of sugar on the market, or whether existing products were reformulated. No study reported changes in portion size as a reformulation mechanism, except for the SRP progress monitoring reports and these reported on calories per portion rather than grams.

It was generally difficult to determine the importance of the results both overall and when looking at product categories, as only two of the studies reported on statistical significance (136, 137), only one of these reported a statistically significant result (136) and any reductions reported were small. That said, the results suggest that sugar reformulation may be more feasible in certain product categories and that modest reformulation might be achievable by businesses under the correct conditions. None of the included studies had examined the different approaches taken by industry to achieve reductions in sugar content or sales and none had examined impact on sugar intake.

I excluded modelling studies from this systematic review as they had already been synthesised in a previous review but also to enable a focus on the impacts of policies when implemented in the real world as opposed to the potential impacts under assumed conditions. That said, modelling studies do enable a longer term analysis of outcomes and comparison different types of policy so may well have provided useful insight alongside the limited empirical evidence available.

7. Results of Study 2: Case study of salt reformulation policy in England

This chapter presents the results of my case study which analysed evidence on the implementation and impacts of voluntary salt reformulation policy in England with a view to identifying implementation factors that may be important in the successful implementation of voluntary reformulation policy targeting sugar. England's salt reformulation policy has been in place for around 20 years. Its approach has iterated over time and for ease of reporting, it will be reported based on four distinct phases:

- The FSA phase (2003 – 2010) (60, 68, 140, 141)
- The RD phase (2011 – 2015) (60, 68, 140)
- The PHE phase (2017 – 2020) (140)
- The OHID phase (October 2020 onwards) [no references available][3]

A timeline of key policy events is provided in Appendix 10 based on three existing timelines (60, 140, 141) and short descriptions of the policy phases are provided in Table 13.

7.1 Types of evidence identified and analysed

This case study draws on evidence from 20 papers published in peer review journals, one government report, 15 non-government reports and eight webpages. The papers published in peer review journals were predominantly (n=13) narrative papers or opinion pieces lacking any specific methodology. Some of these narrative papers or opinion pieces provided detailed reviews of salt reduction policy in England whereas others were very short papers with only small amounts of content relevant to the policy. Seven research studies were identified – six of these were observational studies evaluating the initial FSA phase of the policy (3 studies (61, 64, 142)), the RD phase (2 studies (70, 71)) or both (1 study (143)). In addition, a DrPH thesis was identified which comprised of a qualitative study examining the FSA and RD phases of the policy (60).

[3] The Consensus Action on Salt and Health timeline has not been updated since 2020

Table 13. Summary descriptions of the phases of salt reformulation policy in England between 2003 and 2024

Phase	Policy description
FSA Phase 2003 – 2009	Salt reformulation policy was implemented by the Food Standards Agency (FSA), an arms-length body (non-ministerial department) funded by the Department of Health and Social Care (DHSC). The policy formed part of a national salt reduction programme focused exclusively on reducing salt intake and was implemented alongside food labelling policy and a consumer awareness campaign (66, 144). Voluntary reformulation targets were set across 85 food product categories and progress was monitored using a combination of industry-reported and independent data. The successful campaign (144) focused on public education and improving awareness of the links between salt and health and the amount of salt in processed foods. It was implemented in four bursts over a 5-year period (September 2004 to October 2009) using television as well as online and printed materials (60) and a character 'Sid the Slug' which was heavily disliked by industry. The food labelling policy involved 'front of pack' labels using a combination of traffic light system and the words 'high, medium or low' to reflect the amount of salt in products as well as guideline daily amounts (60). Labels focused on individual nutrients, including overall fat, saturated fat and sugars alongside salt (145).
RD Phase 2011 – 2015	Implementation of the salt reformulation policy was moved to the Department of Health (DH) as part of the Public Health Responsibility Deal (the RD). The RD was a government-led collaboration with industry and the voluntary sector which had goals around health improvement. The RD involved five topic-focused networks (focused on food, physical activity, alcohol, health at work and behaviour change) and a series of 28 pledges that participants could choose to sign up to in order to be involved(146). The food pledges targeted salt, calories, trans-fats and fruit and vegetables initially (146) with pledges on front of pack labelling and saturated fats (70) added later on. Two pledges focused on salt: one focused on the on salt in catering, another on the salt reformulation targets. A campaign was implemented in 2013 and that included information about salt as well as other dietary goals (147). There was minimal pressure on industry to implement salt reformulation and monitoring was based on self-reported data with limited engagement.
PHE 2017 – 2021	Implementation of salt reformulation policy moved to PHE, an arms-length body (executive agency) funded by DHSC. The policy was incorporated into a reformulation and reduction programme that focused on reducing sugar and calories as well as salt, and new targets for salt were set in September 2020. The Change4Life campaign was also implemented by PHE during this time, focused on raising awareness of the role of salt in health as part of a broader range of nutrition topics (148).

Phase	Policy description
OHID 2021 – 2024	Salt reformulation policy is currently overseen by the Office for Health Improvement and Disparities (OHID) within DHSC, following transition of the health improvement function that previously existed within PHE. The policy is still part of the wider reformulation and reduction programme now led by OHID (149). New targets have not been set by OHID.

I did not identify any research studies evaluating the impact of the PHE or OHID phases of the policy, and to my knowledge no formal evaluations of these phases have been conducted. The webpages and government reports typically included reformulation targets, progress monitoring reports, summaries of stakeholder engagement and other information about policy development or implementation. Most of this information was obtained via archived websites.

7.2 Implementation of salt reformulation policy in England

This section reports on implementation of salt reformulation policy in England, based on the four core components of reformulation set out by Van de Velde et al. (2016) (86) and the best practice statements producted by Swinburn et al. (2013) within the Food-EPI framework specific to the reformulation policy domain (24).

7.2.1 Analysis based on the Van de Velde et al. (2016) reformulation framework (109, 110)

Government policy ('legislation')

Government policy ('legislation') was described as a core feature of reformulation by Van de Velde et al. (2016), who acknowledged a range of policies that could be used by government to encourage product reformulation by industry (86). Reformulation policy is described as 'reformulation targets' which could be voluntary or mandatory. Other legislative options described (based on their potential role in encouraging product reformulation) include nutrition labelling and front of pack labelling, legislation on additives or ingredients, nutrition and health claims, and pricing policies (109).

England's salt reformulation policy has always been implemented as part of a package of nutrition policies focused either on salt or on other nutritional outcomes. During the FSA phase reformulation policy was part of a national salt reduction programme, implemented alongside food labelling policy and a consumer awareness campaign (66, 144) which collectively were designed to lead to reduced intake of salt. During the RD phase, it was implemented as part of a wider policy covering a range of health improvement outcomes. Participants were encouraged to sign up to 'pledges' for action across a range of strategies, and salt reformulation was one of the eight pledges within the food network (146), (70).

> *"We commit to the salt targets for the end of 2012 agreed by the Responsibility Deal, which collectively will deliver a further 15% reduction on 2010 targets. For*

some products this will require acceptable technical solutions which we are working to achieve."

DH [date unknown], RD pledge – salt reformulation

A campaign was implemented in 2013 and that included information about salt as well as other dietary goals (147) and food labelling was incorporated as one of the eight food pledges (60, 70). The salt reformulation policy later moved to PHE when it became part of a reformulation and reduction programme that focused on reducing sugar and calories as well as salt. Again, campaigns were implemented during the policy timeframe – the Change4Life campaign – including salt as part of a broader range of nutrition topics, although the campaigns appeared to have had a more substantial focus on sugar than on salt (150).

England's salt reformulation policy has always been a voluntary policy, so it is not possible to draw any comparisons to a mandatory approach, however the threat of mandatory action has been documented throughout different phases of the policy (66, 150). One paper described this as an important driver of work with industry during the FSA phase of the policy (66), although the threat of mandatory action did not feature in the Wyness et al. (2011) review of this phase (144). It is worth noting that the authors of this review were employed by the British Nutrition Foundation who, whilst being an independent charity with clear governance structures in place, are funded by and work in collaboration with the food industry. **(**69**)**

In a case study of England's salt reduction programme which used stakeholder interviews to gather data, Mwatsama (2016) reported how the FSA phase of the policy had been viewed as sitting in between a voluntary and mandatory approach due to its open and transparent progress monitoring approach as a means of regulation and enforcement.

"…[it] had more muscle than a purely voluntary scheme… it was in fact a form of soft regulation…"

Mwatsama (2016), DrPH thesis, Qualitative study (60**)**

It is thus very possible that this contributed to policy impacts during that phase. A quote from an industry stakeholder stated that the policy felt more like a mandatory policy due to the extent of pressure applied (60).

Mandatory action has never been implemented nor has any threshold been set on when mandatory action might be taken.

> *"The Deal has no enforcement options, and while the government has threatened the food industry with legislation, it has not committed to specific, time-bound action if the Deal fails to achieve its objectives…"*

Reeve et al. (2015), Academic, Narrative (69**)**

It is therefore unclear how useful this threat continues to be in encouraging industry action, particularly in the absence of robust monitoring approaches as used by the FSA.

Nutrition and health

The nutrition and health domain considered dietary patterns, relevant nutrients, product groups and reformulation goals (24, 109). All of these components could be identified as core components in the development and delivery of England's salt reformulation policy.

Relevant nutrients and dietary patterns

The need for a public health focus on salt was clearly established in the lead up to initiation of the salt reformulation policy in 2003. The WHO released guidelines recommending that the salt intakes of populations should be reduced (151) and the Scientific Advisory Committee on Nutrition (SACN) published a report setting out evidence on the links between salt (sodium) and health (59). The SACN report concluded that there was an association between salt and high blood pressure, and that population level approaches were needed to reduce salt intake from 9g per day (the average daily intake at the time) to a recommended target of 6g per day. England's salt reduction policy was formally initiated in 2003 following the publication of the SACN report. In addition to this, it had been established via an analysis of data from the National Diet and Nutrition Survey that 80% of salt intake came from processed food (i.e. the food industry), with 15% coming from salt added either at the table or during cooking (the remaining 5% was naturally occurring in food) (66, 144). Later, an aspirational target of 3g of salt per day was set by the National

Institute of Health and Care Excellence in their guidance for prevention of cardiovascular disease (152, 153).

The salt reformulation policy is still in place twenty years after its initiation with most recent targets set to be achieved by 2024 (154), although salt is no longer the primary policy concern. This is despite the fact that evidence on the association between salt and health has not changed since the policy was first initiated (although it has not been formally revisited), cardiovascular disease is still a major public health issue in England (150) and population intake of salt is still higher than the public health target of 7g/day (155). This suggests that data on health issues is important early on in initiating salt reformulation policy, and explaining why reformulation is necessary, but less so for ongoing policy implementation.

The failure of evidence on the links between salt and health to initiate salt reduction policy sooner was also highlighted in the literature. A narrative paper, written by academic and campaigning members of CASH, described how evidence on the associations between salt and cardiovascular disease was originally published in 1994 by the Committee on Medical Aspects of Food and Nutrition Policy (COMA) and a reduction in population salt intake was first recommended (68). This recommendation is said to have been rejected by government initially due to threats from the food industry relating to their withdrawal of funding for government, and later endorsed only once CASH (a non-government organisation involving experts in salt and blood pressure) had been established and worked to influence government's decision (68). This suggests that evidence highlighting nutrition and health of a particular nutrient is not the only driver of policy (or industry) action.

Intake and reformulation targets

A target for population salt intake was originally set at 6g per day prior to implementation of the salt reformulation policy by SACN in 2003 (59). This was adjusted to 7g per day during the PHE phase (156). The intake targets were used by the FSA in developing the initial reformulation targets and to highlight the concerted effort required by all stakeholders to reduce salt intake (144). The new '7g per day' intake target was described by PHE in their 2024 salt reduction targets as government ambition, but it does not appear to have been

used in revising the targets for product reformulation and it is not clear why this target was higher than the original 6g per day.

Reformulation targets across product groups have been an integral part of England's salt reformulation policy throughout its implementation. The intention of these targets was to gradually reduce the salt content of particular product groups and to reduce salt intake as a result of this. For example, the salt targets set in 2014 were reported to be on average 10% lower than the previous targets (140).

> *"Every update of the salt reduction targets was designed to drive gradual stepwise reductions in the salt content of foods, contributing to reducing average dietary salt intakes towards the recommended population average of 6g per day. The targets are intended to be stretching but achievable, and to achieve incremental salt reduction without people being affected so that everyday foods remained acceptable."*
>
> **PHE (2020), Second progress report on salt targets (**72**)**

A combination of average and maximum targets has been used, to allow for some flexibility on reformulation within a product category (average targets) whilst also encouraging reformulation of those products that are particularly high in salt (maximum targets) (157).

When the policy was initially developed, the FSA produced a model (56, 158) showing levels of salt consumption across a range of product groups (n=48), their contribution to sodium in the diet and the reductions that could be achieved through target reductions which ranged from 0% in milk and milk products to 81% in tinned vegetables. The model was used to inform stakeholder discussions around the scale of reductions that would be needed and ultimately the first set of targets published (56, 60, 66, 144). The product groups were selected due to their contribution to salt intake and were accepted and finalised through stakeholder consultation (159). The FSA had first planned to produce targets for ten categories of food with the greatest contribution to salt intake, however this was extended following discussions with stakeholders in order to increase the reach of the policy and improve the potential for success (60).

To date, five sets of salt reduction targets have been published for between 76 and 85 product groups in 2006, 2009, 2014, 2017 and 2020. Some examples are provided in Table 14. Whilst five sets of targets have officially been published, the targets published by PHE in 2017 were the same as those published in 2014 targets – the end date was moved from 2017 to 2020. It is now ten years since the new targets have been set. There is limited information about the 2009 and 2014 targets, and as each new set of targets builds on the previous it is overall unclear and not transparent how targets have been set and / or adjusted since 2006.

Food technology

Food technology was described by Van de Velde (2016) as including i) taste and flavour, ii) texture and stability, iii) processability, iv) microbial stability and v) replacement strategies (109). These aspects of food technology were considered in the implementation of salt reformulation policy, in particular when the salt reduction targets were developed (36). Some technological challenges were acknowledged in reducing the salt content of certain products (for example, bread, cheese and some meat products), but there was general consensus in the literature that reducing the salt content of processed food was technically feasible.

Even amongst those products considered more technically challenging, the variations in salt in products within the same product groups showed that lower levels of salt were achievable (144, 160).

> *"Reducing population salt intake is relatively easy for manufacturers…there are few technical barriers. For the small minority of products in which salt has a technical function, large variations in the salt content of similar products show how much salt can still be innocuously removed."*
>
> **Buttriss (2013), Nutritionist, Narrative paper (**36**)**

In their review of the FSA phase of the policy, Wyness et al. (2012) described how the FSA commissioned research to check food safety, sought expert advice from their independent advisory committee for microbiological food (ACMSF) and encouraged manufacturers to consider food safety during the product reformulation process (144).

Table 14. Example salt reduction targets taken from the 2024 targets published by PHE (154**)**

Main product category	Sub-categories (where relevant)	SALT TARGET FOR 2024 (g salt or mg sodium per 100g)	SALT TARGET FOR 2017 (g salt or mg sodium per 100g)
1. Meat Products	**1.3 Sausages** **1.3.1 Sausages** Includes all fresh, chilled and frozen meat sausages, eg pork, beef, chicken, turkey, etc	1.08g salt or 430mg sodium (average r) 1.31g salt or 525mg sodium (maximum)	1.13g salt or 450mg sodium (average r) 1.38g salt or 550mg sodium (maximum)
	1.3.2 Cooked sausages and sausage meat products Includes all cooked sausages and sausage meat products eg stuffing, turkey roll with stuffing etc. Excludes Scotch eggs (see category 22.1).	1.30g salt or 520mg sodium (average r) 1.53g salt or 610mg sodium (maximum)	1.38g salt or 550mg sodium (average r) 1.7g salt or 680mg sodium (maximum)
10. Pizzas	**10.1 Pizzas with cured meat toppings (as consumed)** Includes all fresh and frozen pizza with cured meat eg ham, pepperoni, as consumed (following cooking according to manufacturers' instructions)	1.00g salt or 400mg sodium (average r) 1.25g salt or 500mg sodium (maximum)	1.0g salt or 400mg sodium (average r) 1.25g salt or 500mg sodium (maximum)
	10.2 Pizzas with all other toppings (as consumed) Includes all fresh and frozen pizza without cured meat eg chicken, beef, fish, margherita, as consumed (following cooking according to manufacturers' instructions)	0.90g salt or 360mg sodium (average r) 1.13g salt or 450mg sodium (maximum)	
11.Crisps and snacks	**11.5 Savoury popcorn** All savoury and salted popcorn. Includes 'sweet and savoury' popcorn, and coated popcorn. Excludes no added salt popcorn and salt and vinegar popcorn (see category 11.4)	1.23g salt or 490mg sodium (average r) 1.44g salt or 575mg sodium (maximum)	New target for 2024

In relation to taste and flavour, it was anticipated that the gradual reduction in salt over time would minimise any impact on this in that changes would go unnoticed or would be at an acceptable level for consumers. The WHO have reported that taste receptors will adjust to less salty food quickly, over one to two months (38). However, it was also recognised that replacing salt with flavouring or adjusting the overall balance of flavouring and other ingredients could also help (144). In 2013 SACN and the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) were commissioned by DH (following a request from industry) to make an assessment on the risks and benefits of using potassium-based sodium replacers as a means to enable salt reformulation (161). In 2015, PHE reported an increase in the use of salt replacers (56). SACN and COT released a joint statement in 2017 stating that the possible risks of using potassium as a replacement for sodium in food were outweighed by the possible benefits.

Consumer perspectives

Van de Velde et al. (2016) described the importance of consumer perspectives in successful reformulation, and within this considered the role of consumer perceptions, marketing, product labelling and advertising, and cost. The approach to reformulation was purposefully gradual to ensure acceptability of reformulated products to consumers (66, 144). This has been consistently encouraged throughout policy implementation, with even the most recent salt reduction targets re-iterating the preference for reducing the 'saltiness' of foods to enable consumers to adjust to the taste (154).

During the FSA phase, marketing and food labelling policies were used alongside reformulation as a means to encourage consumer acceptability of reformulation efforts and these approaches were also alluded to during later phases [see Table 13]. From an industry perspective, there should be no need to use marketing, advertising and labelling to encourage ongoing purchases of a reformulated product if a gradual reformulation approach to change existing products was being utilised.

Summary of analysis based on the Van de Velde et al. (2016) framework

This analysis shows that each of the core domains set out by Van de Velde et al. (2016) in their framework had been addressed during implementation of the salt reformulation policy. The role of salt in public health and excess population intake of salt in England had

been clearly established, a population intake target was set and so were reformulation targets across a range of product categories. Aspects of food technology had been examined, the gradual reduction of salt in products was considered technically feasible, and data from progress monitoring reports helped to show what was feasible for certain product categories. Consumer perspectives had been addressed through the general approach that was encouraged (gradual reformulation) but also through the implementation of marketing campaigns alongside the reformulation policy. There was evidence of greater alignment with, and activity across, all four domains during the FSA phase of the policy compared with later phases.

7.2.2 Analysis based on the Food-EPI framework published by Swinburn et al. (2013) (24)

The Food-EPI framework considers aspects of reformulation policy implementation not covered by the Van de Velde framework, so this section builds on the analysis presented in Section 7.2.1.

Intake and food composition targets (statements 1 and 2)

The role of intake and food composition targets with the salt reformulation policy are described in Section 7.2.1 above under 'Nutrition and Health', where I note that both intake and food composition targets have featured throughout implementation of the policy.

Transparent implementation plan (statement 3)

Swinburn et al. (2013) (24) noted the importance of a transparent implementation plan in their best practice statements for reformulation policy. Throughout implementation, information pertaining to the policy was published online either on the FSA website (the FSA Phase), the RD webpages (the RD phase) or on gov.uk (the UK government webpages) following transfer to PHE during the PHE phase. This shows transparency around implementation. In particular, population intake targets for salt were published in the lead up to the policy, salt reduction targets were published prior to and during the policy across the FSA, RD and PHE phases. Progress monitoring plans and reports were also published, including details of how data were gathered and collated. Websites include for example, summaries of stakeholder consultations (FSA and PHE phase), impact assessments (FSA phase), network action plans (RD phase) and progress reports (FSA, RD and PHE phases). High level plans or commitments have also been published in government strategies, and the evidence underpinning the policy was published by SACN. In particular, the FSA was

praised for its transparency and there does appear to be more information about the policy publicly available during that time.

I have not identified any 'implementation plans' that set out the planned approach to implementation and delivery by teams over and above the targets, progress monitoring and any stakeholder engagement. It is possible that no further delivery plans were in place. Clarity around an implementation and delivery model would be useful, particularly in relation to any continued action to support or strengthen policy implementation. Further consideration is given to this in relation to the use of progress monitoring outputs in the next section of this analysis.

Progress monitoring systems (statement 4)

Progress monitoring systems have always been incorporated into the policy although the approach to this differed for the different phases. The FSA is reported to have set up multiple mechanisms for monitoring in relation to industry progress, salt content of products and salt intake (69). A self-reporting framework was developed in consultation with industry and industry could choose whether to report progress using sales weighted averages or average salt content (162), although the salt content of products was also monitored using an independent dataset (60). Progress review meetings are described (these were used to understand progress made as well as in the setting of revised targets) and industry progress was published on the FSA website (163). I was able to locate a short summary of an initial stakeholder meeting in December 2007 and a 'Salt Commitments Table' (164) which provided statements of progress by each individual company. Some of the statements describe specific examples of the salt content of products and salt reductions that have been made, whereas others provide more generic progress statements expressing commitments to work towards salt reduction targets. I was unable to locate any further information (or any collated information) describing industry progress against targets. It is possible that there was a report that I have been unable to locate (it is referred to in one paper (144)), or that the review was not formally written up. Salt intake reports, based on urinary sodium surveys, were also published by the FSA.

During the RD phase progress was self-reported by industry and I did not identify any information regarding how progress monitoring reports were used. Companies were asked to provide information on i) how many of the salt targets were within their product range, ii)

the number and proportion of those that were meeting targets, and iii) which product groups this referred to (165). Free text boxes were available for any additional information that companies may have wished to provide. It is noted that progress would be published on the RD website (166), however I was unable to locate any progress reports. I have seen these referenced and references are unobtainable, most likely due to archiving, although in their analysis of progress reports Knai et al. (2015) reported that these were *"very inconsistently provided on the RD website and mostly unavailable"* (70). Government was criticised by the health sector for this approach which lacked transparency and accountability, and it was later condemned by certain industry stakeholders who felt their reformulation efforts could not be recognised (60).

> *"Unlike the FSA, the RD's monitoring mechanism was built on trust – companies were able to report progress either qualitatively or quantitatively – as opposed to through a standardised process which was open to independent verification and public scrutiny."*
>
> *"This approach eventually proved to be unpopular with some sections of industry as those actors who were making progress through product and practice improvements became frustrated when it became apparent that they were unable to shine."*
>
> **Mwatsama (2016), DrPH Thesis, Qualitative study**

When the policy moved formally to PHE progress monitoring was conducted by PHE analysts. Independent data from Kantar FMCG were used to analyse change in salt content of products purchased for consumption at home. For products in the out of home sector data on the salt content of products were provided to PHE by businesses. The intention had been to use independent data from a third-party (MCA) as this included sales data, however there was insufficient nutrition information to warrant the use of this dataset (72). Industry progress against targets was published by PHE on the government website in two progress monitoring reports (72, 157). Tables show the average salt content of products, the number of products and the proportion of products which do not exceed the maximum targets. PHE reports compared data from retailers and manufacturers and the most recent report showed changes at the business level, with a focus on those businesses in the top 15 for salt sales for the 15 product categories contributing to the greatest intake of salt. As well as highlighting where targets are or are not being met by certain businesses, this helps to show

what is achievable in terms of reformulation within certain products and the variation across businesses. It is unclear if progress monitoring is still underway following the move of the policy to OHID, although salt intake data is being collected via the NDNS.

Use of progress monitoring reports

Based on the FSA, I identified some examples of how the progress monitoring data were used. The 'naming and shaming' of companies was described as a core component of policy implementation as it helped to encourage further engagement or reformulation. The progress monitoring data enabled this. He et al. (2014) describe the 'naming and shaming' of companies making insufficient progress on salt reduction as a key part of the FSA phase of the policy, but in relation to engagement work conducted by the FSA and through the media as opposed to published reports (66) although companies are named in the Salt Commitments Tables (164).

> *"Both CASH and the FSA have been working with all sectors of the food industry to engage, praise, cajole and, if necessary, shame manufactures to ensure they reduce salt and meet the targets. As a result, nearly all food manufacturers, retailers and trade associations, as well as several catering companies have agreed to work towards the targets and started reformulation."*
>
> **He et al. (2013), Academic / lobbying group, Narrative paper (**66**)**

Conversely, in their frequently asked questions the FSA note that they would not use company names in progress monitoring (167).

> *"We do not intend to use the data that we collect through the framework to name and shame companies. The purpose of the self-reporting framework is to monitor and provide a public record of progress towards achieving the salt targets, and to inform the review in 2008."*
>
> **FSA (2007), Frequently Asked Questions on Self-reporting framework (**167**)**

The naming and shaming of companies appears to have been implemented informally through stakeholder meetings during the FSA phase. Companies were named as part of reporting, but that's mainly due to the self-report nature of this where companies provided their own data. PHE named companies in their second progress report to show variation in

progress made against salt targets for the 15 product categories contributing the most to salt intake and up to 15 companies selected based on salt sales. In some instances, this data shows companies that have not met targets but it also showcases companies that have. It is unclear if, or how, this information has been used to further progress against targets.

Instances were reported where industry had cited technical difficulties as a reason for lack of progress in reformulation, and robust and transparent reporting of salt content in products was considered important for challenging this (66).

> "*…the wide range of salt levels seen in similar range of food that are already on the market, many of which are below the target, demonstrate that, technically, it is feasible to reduce salt levels further in almost all processed food."*
>
> **He et al. (2013), Academic / lobbying group, Narrative paper (**66**)**

Similarly, Mwatsama (2016) described how during the RD phase industry contested the setting of further targets stating that *"…food technology targets had been reached"*. This links to the 'technical considerations' section featured in the Van de Velde et al. (2016) (109) framework and highlights the potential for progress monitoring reports (and variation in salt content reported within these) to show what is technically feasible for certain product categories. The ability to do this is strengthened through the use of robust and independent data, as featured in the FSA and PHE phases of the policy.

Government-led policy

The concept of reformulation policy and its implementation being 'government led' was not set out as one of the best practice statements by Swinburn et al. (2013), however it is consistently referred to in their description of reformulation policy and throughout the best practice statements. The salt reformulation policy in England has always been led by government to the extent that it was funded and backed by government, however government involvement in its delivery has varied. During the FSA phase, responsibility for the policy sat with the FSA which had been established in 2000 to oversee food safety and some nutrition policy (168). As an arms-length body (specifically, a non-ministerial department), the FSA was accountable to Parliament and the Secretary of State for Health but did not require ministerial permission to publish (60). That said, there was strong

support from government (at that time Labour) ministers who put pressure on industry to engage in the salt reduction programme (60).

During the RD phase, the policy was moved into DH which is a government department with direct accountability to ministers. The RD was a public-private partnership, involving industry, academia and the voluntary sector. The partnership responsible for its delivery was 95% industry (68, 70) who were viewed by those outside of government as an unreliable partner (69). During the PHE phase the policy was again led by an arms-length body, although as an executive agency PHE did have some accountability to ministers. Responsibility for the policy moved back into DHSC in October 2020, and it is unclear if it is still a live policy or has been quietly discontinued as the 2024 targets were published by PHE. It is worth considering that whilst government leadership for a policy might be important, where possible it may be better for policy implementation to be led outside of government to enable independence from government as well as other stakeholders.

Summary of analysis based on the Food-EPI framework

This analysis builds on my analysis using the Van de Velde framework as it starts to consider a wider range of implementation factors that may be important in the success of voluntary reformulation policy. It highlights the importance of transparent implementation plan and progress monitoring systems that can be used to highlight technical feasibility of reformulation across a range of products and to encourage wider engagement from industry. Conversely, implementation of salt reformulation policy has shown how a lack of transparency and independence in progress monitoring can lead to disengagement with implementation. Tensions around the role of government leadership were observed, and these are considered more fully in the following section.

7.2.3 Additional implementation factors: leadership, governance and infrastructure

A number of additional implementation factors were identified during my analysis that did not feature within the Van de Velde and Food-EPI frameworks. These generally fit within a high-level theme of 'leadership, governance and infrastructure', and included i) political commitment, ii) leadership and delivery team structures, iii) lobbying and political pressure and iv) wider leadership and momentum. Aspects of leadership and governance were described as essential supporting infrastructure for nutrition policy in the Food-EPI

framework (24), however – as explained in Chapter 3, Section 3.1 – as this focused on nutrition policy delivery more broadly it was unclear where or how the seven elements of supporting infrastructure were of particular importance to reformulation policy. These were not included in the reformulation frameworks or best practice principles drawn upon throughout this section, so are reported here.

Political commitment

Swinburn et al. (2013) defined leadership as solid, visible political support where there is a comprehensive plan to tackle a nutritional issue (24). Political commitment can be observed through published strategies or plans, and salt reformulation has featured in numerous of these over the years with intake targets, commitments to set reformulation targets and the threat of mandatory action included (see Box 5). Political support can also be shown via support from key political leaders, and this has been an important driver of the salt reformulation policy during its various stages. The FSA phase of the programme has been described as having *"high-level political leadership"* (144) where government ministers were proactive in putting pressure on industry to engage (60), whereas the RD was considered as government stepping away from their responsibilities and handing control of the policy over to industry (68).

Political support invariably changed over time due to wider political changes, including changes in government, and this was the main reason for changes in implementation approach that was observed over the four phases of implementation. The first move of the policy from the FSA to DH occurred following the general election in 2010 when a new coalition government was formed (Conservatives and Liberal Democrats) and a new Secretary of State for Health appointed. Reportedly, the RD was dissolved following the 2015 general election where there was a further change to a Conservative government (140). It is unclear what happened to the policy between 2015 and its transfer to PHE in 2017 or why this decision was made. The later transfer back into DHSC took place when PHE was dissolved in September 2020, and its health improvement function moved to DHSC into a new department focused on health improvement (OHID).

These frequent changes led to changes in governance (described in more detail in a section on 'governance' below) and have been considered a key reason why the good progress seen in the early days of the voluntary salt reduction programme has not been sustained (the

evidence underpinning this is presented in Section 7.3 of this Chapter). But equally, change in government also enabled the policy. Salt reduction was first adopted as a national priority in England following a change in government from Conservative to New Labour in 1997(60). Mwatsama (2016) also described how during the FSA phase public health ministers played a central and proactive role in policy implementation, very publicly using their influence to encourage implementation and engagement by industry (60).

Box 5. Government strategies or plans supporting salt reformulation	
2001	**Chief Medical Officer's Annual Report (**169**)** Support for the national intake target of 6g/day
2004	**DH White Paper: Choosing Health: Making healthier choices easier (**170**)** Commitment to set salt reduction targets with industry
2005	**FSA Strategic Plan 2005 – 2010 (**171**)** Target to reduce the average population salt intake to 6g/day by 2010
2018	**DHSC vision document: Prevention is better than cure (**172**)** Promise of salt reduction plans in a Green Paper due to be released in 2019.
2018	**Chief Medical Officer's Annual Report (**173**)** Recommendation for more ambitious salt reduction targets and additional targets for the out of home sector. Threat of mandated targets.
2019	**Prevention Green Paper – Consultation (**174**)** Highlighted salt reduction as a priority and set new intake target of 7g/day. Committed to revised targets published in 2020, a progress report in 2024 and a urinary sodium survey in 2003.
2020	**Policy paper – Tackling obesity: Empowering adults and children to live healthier lives (**17**)** Describes continued work on salt reformulation and commitment to further action if insufficient progress is seen.

Governance

Good governance was described by Swinburn et al. (2013) as [government] having *"…the structures in place to ensure transparency and accountability"* and to enable involvement in policy development and implementation (24). In some respects, it is a running theme

throughout policy implementation so has already been considered within my analysis however I've drawn out some of the key elements here. Governance varied over the four phases of implementation and as described above, this was driven at least in part by changes in leadership and political commitments and in particularly where responsibility for delivery of the policy sat. There are some explicit examples of good governance:

- Delivery outside of government and without accountability to ministers
- Transparency around implementation
- Independent progress monitoring and review processes

Less visible examples include the ability to publish information about the policy (plans but also industry progress) without influence of others, and the protection from commercial influences. The FSA was praised for its governance, whereas the RD was heavily criticised for its extensive involvement of industry in governance structures and *"inadequate monitoring and review mechanisms"* (69). There has been little reported on this in relation to the PHE phase. Although PHE was an arms-length body (ALB) it did still have accountability to ministers although, with more flexibility in their work than is the case within central government.

Leadership team and team structures

The role of the leadership team and team structures also warrants mention, although on the whole there was a lack of information about this and how it may have influenced (or not) successful policy implementation. A case study on salt reduction reported major budget cuts within government around the time that the RD was introduced, and that *"reduced resources and fewer staff [were] a key difference in the salt programme's delivery between the FSA and RD mechanisms"* although the FSA team responsible for the policy did move across to DH (60). Whilst I have not identified any public information, I know from my position within PHE that the team, which originally moved across from DHSC to PHE to work on the PHE RRP, has also been moved across to OHID. It would be helpful to understand the size, structures and expertise of teams to determine what is needed for effective implementation.

Use of lobbying and political pressure

When the policy was first initiated in 2003, there had been considerable lobbying by the non-government organisation CASH and this is said to have helped to generate political

support for the policy (68). Conversely, pressure from industry has also been described as influencing the policy when it became part of the RD so that there were no changes to the targets they needed to achieve (71).

> *"…there was considerable pressure from food industry members to water down the salt reduction commitment, resulting in the final pledge merely being the Food Standards Agency 2012 salt reduction targets. The food industry had already agreed to these targets back in 2008, so the Responsibility Deal has made no progress in this area."*
>
> **Hashem et al. (2011), Academic, Policy review (**71**)**

I did not identify any reports signifying extensive lobbying over recent years, although a recent paper in the BMJ entitled 'Salt: the forgotten foe in UK public health policy' pushed for renewed policy action (160). It is possible that the focus of lobbying has shifted to sugar (CASH is now Consensus for Action on Salt, Sugar and Health, CASSH). As there have been fewer papers published recently on salt it may be that any ongoing lobbying for salt reformulation policy has not been reported. Regardless, the lack of visible lobbying for salt reformulation policy may have contributed to the lack of emphasis on salt in current policy.

Wider leadership and momentum

Finally, whilst not necessarily documented, the available evidence shows considerable leadership from the WHO around salt reduction based largely on the FSA phase of the policy in England. In 2010, the WHO and FSA produced technical guidance for salt reduction following an expert meeting and this stressed the importance of salt reformulation policy (65). The WHO has continued to support salt reduction activity through publishing renewed guidance in relation to salt reduction (38) and reformulation (35), setting a global target of a 30% reduction in population level salt intake and producing a sodium scorecards to monitor the extent to which countries are implementing salt reduction policies (175).

7.3 Impacts of the salt reformulation policy in England

This section describes the impacts of the salt reformulation policy in England. As per my systematic review, reported in Chapter 6, I have used the Gressier et al. (2020) framework to categorise evidence on policy impacts (40). The evidence included in this analysis

generally reports that the FSA phase was the most impactful, but this is largely compared to the RD and very little has been reported about the PHE phase.

Salt intake and health outcomes

Two studies evaluating the FSA phase of the policy examined change in salt intake reporting a reduction in salt intake of between 10% (64) and 14% (61). These studies were based on analysis of Health Survey for England data between 2003 and 2007 which uses spot urine tests to measure salt intake. Different techniques were used to analyse the data hence differences in results. A later study used five years of survey data to examine trends in population-level salt intake in England between 2001 and 2014 (176). The study reported a slowing in the mean reduction of salt intake following implementation of the RD compared with the preceding FSA policy for both men and women. It was estimated that this slowing in the reduction of salt intake could lead to additional cases of cardiovascular disease and gastric cancer.

Changes in salt intake have also been published as part of routine monitoring, initially by the FSA via their urinary sodium surveys and then by PHE via the National Diet and Nutrition Survey (NDNS) established in its current form in 2008.[4] Intake is reported to have gradually reduced from 9.5g per day prior to policy implementation to 8.4g per day in 2018/19 (see Table 15). Intake was at its lowest in the 2016 NDNS report at 8.0g per day. Trend analyses conducted based on the NDNS reported an 11% reduction in salt intake between 2005/06 and 2014, however this was not statistically significant (177). Further the small reduction in salt intake between 2014 and 2018/19 was not statistically significant (178). The reduction in intake reported between 2005/06 and 2008/09 was statistically significant (177). This suggests there was a reduced salt intake during the FSA phase of policy implementation but not during later phases, and any early reductions were not sustained over an extended period of time.

Change in the salt content of products

One study examined changes in the salt content of products following implementation of the FSA phase of the policy. This study was based on 12-month continuous household

[4] The NDNS was set up in 1992 initially as a series of individual cross-sectional surveys. In 2008 the approach to data collection was changed to a continuous rolling programme format

purchase data from Kantar (2006 and 2011), supplemented by nutrition information available on product labels (142). An overall mean reduction in sodium of 7% (-26mg/100g sodium, p<0.001) was reported across 14 food groups (56 product categories). The sales weighted mean reduction was lower at 6% (-21mg/100g, p<0.001) and higher at 9% when examining only products available each year (-23mg/100g, p<0.001). Mean reductions in sodium were reported in less than half of the 14 product groups, and there were mean increases in sodium in two of the product groups. In an analysis of categories considered directly comparable to categories included in the FSA policy, Eyles et al. reported that 81% had met the 2010 target in 2011. Further analysis showed that the reduced sodium content in products between 2006 and 2011 (the FSA phase) was due to a combination of reformulation and the introduction of new, lower sodium products (product renewal) (142).

Table 15. Timeline of key changes based on progress monitoring

Date	Theme	Details
March 2007	Intake	FSA published results of urinary sodium analysis. Estimated mean population level salt intake of 9g per day.
June 2008	Intake	FSA published results of urinary sodium analysis. Estimated mean population level salt intake of 8.6g per day.
March 2016	Intake	PHE published results of NDNS based on 2014 data. Estimated mean population salt intake of 8.0g per day. Between 2005/06 and 2008/09 statistically significant reduction in intake. Between 2008/09 and 2014 the reduction in intake was not statistically significant.
Dec 2017	Salt in products	PHE published progress monitoring report, showing 52% of the 2017 average targets had been met and 81% of maximum targets (based on 2017 data).
March 2020	Intake	PHE published results of NDNS based on 2018/19 data. Estimated mean population salt intake of 8.4g per day. Between 2014 and 2018/19: no statistically significant change observed in average salt intake.
Sept 2020	Salt in products	PHE published progress monitoring report, showing 52% of the 2017 average targets had been met and 84% of maximum targets (based on 2018 data).

A more recent study reported a 17% reduction in the salt content of products based on data from the NDNS over nine years from 2008/09 to 2016/17 (143) (this includes the FSA and RD phases of the policy).

Changes in the salt content of products was also assessed via routine progress monitoring, although the approach to this has differed across the different phases as already reported in Section 7.2. As noted, I was unable to locate any summary reports describing industry progress against the salt reformulation targets during the FSA phase. Results of progress monitoring are described by Wyness et al. (2011) in their review of the FSA phase (144) who reported that whilst progress had been made there was still considerable variation in the salt content of similar products and that further reformulation would therefore be possible.

> *"The main findings [of the review] were that many companies had made significant reductions and that, for some foods, reductions had gone further than that which the industry had indicated would be possible before the 2006 targets were published. However, the review also found that the range of levels among similar products was still wide and therefore there was the potential to reduce levels further in many products."*
>
> **Wyness et al. (2011), Nutritionist, Narrative review (**144**)**

Progress against targets was not collated during the RD phase. In 2018, PHE reported that 52% of the average salt reduction targets that had originally been published in 2014 had been met by 2017 and 81% of maximum targets (72) increasing to 84% by 2018 with no change in the proportion of average targets met (157). This suggests a slowing of progress in salt reduction over time. PHE also reported variation across product categories and when comparing retailers (unbranded products) and manufacturers (branded products). All targets had been met for some product categories (for example, breakfast cereal and pasta) whereas other product categories did not meet any of their targets (for example, meat products and biscuits). In considering the 15 sub-categories of products which made the greatest contribution to salt intake only half of average targets had been met. In 2018, retailers were meeting around twice the amount of average salt targets (73%) than manufacturers (37%).

Consumer behaviour

Under its intended approach, consumer behaviour needs to remain stable in order for nutritional intake to improve as a result of reformulation (40). However, it has been recognised that consumers may change their behaviour as a result of reformulation for example, consuming more of a reformulated product, switching to another product that has not been reformulated or consuming more of the reformulated nutrient in other ways to compensate. Consumers may also need to change their behaviour in order to improve the nutritional intake, for example if new reformulated products were added to the market rather alongside existing products they would have to choose to purchase the reformulated products within this expanded product range.

Several studies have examined consumer behaviour in relation to England's salt reformulation policy. Sutherland et al. (2013) reported a reduction in the use of table salt following implementation of the FSA policy, and this was considered a success of the campaign component of the policy (179) although it could also suggest that consumers did not consume more table salt to compensate for reduced salt in products. Based on an analysis of household purchase data between 2005 and 2011, Griffith et al. (2016) reported very little changes in consumer behaviour and noted that the -5.1% reduction in salt content of products purchased was almost entirely due to reformulation (180). Although the focus of this paper was to compare the effects of the reformulation policy with the concurrent consumer awareness campaign, results also suggest that consumers continued to purchase reformulated products. In a later study, Gressier et al. (2021) reported similar results with the majority of the reduced salt content of products consumed (-12mg sodium/100g) due to reformulation. There were minor changes in consumer purchasing within and between product categories which contributed to a reduction in the volume of salt purchased overall (-1.6mg sodium / 100g) (143).

Context or approach under which the policy was more (or less) effective

On the whole, there is a consistent narrative throughout all papers and records that the FSA phase of the policy was effective in reducing salt intake and achieving subsequent health outcomes, and this is backed up by published studies. Narrative around the effectiveness of the policy beyond the FSA phase is limited and as time has gone on there have been fewer independent evaluations (although the availability of monitoring has improved). The RD

phase of the policy has been heavily criticised and there was a general sense that *"salt reduction lost momentum"* (68) when the policy became part of the RD although there was limited data to enable a robust examination of the impacts of the RD phase. Reductions in population salt intake appear to have slowed, however it is possible that this slowing would have occurred if the policy had continued under the FSA.

Recent government narrative around the effectiveness of the salt reduction describing the success of the policy is based entirely on the FSA phase which differed to later phases of the policy (93, 150) in various ways as described.

> *"Overall, the available evidence shows that since the programme began in 2004 there has been clear progress. Along with consumer campaigning and a range of other interventions, the stepwise lowering of salt targets for foods by up to 54 % between 2006 (when targets were first set) and 2014 (when the 2017 targets were published) is linked to a reduction in average population salt intake of 11 % between 2005–2006 and 2014."*
>
> **Tedstone et el. (2020), Nutritionist / PHE, Opinion piece (**150**)**

Progress monitoring conducted during the PHE phase suggests that only half of the average salt targets are being met, and that population salt intake had started to increase. The PHE phase has been criticised for having an insufficient focus on salt, and lack of incentive for further action (160). Further evaluation of the current policy is needed.

7.4 Chapter summary

This study examined how the salt reformulation policy in England had been implemented and the impacts achieved. The policy has always been voluntary and has transitioned through four phases of implementation since first initiated in 2003. These phases were largely defined by changes in leadership and governance that in turn impacted on aspects of policy implementation. In its original form, the FSA phase, the salt reformulation policy was well defined. This phase of implementation was consistently described as a success within the literature, and changes in salt intake of between 10% and 14% were reported following its implementation (61, 64). It was led by the Food Standards Agency (FSA), with strong and persistent backing from government, and delivered as part of a national salt reduction

programme involving a public health campaign and food labelling alongside reformulation. Targets were set for salt intake and for the salt content of a wide range of products. Progress against salt reduction targets were monitored closely by the FSA using independent data and used to encourage further action in a manner described as 'soft-regulation'. Gradual reduction of salt was considered to be technically feasible, and acceptable to consumers – particularly as taste receptors can quickly adjust to less salty food.

Following a change of government in 2011, the policy was moved into the Department of Health (DH) and incorporated into the Responsibility Deal (the RD). Described as a public-private-partnership, the RD encouraged industry and non-government partners to sign up to pledges across a range of different health-related topics, including but not limited to salt reduction. The RD was widely and publicly criticised by non-industry stakeholders and government were accused of stepping away from their responsibilities towards health. Industry monitored their own progress against salt reformulation during this time and it is unclear how much reformulation occurred. A lack of change in salt intake was reported following this change in approach to policy implementation.

After a gap of around one year when the RD was dissolved (2015 – 2016), the policy moved to Public Health England (PHE). The salt reduction targets originally developed by the FSA were republished by PHE and industry progress against these was monitored by PHE analysts using data purchased from Kantar FMCG (formerly Kantar Worldpanel). Salt reformulation became part of a wider reformulation and reduction programme that also focused on reducing sugar and calories, and a new salt intake target was set. There is little information around any other implementation mechanisms in place during the PHE phase, but progress monitoring reports were published with the most recent reporting that 84% of maximum salt targets had been met and 52% of average targets. The policy has now moved back into the Department of Health and Social Care (DHSC) following the closure of PHE in October 2021. No public information has been made available regarding the policy since that time and there have been no evaluations of the PHE or OHID phases.

8. Results of Study 3: Quantitative analysis of changes in sugar content, portion sizes and sugar purchases of products following initiation of the SRP in England

This chapter presents the results of a quantitative analysis examining changes in sugar, portion sizes and sugar sales in three product categories that were included in the English sugar reformulation policy: Breakfast cereal, Chocolate confectionary and Sweet confectionary. The analysis examines changes between baseline, 2017 (year 1 of the policy) and 2018 (year 2 of the policy) and focuses on products purchased for in-home consumption.

8.1 Descriptive statistics

8.1.1 Number of products and breakdown by product sub-categories

A total of 9,339 unique products (as determined by 'product code') were present in the combined dataset. The number of products decreased from 6,073 in 2015 to 5,937 in 2018 (see Table 16) suggesting that the panel were purchasing fewer different products overall. Chocolate confectionary comprised the largest proportion of products (n=4344, 47% of all products), followed by the Sweet confectionary (n=2927, 31% of all products) then Breakfast cereal (n=2068, 22% of all products) categories.

Table 16. Number of products purchased by the panel and available in the dataset, by year, by product category, branded / unbranded, single serve

	n (%) products			
	2015	**2017**	**2018**	**All years**
All products	6073	6097	5937	9339
Breakfast cereal	1416 (23)	1473 (24)	1322 (22)	2068 (22)
Chocolate confectionary	2795 (46)	2708 (44)	2742 (46)	4344 (47)
Sweet confectionary	1862 (31)	1916 (31)	1873 32)	2927 (31)
Branded	3876 (64)	4070 (67)	4078 (69)	6180 (66)
Unbranded	2197 (36)	2027 (33)	1859 (31)	3159(34)
Single serve products	1615 (27)	1602 (26)	1520 (26)	2436 (26)

The proportion of branded products was higher than unbranded. This was the case for each of the product categories, although a greater proportion of Breakfast cereal products were unbranded (39%) compared with 32% for Chocolate and Sweet confectionary, data not shown).

Roughly one quarter of product in the dataset were single serve products (Table 16), and approximately one third of all Chocolate and Sweet confectionary products were single serve products (see Table 17).

Table 17. Number of single serve products purchased by the panel and available in the dataset, by year, by product category

	n (%) single serve products			
	2015	**2017**	**2018**	**All years**
All single serve products	1615	1602	1520	2436
Breakfast cereal	-	-	-	-
Chocolate confectionary	1040 (37)	969 (36)	917 (33)	1499 (35)
Sweet confectionary	575 (31)	633 (33)	605 (32)	

8.1.2 Availability of products in the dataset: Product portfolios

Availability of products in the dataset is used in later analyses to examine changes in product portfolios (i.e. the extent of new, continued and discontinued products), for complete case analyses and for comparisons of products deemed to be new, continued or discontinued. Graphs displaying these data are provided in Appendix 11. One third of products were available in all years, 21% of products were available only in 2015 (therefore considered 'discontinued' before 2017), 22% were available in 2017 only or 2017 and 2018 (so were considered 'new' in 2017) and 13% of products were sold in 2018 only (so were considered 'new' compared to other years). A greater proportion of products in the Breakfast cereal category were available in all years (37%), compared with 32% of Chocolate confectionary and Sugar confectionary products and a smaller proportions of products were new (Breakfast cereal: 9%, Chocolate confectionary: 14%, Sweet confectionary: 13%).

Availability of single serve products followed a similar pattern overall as all products although a higher proportion of Chocolate confectionary (35%) products were available in

all years compared with Sweet confectionary (31%) and a higher proportion of Sweet confectionary products were considered new in 2017 or 2018 compared with Chocolate confectionary.

The proportions of branded and unbranded products available in all years were the same at 33%. A quarter of unbranded products appeared to have discontinued after 2015 compared to 19% of branded products. For products available in single serve portions, the proportion of branded products available in all three years (36%) was higher than unbranded products (26%). The proportion of branded products that appeared to have discontinued after 2015 (20%) was lower than unbranded products (30%).

8.2 Reformulation of sugar content

This section examines the extent to which sugar content of products changed over time and provides a more detailed exploration of changes (or lack of changes) observed. It includes data on the mean and percentage change in g/100g of sugar content for all products and sub-categories of products; the proportions of products overall categorised as low, medium or high sugar; and differences in mean sugar content of new, continued and discontinued products. The data presented in this section reflect the nutrient information of products available in the dataset and are unrelated to the amount (or volume) of product or sugar purchased. All sugar data were available in g/100g.

8.2.1 Sugar content and changes in sugar content, grams per 100g

Mean sugar content for all products, sub-categories of products and changes over time are displayed below in Table 18. Mean sugar content of all products was 46.29g/100g in 2015, 45.52g/100g in 2017 and 45.89g/100g in 2018. Overall means were not reflective of the different product categories; for example, the mean sugar content for products in the Breakfast cereal category was 18.21g/100g in 2018 compared with 51.37g/100g for Chocolate confectionary and 60.01g/100g for sweet confectionary.

There was evidence of an overall mean reduction in sugar content of all products between 2015 and 2017 (-0.77g/100g, -1.66%, p = 0.044) but this was not sustained when examining change between 2015 and 2018 (-0.40g/100g, -0.86%, p = 0.301). For product categories there was evidence of an almost 10% decrease in mean sugar content between 2015 and

2018 within the Breakfast cereal category, with a mean sugar reduction from 18.21g/100g in 2015 to 16.48g/100g in 2018 (-1.73g/100g, -9.5%, $p < 0.001$). Each year, the mean sugar content of branded products was higher than that of unbranded, and there was evidence of a 3% reduction in the mean sugar content of unbranded products between 2015 and 2018 (-1.39g/100g, -3.17%, $p = 0.018$). There was no evidence of reduced sugar content in other product categories or in branded products.

Looking only at single serve products (see Table 19) there was evidence of a -1.32g/100g reduction in mean sugar content overall, which decreased from 54.36g/100g in 2015 to 53.04g/100g in 2018 (-1.32g/100g, -2.43%, $p = 0.017$). The reduction was greatest (although the evidence is weak) in single serve Sweet confectionary products (-1.97g/100g, -3.37%, $p = 0.103$), although there was also evidence of a reduction in sugar content of Chocolate confectionary (-1.33g/100g, -2.55%, $p = 0.005$) and branded single serve products (-1.56g /100g, -2.84%, $p = 0.017$). The latter is in contrast to the results for sugar content in all products (Table 18), where sugar content was higher in branded compared to unbranded products (likely due to unbranded Breakfast cereals). These results suggest that specific reductions in sugar may have been made to certain single serve products, as opposed to any other Sweet or Chocolate confectionary products not available as single serve (noting that single serve products accounted for approximately one third of all Chocolate and Sweet confectionary products and there was no evidence of reduced sugar content in these products categories overall).

Table 18. Mean sugar (g/100g) and change in sugar (g/100g, %), by year, product category, branding and single serve

	Mean sugar (standard deviation), range, n products			Change in sugar 2015 – 2017			Change in sugar 2015 – 2018		
	2015	2017	2018	Mean	%	p	Mean	%	p
All products	46.29 (20.73) 0 – 99.8 n=6073	45.52 (21.47) 0 – 99.2 n=6097	45.89 (21.21) 0 – 100 n=5937	-0.77	-1.66	0.044*	-0.40	-0.86	0.301
Breakfast cereal	18.21 (10.11) 0.1 – 56.7 n=1416	17.47 (10.18) 0 – 92 n=1473	16.48 (10.11) 0 – 92 n=1322	-0.76	-4.17	0.049*	-1.73	-9.5	<0.001*
Chocolate confectionary	51.37 (10.36) 0 – 90 n=2795	51.14 (10.72), 0 – 90 n=2708	51.00 (10.64) 0 – 90 n=2742	-0.23	-0.45	0.420	-0.37	-0.72	0.193
Sweet confectionary	60.01 (18.36) 0 – 99.8 n=1862	59.14 (19.76) 0 – 99.2 n=1916	59.17 (19.06) 0 – 100 n=1873	-0.87	-1.45	0.161	-0.84	-1.40	0.171
Branded	47.66 (20.46) 0 – 99.2 n=3876	47.00 (21.24) 0 – 99.2 n=4070	47.44 (21.03) 0 – 100 n=4078	-0.67	-1.4	0.156	-0.21	-0.44	0.650
Unbranded	43.87 (21.00) 0 – 99.8 n=2197	42.57 (21.65) 0 – 99.2 n=2027	42.49 (21.23) 0 – 99.2 n=1859	-1.31	-2.99	0.046*	-1.39	-3.17	0.037*
Single serve products	54.36 (14.38) 0 – 99.2 n=1616	53.34 (16.29) 0 – 99.2 n=1606	53.04 (16.42) 0 – 97 n=1524	-1.02	-1.88	0.059	-1.32	-2.43	0.017*

*Statistically significant at $p < 0.05$

Table 19. Mean sugar (g/100g) and change in sugar (g/100g, %) for single serve products only, by year, product category and branding

	Mean sugar g/100g (standard deviation), range, n products			Change in sugar 2015 – 2017			Change in sugar 2015 – 2018		
	2015	2017	2018	Mean	%	p	Mean	%	P
All single serve products	54.36 (14.38) 0 – 99.2 n=1616	53.34 (16.29) 0 – 99.2 n=1606	53.04 (16.42) 0 – 97 n=1524	-1.02	-1.88	0.059	-1.32	-2.43	0.017*
Breakfast cereal	-	-	-	-	-	-	-	-	-
Chocolate confectionary	52.08 (9.63) 0 – 90 n= 1040	51.24 (10.73) 0 – 90 n=969	50.74 (11.20) 0 – 90 n=917	-0.83	-1.59	0.067	-1.33	-2.55	0.005*
Sweet confectionary	58.47 (19.68) 0 – 99.2 n=576	56.52 (21.85) 0 – 99.2 n=637	56.51 (21.63) 0 – 97 n=607	-1.96	-3.35	0.103	-1.97	-3.37	0.103
Branded	54.76 (14.45) 0 – 99.2 n=1168	53.35 (16.88) 0 – 99.2 n=1211	53.20 (17.05) 0 – 97 n=1174	-1.42	-2.60	0.028*	-1.56	-2.84	0.017*
Unbranded	53.30 (14.07) 0 – 95.7 n=448	53.30 (14.35) 0 – 90.7 n=395	52.50 (14.10) 0 – 90.7 n=350	0	0	0.994	-0.80	-1.5	0.428

*Statistically significant at $p < 0.05$

Summary: whilst there was no evidence of a mean reduction in sugar content of all products there was evidence of reduced sugar content in Breakfast cereals, unbranded products, and single serve products. In single serve products, there was evidence of reduced sugar content for both Chocolate and Sweet confectionary and branded products.

8.2.2 Proportion of all products with changes (or no change) in sugar content (g/100g)

Between 2015 and 2017, based on 4,024 products available in both years, 12% of products showed a reduction in sugar, but concurrently 10% of products showed an increase in sugar content. The majority of products (79%) did not change at all (see Figure 5). Between 2015 and 2018, based on 3,156 products available in both years, a greater proportion of products changed: 18% of products showed a reduction in sugar content, and 14% showed an increase but again the majority of products showed no change in sugar content (see Figure 6). To note, this analysis reports on any change as opposed to magnitude of change.

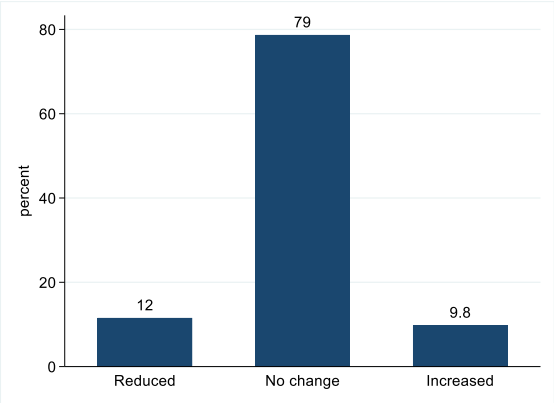


Figure 5. Proportion of all products with changes in sugar content (%), 2015-2017 (n=4024)

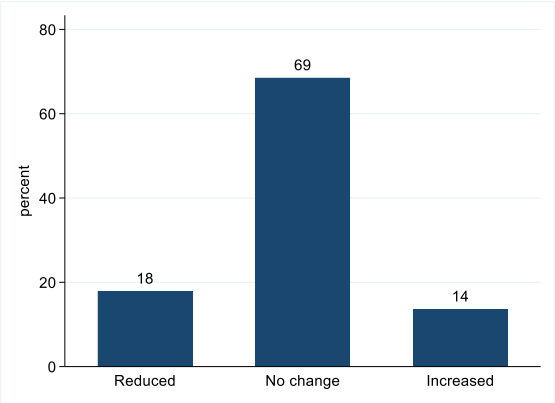


Figure 6. Proportion of all products with changes in sugar content (%), 2015-2018 (n=3156)

The proportion of products with a change in sugar content over time varied by product category (see Table 20). Between 2015 and 2017, 15% of products in the Breakfast cereal category showed reduced sugar content compared with 12% and 7% in Chocolate and Sweet confectionary respectively. Similarly, only 7% of products in the Breakfast cereal category showed increased sugar content compared with 13% and 9% in Chocolate confectionary and Sweet confectionary respectively.

Table 20. Products with changes (or no change) in sugar content (n, %) between 2015 – 2017 and 2015 – 2018, by product category, branding, single serve

	Change / no change	2015 – 2017		2015 – 2018	
		n	%	n	%
Breakfast cereal		n=1013		n=779	
	Reduced	151	15%	222	29%
	Increased	67	7%	67	9%
	No change	795	67%	490	63%
Chocolate confectionary		n=1786		n=1429	
	Reduced	214	12%	221	15%
	Increased	224	13%	246	17%
	No change	1348	75%	962	67%
Sweet confectionary		n=1225		n=948	
	Reduced	99	8%	121	13%
	Increased	103	9%	117	12%
	No change	1023	84%	710	75%
Branded		n=2638		n=2097	
	Reduced	313	12%	336	16%
	Increased	292	11%	276	13%
	No change	2033	77%	1485	71%
Unbranded		n=1386		n=1059	
	Reduced	151	11%	228	22%
	Increased	102	7%	154	15%
	No change	1133	82%	677	64%
Single serve		n=1051		n=830	
	Reduced	147	14%	137	17%
	Increased	125	12%	129	16%
	No change	779	74%	564	68%

Between 2015 and 2018, the proportion of products with reductions in sugar content was higher in all product categories in 2015 compared with 2017, however the proportions of products showing an increase in sugar content were also higher. For Chocolate and Sweet confectionary product categories a greater proportion of products showed an increase in sugar content than a decrease. For the Breakfast cereal category where one third of products increased sugar content, approximately two thirds showed reduced sugar content.

There were also some differences when examining branded versus unbranded products. Between 2015 and 2017, a similar proportion of branded and unbranded products showed a reduction in sugar content (branded: 12%, unbranded: 11%) although fewer unbranded products showed an increase in sugar content (branded: 11%, unbranded: 7%). Between 2015 and 2018 the proportion of both branded and unbranded products with a sugar reduction was higher, particularly for unbranded products (branded: 16%, unbranded: 22%). The proportion of products with increased sugar content was lower in 2018 for branded but higher for unbranded products (branded: 13%, unbranded 15%).

Summary: These results suggest that only some products have been reformulated, and that reformulated products had both reduced and increased sugar content. There was no overall change in g/100g sugar content of these products (as set out in section 8.2.1 above) however, it is possible that mean reductions were overridden by concurrent increases in sugar. It is interesting to see that 15% and 13% of products in the Chocolate and Sweet confectionary categories respectively had reduced sugar content between 2015 and 2018, as it has been previously acknowledged that these products may be difficult to reformulate (57). A closer look at the extent of reformulation across is provided in section 8.2.3 below.

8.2.3 Extent of reformulation in products with reduced sugar content (g/100g)

Further analysis of the sugar content of the subset of products that showed a reduction in sugar (n=564, see Table 21) enabled a closer look at the extent to which products had been reformulated. This analysis showed evidence of an overall mean reduction in sugar content of 3.81g/100g (-9%, $p < 0.0001$) from 41.56g/100g in 2015 to 37.75g/100g in 2018. Consistent with previous analyses, based on 2015 and 2018 data, the greatest reductions were in the Breakfast cereal (n=222, -3.07g/100g, -14.35%, $p < 0.0001$) and unbranded product (n=228, -4.63g/ 100g, -12.37% $p < 0.0001$) categories. Sweet confectionary products with reduced sugar content had reduced by 10% on average (n=121, -6.24g/100g, -10.45%, $p < 0.0001$) and Chocolate confectionary products with reduced sugar content had reduced by almost 7% (n=221, -3.21g/100g, -6.19%, $p < 0.0001$). Despite modest sample size, the results suggest that it is feasible to reformulate these product categories.

Table 21. Mean and median sugar (g/100g) by year and change in sugar between 2015 and 2018 for only products with any sugar reduction (g/100g, %), by product category, branding and single serve

	Mean sugar g/100g (standard deviation)		Change in sugar 2015 – 2018 in g/100g				
	2015	2018	Mean (SD)	%	p	Range	Median (IQR)
All products (n = 564)	41.56 (20.92)	37.75 (21.25)	-3.81 (5.86)	-9.16	<0.0001*	-50 to -0.001	-2 (-4.7, -0.7)
Breakfast cereal (n = 222)	21.39 (8.32)	18.32 (8.24)	-3.07 (3.51)	-14.35	<0.0001*	-26.2 to -0.1	-2.2 (-3.7, -1)
Chocolate confectionary (n = 221)	51.88 (9.92)	48.68 (10.38)	-3.21 (4.84)	-6.19	<0.0001*	-36.1 to -0.02	-1.8 (-4.7, -0.5)
Sweet confectionary (n = 121)	59.70 (21.56)	53.46 (25.08)	-6.24 (9.38)	-10.45	<0.0001*	-50 to -0.0001	-2.8 (-6.5, - 0.6)
Branded (n = 336)	44.36 (19.81)	41.12 (20.79)	-3.24 (6.13)	-7.30	<0.0001*	-50 to -0.02	-1.8 (-3.7, -0.5)
Unbranded (n = 228)	37.43 (21.86)	32.80 (21.00)	-4.63 (5.35)	-12.37	<0.0001*	-33.2 to -0.0001	-3 (-6.1, -1.1)
Single serve (n = 137)	51.62 (14.54)	47.97 (16.95)	-3.65 (7.46)	-7.07	<0.0001*	-50 to -0.0001	-1.7 (-3.7, -0.5)

*Statistically significant at $p < 0.05$

The extent of reduction in sugar content ranged from trace amounts (-0.001g/100g) to -50g/100g reductions (in one product in the Sweet confectionary category). However, these data were highly skewed with the majority of products having reduced their sugar content by up to -2g/100g (the median sugar reduction overall was -2g/100g). As with other analyses, there was variation across product categories although the median change was relatively consistent at -2g/100g for Breakfast cereals, -1.8g/100g for Chocolate confectionary and -2.4g/100g for Sweet confectionary. Whilst the gram/100g changes are similar, the extent of reformulation is much greater for Breakfast cereals which contained less sugar prior to reformulation.

Summary: Sugar reduction is technically feasible in all product categories. Large amounts of reformulation can be achieved, but the median amount of reformulation across all product categories ranged between -1.8g/100g and -2.8g/100g suggesting that smaller amounts of reformulation are more common.

8.2.4 Sugar content and changes in sugar content (g/100g), complete case analysis

In light of the data presented in Section 8.1.2 which showed the extent of changes in product portfolios; a complete case analysis was conducted using a subset of products available in the dataset each year (3,100 observations; Breakfast cereal n = 769, Chocolate confectionary n = 1400, Sweet confectionary n = 931). This analysis eliminated the effect of changing product portfolios on results enabling a focus on product reformulation. An overview of sugar content and change in sugar content is displayed in Table 22 below.

The mean sugar content of all products was 45.44g/100g in 2015, 45.34g/100g in 2017 and 45.32g/100g in 2018. As with the available case analysis, the overall data were not reflective of product categories: for example, the mean sugar content of Breakfast cereal products ranged between 16.5g/100g and 17.5g/100g whereas the mean sugar content of Chocolate confectionary products was around 51g/100g and around 60g/100g for Sweet confectionary.

There was continued evidence of a reduction in sugar content in Breakfast cereal products (-0.75g/100g, -4.33%, $p < 0.001$). Although consistent this was only half of the 9.5% reduction observed within the available case analysis set out in 6.3.2a.

In contrast with the available case analysis, there was:

- weak evidence of an increase in sugar content in the Chocolate confectionary category (+0.23g/100g, +0.45%, p=0.078);
- weak evidence of a reduction in sugar content of branded (-0.13g/100g, -0.35%, p = 0.092) but not unbranded (-0.10g/100g, -0.24%, p = 0.578) products; and
- no evidence of a change in sugar content for single serve products; and when product sub-categories were examined (see Table 23) there was evidence of only a small reduction in the sugar content of branded products and this was greatest between 2015 and 2017 (-0.33g/100g, -0.6%, p = 0.015).

These results suggest that:

- the reductions in sugar content of Breakfast cereal products observed overall were the result of a relatively equal combination of changing product portfolios (where new products with lower sugar may have been introduced or higher sugar products discontinued) and reformulation of existing products,
- reduced sugar content of unbranded products was accounted for by changing products portfolios rather than reformulation of existing products,
- increased sugar content of Chocolate confectionary products was concealed by changing product portfolios,

changes in sugar content of single serve products may not have been due to reformulation of existing products but due to changing product portfolios (see further analysis of this in Section 8.2.6).

Table 22. Complete case analysis. Mean sugar (g/100g) by year and change in sugar (g/100g, %), by product category, branding and single serve

	Mean sugar (standard deviation), range, n products			Change in sugar 2015 – 2017			Change in sugar 2015 – 2018		
Product category	2015	2017	2018	Mean	%	p	Mean	%	p
All products (n = 3100)	45.44 (21.86) 0 – 99.8	45.34 (22.03) 0 – 99	45.32 (22.10) 0 – 99	-0.10	-0.22	0.151	-0.12	-0.26	0.120
Breakfast cereal (n = 769)	17.34 (10.57) 0.1 – 56.67	16.93 (10.45) 0.5 – 55	16.59 (10.33) 0.5 – 55	-0.41	-2.37	<0.001*	-0.75	-4.33	<0.001*
Chocolate confectionary (n = 1400)	50.78 (11.08) 0 – 90	50.91 (10.72) 1 – 90	51.00 (10.61) 1 – 90	+0.14	+0.28	0.236	+0.23	+0.45	0.078
Sweet confectionary (n = 931)	60.61 (19.73) 0 – 99.8	60.41 (20.30) 0 – 99	60.49 (20.21) 0 – 99	-0.20	-0.33	0.153	-0.21	-0.35	0.427
Branded (n = 2054)	47.58 (21.52) 0 – 99	47.43 (21.72) 0 – 99	47.44 (21.75) 0 – 99	-0.03	-0.06	0.060	-0.13	-0.27	0.092
Unbranded (n = 1046)	41.23 (21.93) 0 – 100	41.22 (22.05) 0 – 99	41.14 (22.18) 0 – 99	-0.01	-0.02	0.925	-0.10	-0.24	0.578
Single serve (n=815)	54.34 (15.73) 0 – 98	54.11 (16.19) 0 – 97	54.25 (16.08) 0 – 97	-0.23	-0.42	0.063	-0.10	-0.18	0.479

*Statistically significant at $p < 0.05$

Table 23. Complete case analysis: Mean sugar (g/100g) by year and change in sugar (g/100g, %) for single serve products, by product category and branding

	Mean sugar g/100g (standard deviation), range, n products			Change in sugar 2015 – 2017			Change in sugar 2015 – 2018		
	2015	2017	2018	Mean	%	p	Mean	%	P
All single serve products	54.34 (15.73) 0 – 98	54.11 (16.19) 0 – 97	54.25 (16.08) 0 – 97	-0.23	-0.42	0.063	-0.10	-0.18	0.479
Breakfast cereal	-	-	-	-	-	-	-	-	-
Chocolate confectionary (n=525)	51.47 (10.41)	51.40 (10.31)	51.54 (10.26)	-0.08	-0.16	0.477	-0.07	-0.14	0.593
Sweet confectionary (n=290)	59.54 (21.40)	59.03 (22.52)	59.15 (21.40)	-0.52	-0.87	0.078	-0.39	-0.66	0.190
Branded (n=641)	55.35 (15.65)	55.01 (16.27)	55.08 (16.23)	-0.33	-0.60	0.015*	-0.27	-0.49	0.049*
Unbranded (n=174)	50.65 (15.51)	50.78 (15.47)	51.19 (15.19)	-0.13	-0.26	0.664	-0.54	-1.07	0.155

*Statistically significant at $p < 0.5$

8.2.5 Sugar categories: low, medium or high

The proportions of products with low (≤5g/100g), medium (>5 and ≤22.g/100g) or high (>22.5g/100g) sugar were examined to understand the extent to which new, lower sugar products had been created (see Table 24) either due to reformulation or changes to product portfolios. Breakfast cereal products had the highest proportion of low and medium sugar products, which made up almost three quarters of Breakfast cereal products by 2018. The majority of products in the Chocolate and Sweet confectionary categories were classified as high sugar. A higher proportion of unbranded products were low (7%) and medium (16%) sugar in 2018 compared to branded products (5% and 12% respectively). Accordingly, a lower proportion of unbranded products were classified as high sugar (77%) compared to branded products (95%).

Across all products, there was evidence of a 1.5% decrease in the proportion of high sugar products between 2015 and 2018 ($p = 0.038$). The proportion of high sugar Breakfast cereal products reduced by 8.1% from 35.5% in 2015 to 27.4% in 2018 ($p<0.001$). This was accompanied by an increased proportion of products in the medium sugar category (5.6%, $p = 0.004$), suggesting that reductions in sugar content were made to higher sugar products and that these were substantial enough to move products from being high sugar (with >22.5g/100g) to medium sugar (with >5 and ≤ 22.5g/100g). There was weak evidence of a 2.6% increase in low sugar Breakfast cereal products ($p = 0.082$) which could be indicative of reductions in medium sugar products (from >5g/100g to ≤5g/100g sugar) or even larger reductions in the sugar content of high sugar products.

In addition, there was evidence of a 2.9% reduction in the proportion of unbranded products classified as high sugar in 2015 compared to 2018 ($p = 0.028$) but without accompanying increases in medium or low sugar products. Given the number of unbranded products was lower in 2018 (n=1859, 31% of all products, see Table 16) compared with 2015 (n=2197, 36% of all products) it is likely that this is the result of discontinuation of products as opposed to reformulation.

There was evidence of a 2% reduction in high sugar single serve products between 2015 and 2018 ($p = 0.004$). There was also evidence of an increase in low sugar single serve products

(although this was based on small numbers; +0.8%, p = 0.022) and weak evidence of an increase in medium sugar single serve products (+1.2%, p = 0.053). This is consistent with results suggesting that these products were lower in sugar content in 2018 compared with 2015 (Table 19) and could be due to either the creation of new lower sugar products or reformulation of existing ones.

Table 24. Number and % products with low, medium, high sugar (g/100g), by year, by product category, branding, and single serve

		Frequency n (%)			Change 2015 – 2017		Change 2015 – 2018	
	Sugar category	2015	2017	2018	pr	p	pr	p
All categories	Low	283 (4.66)	318 (5.22)	309 (5.20)	+0.006	0.157	+0.005	0.168
	Medium	758 (12.48)	864 (14.17)	795 (13.39)	+0.017	0.006*	+0.009	0.138
	High	5032 (82.86)	4915 (80.61)	4833 (81.40)	-0.022	0.001*	-0.015	0.038*
Breakfast cereal	Low	241 (17.02)	254 (17.24)	259 (19.59)	+0.002	0.873	+0.026	0.082
	Medium	672 (47.46)	760 (51.60)	701 (53.03)	+0.414	0.026*	+0.056	0.004*
	High	503 (35.52)	459 (31.16)	362 (27.38)	-0.044	0.013*	-0.081	<0.001*
Chocolate confectionary	Low	9 (0.32)	8 (0.30)	11 (0.40)	0	0.859	+0.001	0.624
	Medium	49 (1.75)	56 (2.07)	48 (1.75)	+0.003	0.393	0	0.994
	High	2737 (97.92)	2644 (97.64)	2683 (97.85)	-0.003	0.468	-0.001	0.843
Sweet confectionary	Low	33 (1.77)	56 (2.92)	39 (2.08)	+0.012	0.020*	+0.003	0.491
	Medium	37 (1.99)	48 (2.51)	46 (2.46)	+0.005	0.283	+0.005	0.331
	High	1792 (96.24)	1812 (94.57)	1788 (95.46)	-0.017	0.014*	-0.008	0.233
Branded	Low	159 (4.1)	187 (4.59)	185 (4.54)	+0.005	0.282	+0.004	0.341
	Medium	440 (11.35)	519 (12.75)	492 (12.06)	+0.014	0.056	+0.007	0.323
	High	3277 (84.55)	3364 (82.65)	3401 (83.40)	-0.019	0.023*	-0.011	0.164
Unbranded	Low	124 (5.64)	131 (6.46)	124 (6.67)	-0.00+	0.264	+0.010	0.174
	Medium	318 (14.47)	345 (17.02)	303 (16.30)	+0.025	0.023*	+0.018	0.108
	High	1755 (79.88)	1551 (76.52)	1432 (77.03)	-0.034	0.008*	-0.029	0.028*
Single serve	Low	10 (0.62)	23 (1.43)	22 (1.44)	+0.008	0.022*	+0.008	0.022*
	Medium	41 (2.54)	60 (3.74)	57 (3.74)	+0.012	0.051	+0.012	0.053
	High	1565 (96.84)	1523 (94.83)	1445 (94.82)	-0.020	0.004*	-0.020	0.004*

There was further evidence of changes between 2015 and 2017; for example, there was evidence of an increase in the proportion of both low and high sugar Sweet confectionary products and of branded products. However, these were not sustained in 2018. There was no evidence of any changes in Chocolate and Sweet confectionary products.

Due to the high sugar levels of Chocolate and Sweet confectionary products, which had on average between 50.74g/100g and 58.74g/100g of sugar, considerable (and likely unrealistic) reformulation would have been necessary to see a reduction in the proportion of high sugar products. Whilst, as set out in section 8.2.3, some of these products did show large amounts of reformulation these were atypical for these products. Rather than creating alternative categories, the distribution of products by sugar content was also examined for these product types; and this showed equally little change (see Table 25 for percentiles).

Table 25. Median and percentiles sugar (g/100g) for Chocolate and Sweet confectionary and single serve products, by year

		Sugar g/100g		
	Percentile	2015	2017	2018
Chocolate confectionary	5th	29.9	29.9	30
	25th	47.3	47	46.5
	50th	53.3	53	53
	75th	57.5	57.5	57
	95th	64.6	65.5	65
Sweet confectionary	5th	27.8	20.1	24.7
	25th	50	50	49.4
	50th	59.8	59	58.4
	75th	70.8	71	70.8
	95th	91	91	90.3
Single serve	5th	28.2	21.7	21.7
	25th	48.2	47.6	46
	50th	54.5	54	53.7
	75th	60	60	60
	95th	82.3	83.1	83.1

Although, the sugar content of Sweet confectionary products at the 5th percentile 27.8g/100g sugar to 24.7g/100g suggesting a small shift to less sugar in lowest sugar products. There was no change in value for upper percentiles. There was a shift in the sugar

content of lowest sugar single serve products from 28.2g/100g in 2015 to 21.7g/100g in 2018.

Summary: Between 2015 and 2017 there was evidence of an 8% reduction in the proportion of high sugar Breakfast cereal products, with accompanying increases in both medium and low sugar products. There was evidence of a reduction in the proportion of unbranded products categorised as high sugar, which is most likely due to changes in unbranded breakfast cereal products. There was evidence of a 2% reduction in the proportion of high sugar single serve products, but the number of single serve products was very low.

8.2.6 Comparison of sugar content (g/100g), new compared with discontinued products

Further analysis examined the sugar content for products considered to be discontinued (available in 2015 only) or new (in both 2017 and 2018) compared with products considered to be continued (available in all years) in order to determine whether high sugar products had been discontinued and new lower sugar products created. Results are presented in Tables 26 and 27. Using 2015 data, the mean g/100g sugar in continued products was lower than those that discontinued (-2.44g/100g, -5.01%, p <0.0001) suggesting that higher sugar products were more likely to have been discontinued. In looking at product sub-categories, there was evidence that sugar content in 2015 was lower in continued compared to discontinued products in Breakfast cereals (-1.93g/100g, -9.80%, p = 0.002) Chocolate confectionary (-1.11g/100g, -2.35%, p = 0.005) and unbranded products (-6.04g/100g, -12.66%, p <0.0001). As with previous analyses, it is likely that there was overlap between the breakfast cereal and unbranded sub-categories.

The overall mean sugar content of new products in 2018 was higher than continued products at 47.40g/100g compared with 45.32g/100g (+2.08g/100g, +4.59%, p = 0.004). This suggests that new lower sugar products were not created. Although there were some differences in product sub-categories: there was evidence that the sugar content of new Sweet confectionary products was lower in both 2017 and 2018 compared with continued products based on sugar data from the same year (2017 comparison: -2.80/100g, -4.63%, p = 0.005; 2018 comparison: -2.64g/100g, -4.36%, p = 0.026) and that the sugar content of single serve products new in 2018 was also lower (at 51.08g/100g) compared with continued products (54.25g/100g; -3.17g/100g, -5.84%, p=0.005). This aligns with earlier

results that indicated a lower proportion of high sugar products / higher proportion of low sugar products (Table 24). The mean sugar content of unbranded products that were new in 2018 was 14% higher than the 2018 sugar content of continued products at 47.10g/100g compared with 41.14g/100g (+5.96, +14.49%, $p < 0.0001$) and it is likely that this was driving the higher levels of sugar in these products overall.

This analysis suggests that new Sweet confectionary products and single serve products may have been produced that were lower in sugar, but that new unbranded products were higher in sugar compared with products already available despite some higher sugar products having been discontinued between 2015 and 2017.

Table 26. Difference in sugar content of continued compared with discontinued products (sugar g/100g, mean (SD), range, n)

	Discontinued in 2015	Continued in 2015	Continued compared with discontinued in 2015		
	2015 sugar g/100g	*2015 sugar g/100g*	g/100g difference	%	p
All product categories	47.87 (18.70) 0 – 98 n=1993	45.44 (21.86) 0 – 99 n=3100	-2.44	-5.01	<0.0001*
Breakfast cereal	19.27 (9.40) 0 – 43 n=393	17.34 (10.57) 0.5 – 55.56 n=769	-1.93	-9.80	0.002*
Chocolate confectionary	52.00 (9.35) 3 – 80 n=980	50.77 (11.08) 1.2 – 90 n=1815	-1.22	-2.35	0.005*
Sweet confectionary	59.48 (9.35) 0 – 98 n=620	60.61 (19.73) 0 – 99 n=931	+1.13	+1.90	0.234
Branded	48.28 (18.54) 0 – 98 n=1195	47.58 (21.52) 0 – 99 n=2054	-0.70	-1.43	0.347
Unbranded	47.27 (18.94) 0 – 97 n=798	41.23 (21.93) 0 – 99.27 n=1046	-6.04	-12.66	<0.0001*
Single serve	54.57 (12.20) 1 – 98 n=550	54.34 (15.73) 0 – 97 n=815	-0.22	-0.40	0.781

*p<0.05, unpaired t-test. 'Discontinued' products were available in 2015 only and used 2015 sugar content. 'Continued in 2015' products were available in 2015, 2017 and 2018, and 2015 sugar content was used.

Table 27. Difference in sugar content of new compared with continued products, sugar g/100g mean (SD), range, n and continued products (mean)

	Continued 2017	New in 2017	New in 2017 compared with continued			Continued 2018	New in 2018	New in 2018 compared with continued		
	2017 sugar g/100g	*2017 sugar g/100g*	g/100g	%	p	*2018 sugar g/100g*	*2018 sugar g/100g*	g/100g	%	p
All product categories	45.34 (22.03) 0 – 99 n=3100	45.79 (20.89) 0 – 99 n=2073	+0.45	+0.99	0.461	45.32 (22.10) 0 – 99 n=3100	47.40 (18.87) 0 – 98 n=1193	-2.08	-4.59	0.004*
Breakfast cereal	16.93 (10.45) 0.5 – 56 n=769	17.51 (10.11) 0 – 92 n=460	+0.58	+3.43	0.341	16.59 (10.33) 0.5 – 55 n=769	16.08 (9.31) 0 – 37 n=192	-0.51	-3.07	0.529
Chocolate confectionary	50.91 (10.72) 1 – 90 n=1400	51.03 (11.16) 0 – 83 n=922	+0.12	+0.24	0.794	51.00 (10.61) 1 – 90 n=1400	50.75 (10.21) 0 – 77 n=627	-0.25	-0.49	0.620
Sweet confectionary	60.41 (20.30) 0 – 99 n=1225	57.61 (19.13) 0 – 99 n=691	-2.80	-4.63	0.005*	60.49 (20.21) 0 – 99 n=1225	57.85 (16.88) 1 – 98 n=374	-2.64	-4.36	0.026*
Branded	47.43 (21.72) 0 – 99 n=2054	46.64 (20.83) 0 – 99 n=1432	-0.79	-1.67	0.281	47.44 (21.75) 0 – 99 n=2054	47.51 (19.59) 0 – 98 n=872	-0.06	-0.13	0.941
Unbranded	41.22 (22.05) 0 – 99 n=1046	43.89 (20.89) 0 – 99 n=641	+2.67	+6.48	0.014*	41.14 (22.18) 0 – 99 n=1046	47.10 (16.77) 0 – 77 n=321	+5.96	+14.49	<0.0001*
Single serve	54.11 (16.19) 0 – 97 n=815	52.18 (16.94) 0 – 95 n=555	-1.95	-3.60	0.032*	54.25 (16.08) 0 – 97 n=815	51.08 (15.93) 1 – 93 n=269	-3.17	-5.84	0.005*

*p<0.05, unpaired t-test. 'Continued 2017' uses 2017 sugar data and products available in all years. 'New in 2017' uses 2017 sugar data and products available in 2017 and / 2018. 'Continued in 2018' uses 2018 sugar data and products available in all years. 'New in 2018' uses 2018 sugar data and products only available in 2018.

8.3 Portions sizes of single serve products

This section examines the extent to which the portion sizes of single serve products changed over time for a more detailed exploration of changes (or lack of) observed. It includes data on portion size and change in portion size as g/serving, the proportions of products with changes in portion size and differences in portion sizes of new, continued and discontinued products. It also includes some exploratory work to compare the portion sizes of new single serve products with discontinued products. All portion size data were available in g/serving.

Previous analyses showed that the mean sugar content of single serve products decreased by -1.32g/100g, from 54.36g/100g in 2015 to 53.04g/100g in 2018 (-1.32g/100g, -2.43%, $p = 0.017$), and that in those products that reduced sugar the mean reduction was -3.65g/100g (-7.07%, $p < 0.0001$). This is without accounting for any changes in portion size. Although there was no evidence of any change in the complete case analysis, suggesting that the changes were due to changing product portfolios but it is important to determine whether any additional changes in portion sizes may have contributed to reduced sugar content in single serve products.

8.3.1 Portion sizes in grams

Mean portion sizes (g/serve) of all single serve products, sub-categories of products and changes over time are displayed below in Table 28. The mean portion size of all single serve products was 46.91g/serve in 2015, 47.27g/serve in 2017 and 47.18g/serve in 2018. The weight per serving was higher in Sweet compared with Chocolate confectionary products (for example, 42.64g in 2015 compared with 54.61g), and in unbranded compared with branded products. With the exception of branded products, where there was weak evidence of an increase in portion size between 2015 and 2018 (+1.59g/serve, +0.43%, $p = 0.085$), there was no evidence of any change in portion size over time.

8.3.2 Proportion of single serve products with change in portion size (weight in grams)

Proportions of products with any (or no) change in portion sizes were examined to explore the results set out in Section 8.2.1. This revealed that very few products had changed portion size at all: between 2015 and 2017 (based on n=1,051 products available in both years) less than 1% of single serve products showed any reduction in portion size, less than

1% showed an increase in portion size (6 products in both cases) and the remainder of products showed no change. This was observed again between 2015 and 2018 (based on n=830 products available in both years) with only 7 products showing a decrease in portion size and 8 products showing an increase in portion size (again less than 1%). Due to such small numbers no further sub-group analysis of this data was conducted; however, this supports results presented in Section 8.2.1 above that there was no mean change in the gram weight of single serve portion sizes.

8.3.3 Portion sizes, complete case analysis

As with previous analyses of sugar content, a complete case analysis was conducted using only products available each year (see Table 29 below). Again, no differences in portion size of single serve products were observed either overall, for individual product categories or by branding. Again, this was to be expected as so few products had changed but it also suggests that the weak evidence of an increase in portion size of Chocolate confectionary products set out in Section 8.2.1 was due to changes in product portfolios rather than reformulation of portion sizes.

8.3.4 Portion sizes, new compared with discontinued products

Further analysis examined the portion sizes of products considered to be discontinued (available in 2015 only) or new (in both 2017 and 2018) compared with products considered to be continued (available in all years) in order to determine whether products with larger portion sizes had been discontinued and new products with smaller portion sizes created (see Tables 30 and 31). The portion sizes (g) of single serve products were for the most part lowest in continued products compared with new and discontinued products; for example, in 2015 the portion size of products available in all years was 45.42g (n=815) compared with 49.28g (n=550) for those that were discontinued in 2015 (see Table 31).

There was evidence that mean portion size of all continued products was lower than that of all discontinued products (-3.86g, -7.83%, p = 0.003), suggesting that products with a higher portion size may have been discontinued. In looking at product sub-categories, there was evidence that portion sizes were lower in continued Sweet confectionary (-8.53g, -14.18%, p = 0.002) and unbranded products (-5.29g -9.33%, p = 0.045) compared with discontinued

products. This suggests that products with larger single portion sizes may have been discontinued specifically within these product sub-categories.

There was evidence that products considered new in 2017 had a greater portion size than continued products (+4.64g, +10.22%, p = 0.001) and weak evidence of the same for new products in 2018 (+2.74g, +6.03%, p = 0.090). This is contrary to the hypothesis that new, lower products may have been created in response to the SRP. In looking at product sub-categories, there was evidence that in 2017 new Chocolate confectionary products had larger portion sizes than continued products (+2.91g, +6.93%, p = 0.036) and branded products (+5.12g, +11.69%, p = 0.001). Again, this suggests that new products with larger portion sizes may have been created specifically within these product sub-categories.

As shown previously in Section 8.2.1, the discontinuation or introduction of products did not affect overall portion sizes of available products.

Table 28. Mean grams per portion and change in portion size (g/portion, %) in single serve products, by product category and branding

	Mean portion size g (standard deviation), range, n products			Change in portion size 2015 – 2017			Change in portion size 2015 – 2018		
	2015	2017	2018	Mean	%	p	Mean	%	p
All products	46.91 (23.14) 10 – 100 n=1616	47.27 (23.18) 10 – 100 n=1606	47.18 (23.30) 10 – 100 n=1524	+0.36	-0.77	0.661	+0.27	+0.43	0.743
Chocolate confectionary	42.64 (17.97) 10 – 80 n=1040	43.04 (18.96) 10 – 80 n=969	42.64 (19.14) 10 – 80 n=917	-0.40	+0.94	0.629	0.00	0.00	0.998
Sweet confectionary	54.61 (28.78) 10 – 100 n=576	53.70 (27.20) 10 – 100 n=637	54.03 (27.06) 10 – 100 n=607	-0.92	-1.68	0.569	-0.58	-1.06	0.721
Branded	44.33 (21.67) 10 – 100 n=1168	45.68 (22.71) 10 – 100 n=1211	45.93 (23.03) 10 – 100 n=1174	+1.35	+3.05	0.140	+1.59	+3.59	0.085
Unbranded	53.62 (25.43) 10 – 100 n=448	52.13 (23.93) 10 – 100 n=395	51.38 (23.73) 10 – 100 n=350	-1.49	-2.78	0.384	-2.24	-4.18	0.203

Table 29. Complete case analysis. Grams per portion in single serve products and change in portion sizes, by product category and branding

	Mean portion size (standard deviation), range, n products			Change in portion size 2015 – 2017			Change in portion size 2015 – 2018		
Product category	2015	2017	2018	Mean	%	p	Mean	%	p
All products (n = 815)	45.42 (22.67)	45.42 (22.65)	45.43 (22.66)	0	0	0.587	0.01	0	0.382
Breakfast cereal	-	-	-	-	-	-	-	-	-
Chocolate confectionary (n = 525)	41.98 (18.24)	41.99 (18.23)	41.99 (18.23)	0	0	0.716	0	0	0.445
Sweet confectionary (n = 290)	51.64 (27.99)	51.65 (27.98)	51.65 (27.98)	0.01		0.671	0.01	0	0.671
Branded (n = 641)	43.79 (21.79)	43.79 (21.78)	43.80 (21.78)	0	0	0.587	0	0	0.383
Unbranded (n = 174)	51.43 (24.78)	51.43 (24.78)	51.43 (24.78)	0	0	0	0	0	0

Table 30. Difference in portion size of continued products compared with discontinued products, g/serve, mean (SD), range, n

	Discontinued in 2015 *(2015 only)*	**Continued**	**Continued compared with discontinued in 2015**		
	2015 g/portion	*2015 g/portion*	g/portion difference	%	p
All product categories	49.28 (23.87) 10 – 100 n = 550	45.42 (22.66) 10 – 100 n=815	-3.86	-7.83	0.003*
Chocolate confectionary	43.58 (17.70) 10 – 80 n = 361	41.99 (18.23) 10 – 80 n=525	-1.59	-3.63	0.197
Sweet confectionary	60.17 (29.71) 10 – 100 n = 189	51.64 (27.98) 10 – 100 n=290	-8.53	-14.18	0.002*
Branded	45.13 (21.67) 10 – 100 n = 353	43.79 (21.78) 10 – 100 n=641	-1.33	-2.95	0.355
Unbranded	56.72 (25.81) 10 – 100 n = 197	51.43 10 – 100 n=174	-5.29	-9.33	0.045*

*p<0.05, unpaired t-test. 'Discontinued' products were available in 2015 only and used 2015 portion size. 'Continued in 2015' products were available in 2015, 2017 and 2018, and 2015 portion size was used.

Table 31. Differences in portion size for new products compared with continued products, sugar g/100g mean (SD), range, n and continued products (mean)

	Continued *(2015, 2017 & 2018)*	**New in 2017** *(2017 or 2017 & 2018)*	**New in 2017 compared with continued**			**Continued 2018**	**New in 2018** *(2018 only)*	**New in 2018 compared with continued**		
	Portion size 2017	Portion size 2017	g/portion	%	p	Portion size 2018	Portion size 2018	g/portion	%	p
All product categories	45.42 (22.65) 10 – 100 n=815	50.06 (23.84) 10 – 100 n = 555	+4.64	+10.22	0.001*	45.42 (22.66) 10 – 100 n=815	48.17 (23.84) 10 – 100 n = 269	+2.74	+6.03	0.090
Chocolate confectionary	41.99 (18.23) 10 – 80 n=525	44.89 (20.59) 10 – 80 n = 299	+2.91	+6.93	0.036*	41.99 (18.23) 10 – 80 n=525	42.04 (19.95) 10 – 80 n = 160	+0.05	+0.12	0.974
Sweet confectionary	51.64 (27.98) 10 – 100 n=290	56.09 (25.91) 11 – 100 n = 256	+4.45	+8.62	0.055	51.64 (27.98) 10 – 100 n=290	57.15 (26.21) 12 – 100 n = 109	+5.51	+10.67	0.075
Branded	43.79 (21.78) 10 – 100 n=641	48.91 (24.29) 10 – 100 n = 408	+5.12	+11.69	0.001*	43.79 (21.78) 10 – 100 n=641	47.62 (23.69) 10 – 100 n = 203	+3.83	+8.75	0.033*
Unbranded	51.43 10 – 100 n=174	53.24 (22.31) 12 – 100 n = 147	+1.81	+3.52	0.495	51.43 10 – 100 n=174	49.94 (24.40) 10 – 100 n = 66	-1.59	-3.09	0.656

*p<0.05, unpaired t-test. 'Continued 2017' uses 2017 portion size data and products available in all years. 'New in 2017' uses 2017 portion size data and products available in 2017 and / 2018. 'Continued in 2018' uses 2018 portion size data and products available in all years. 'New in 2018' uses 2018 portion size data and products only available in 2018.

8.3.5 Sugar content and change in sugar content in single serve products, grams per portion

Analysis of portion size data set out in Sections 8.2.1 to 8.2.4 suggests there was little change in portion sizes, and as a result little change in sugar of single serve portions would be expected in these products as it had been anticipated that sugar reduction would be achieved through reductions in portion size (96). However, given there was evidence of a reduction in g/100g sugar content of single serve products (see Table 19), I examined changes in sugar as g/serving.

An overview of sugar content of products available as single serve portions (Chocolate and Sweet confectionary only) is provided in Table 32. Mean sugar content was 25.5g/serve in 2015, 25.2g/serve in 2017 and 24.9g/serve in 2018. Reflecting data previously shown regarding g/100g of sugar content in single serve products, the sugar content per serving was lower in Chocolate confectionary compared with Sweet confectionary and lower in branded compared with unbranded products. There was no evidence of statistically significant change in sugar per serving. Whilst the sugar per serving did reduce in unbranded products by more than 5% between 2015 and 2018 (from 29.6g/serve to 27.93g/serve) this was not significant at conventional levels of statistical significance. The sugar content per serving in unbranded products remained higher in 2018 than that of branded products at 27.93g/serve compared to 23.97g/serve in branded products. Complete case analysis (Table 33) equally showed no change in sugar per serving overall or for product sub-categories, suggesting that the reduction in sugar per serving of unbranded products was due to changes in product portfolios rather than reformulation of sugar content.

Table 32. Mean sugar (g/serve) in single serve products, by year and change in sugar (g/serve, %), by product category and branding

	Mean sugar (standard deviation), range, n products			Change in sugar 2015 – 2017			Change in sugar 2015 – 2018		
	2015	2017	2018	Mean	%	p	Mean	%	p
All products	25.50 (15.02) 0 – 99 n = 1616	25.20 (15.34) 0 – 99 n = 1606	24.90 (15.02) 0 – 91 n = 1524	-0.29	-1.14	0.583	-0.59	-2.31	0.270
Chocolate confectionary	22.20 (10.51) 0 – 59 n = 1040	21.94 (11.01) 0 – 59 n = 969	21.55 (11.17) 0 – 60 n = 917	-0.25	-1.13	0.597	-0.65	-2.95	0.184
Sweet confectionary	31.45 (19.47) 0 – 99 n = 576	30.16 (19.19) 0 – 99 n = 637	29.98 (18.30) 0 – 91 n = 607	-1.29	-4.10	0.245	-1.48	-4.71	0.179
Branded	23.92 (13.41) 0 – 99 n=1168	23.99 (14.50) 0 – 99 n=1211	24.00 (14.43) 0 – 99 n=1174	+0.07	+0.29	0.901	+0.08	+0.33	0.886
Unbranded	29.60 (17.94) 0 – 88 n = 448	28.92 (17.16) 0 – 83 n = 395	27.93 (16.48) 0 – 79 n = 350	-0.69	-2.02	0.571	-1.68	-5.68	0.175

Statistically significant at $p < 0.05$

Table 33. Complete case analysis. Mean sugar (g/serve) in single serve products, by year and change in sugar (g/serve, %), by product category and branding

	Mean sugar (standard deviation), range, n products			Change in sugar 2015 – 2017			Change in sugar 2015 – 2018		
	2015	2017	2018	Mean	%	p	Mean	%	p
All products (n=815)	24.47 (14.54) 0 – 90	24.35 (14.54) 0 – 87	24.41 (14.62) 0 – 87	-0.12	-0.49	0.136	-0.05	-0.20	0.464
Chocolate confectionary (n=525)	21.61 (10.81) 0 – 59	21.61 (10.81) 0 – 59	21.65 (10.80) 0 – 60	-0.01	-0.05	0.825	-0.04	-0.19	0.441
Sweet confectionary (n=290)	29.63 (18.49) 0 – 89	29.31 (18.83) 0 – 87	29.42 (18.74) 0 – 87	-0.32	-1.08	0.133	-0.22	-0.74	0.256
Branded (n=641)	23.71 (13.57) 0 – 89	23.54 (13.72) 0 – 87	23.59 (13.70) 0 – 87	-0.17	-0.72	0.070	-0.12	-0.51	0.156
Unbranded (n=174)	27.27 (17.43) 0 – 77	27.34 (17.40) 0 – 77	27.46 (17.28) 0 – 77	+0.08	+0.29	0.551	-0.19	+0.70	0.182

*Statistically significant at $p < 0.05$

8.4 Consumer behaviour: sugar purchases

This section examines any changes in the volume of sugar purchased and changes in purchasing patterns to lower sugar products. It includes data on change in total sugar purchases (using both available and complete case analysis) and analysis of change in purchases of high, medium or low sugar products. Sugar purchased reflects the amount of sugar purchased through products and was calculated (by PHE analysts) through combining volume of purchases (kg,000s)[5] and the g/100g sugar content of products. The sugar purchase data were skewed considerably to the right so non-parametric tests were used for these analyses. Purchase data (volume of product, which were also positively skewed) are drawn upon to support interpretation of results.

8.4.1 Sugar purchases and changes in sugar purchases, kg,000s

Median sugar purchases and changes in sugar purchases are presented in Table 34 for all products and sub-categories of products. Equivalent purchase data are presented in Table 40. For all products, the median volume of sugar purchased by the GB population was 9,368kg in 2015, 8,074kg in 2017 and 8,874kg in 2018. In product categories, the median amount of sugar purchased was lowest for Chocolate confectionary for all three years (2015: 7,313kg; 2017: 7,066kg; 2018: 7,517kg) and highest for Sweet confectionary (2015: 11,601kg; 2017: 9,968kg; 10,820kg). The median purchase volume was much higher in Breakfast cereal products (for example, at 85,278kg in 2018 compared with 15,115kg and 19,400kg for Chocolate and Sweet confectionary respectively, Table 35) so driving up the volume of sugar purchased. This shows that whilst purchase volume and sugar content differ substantially for the different product categories, when combined the median volumes of sugar purchased are much closer to one another. The median volume of sugar purchased was higher for unbranded compared with branded products (13,249kg in 2018 compared with 7,233kg) and the difference in sugar purchased from these products increased over time.

There was no evidence of a change in the median volume of sugar purchased between 2015 and 2018 overall or for product sub-categories; with the exception of for unbranded

[5] Data provided to PHE on volume of sugar purchased has been weighted to the GB population

products where there was evidence of an increase (2015 median: 11,056; 2018 median: 13,249kg; z = -2.578, p = 0.010). This is despite evidence of a reduction in mean sugar content of Breakfast cereal, unbranded and single serve products during the same timeframe (Table 18) and a consecutive reduction in the median purchase volume of single serve products (Table 35). There was evidence of an increase in purchase volume of unbranded products during the same timeframe (2015 median: 31,084kg; 2018 median: 38,086kg; z = -2.966, p = 0.003), which most likely contributed to the increase in volume of sugar purchased in these products. It is not possible to determine why there was no evidence of a reduction in sugar purchased for Breakfast cereal and single serve products within the scope of this study; it is possible that sugar content was reduced in products with low purchase volume and / or that purchases of reformulated products reduced.

Results differed between 2015 and 2017 where there was evidence of reduced sugar purchases for all products and most sub-categories of products (there was no evidence of any change for Chocolate confectionary or unbranded products). During the same timeframe there was evidence of a reduction in mean sugar in all products, driven by reductions in mean sugar content of Breakfast cereal and unbranded products (Section 8.2.1, Table 18). There was also evidence of reduced purchase volume across all product categories and sub-categories (although the evidence was weak for unbranded products). This suggests that reductions in sugar purchases were driven by reductions in purchase volumes but that reductions in sugar content may also have contributed in some cases.

In summary, these data suggest that whilst there was evidence of reduced sugar in Breakfast cereal, unbranded and single serve products (Section 8.2.1, Table 18) between 2015 and 2018 this did not impact on the amount of sugar purchased from those products overall. If consumers increased purchasing of reformulated products to a sufficient extent, we would expect to see a reduction in sugar purchases unless purchase volume of non-reformulated or higher sugar products increased at a greater rate. Equally, whilst there was evidence of reduced volumes of sugar purchased between 2015 and 2017 this was most likely driven by a reduction in overall purchase volumes during that time. It is not possible to determine the specific contribution of changes in purchasing / sugar content contribute.

The positive distribution of purchase and sugar purchase data are worth noting, as these show that the bulk of products each contribute small amounts of the total volume sugar

purchased and that a small number of products contribute large amounts of sugar purchased. If reformulation is not occurring in the latter products, it would be necessary to see reformulation in a large number of products in order to observe any changes.

8.4.2 Total sugar purchases, complete case analysis

As with previous outcomes, a complete case analysis was conducted using a subset of products available in the dataset each year (3,100 observations; Breakfast cereal: n = 769, Chocolate confectionary: n = 1400, Sweet confectionary: n = 931). This enabled a closer examination of the volume of sugar purchased from products purchased more routinely as these are likely to be the most popular and / or represent 'everyday' purchases. Median sugar purchases and changes in sugar purchases are presented in Table 36 for all products and sub-categories of products. Again, equivalent purchase data (see Table 37) are drawn upon to support interpretation of results.

For all products, the median volume of sugar purchased was 17,849kg in 2015, 17,053kg in 2017 and 13,028kg in 2018. Again, among different product types, the median volume of sugar purchased was consistently lowest for Chocolate confectionary (2015: 13,669kg; 2017: 14,272kg; 2018: 11,701kg). Volumes of sugar purchased were highest for either Sweet confectionary or Breakfast cereal products depending on the year (for example, the median volume of sugar purchased from Sweet confectionary in 2015 was 21,89kg and from Breakfast cereal in 2018 was 16,072kg). In comparing branded and unbranded products, in line with the available case analysis, the median volume of sugar purchased was considerably higher for unbranded compared with branded products (for example 2018 branded: 9,137kg sugar; 2018 unbranded: 21,198kg sugar). Median volumes of sugar purchased were consistently higher (in some product sub-categories around double the amount) in products available each year compared with those observed in the available case analysis. This is consistent with the higher purchase volumes also observed and supports the assumption that these products are purchased more regularly and in larger volumes than those not available in the dataset each year.

There was evidence of a reduction in the median amount of sugar purchased for all products between 2015 and 2018 (2015 median: 17,849kg; 2018 median: 13,028kg, $z = 6.186$, $p < 0.0001$). Reductions in sugar purchases were observed for all product sub-categories, except

for unbranded products. This is inconsistent with the analysis of sugar content (Section 8.2.4, Table 22) which showed evidence of a reduction in sugar content for Breakfast cereal products only which reduced by a mean of 0.75g/100g (-4.33%, $p < 0.001$). There was evidence of reduced purchase volumes over the same time period which most likely led to the reduced volume of sugar purchased.

These results differ from the available case analysis set out in Section 8.3.1 where there was evidence of change (an increase) in sugar purchased from unbranded products only. In further contrast to the available case analysis, there was no evidence of any change in the amount of sugar purchased from unbranded products between 2015 and 2018 (-739kg, -1.52%, $p = 0.685$). Changes in mean sugar content of products available each year (8.2.4, Table 22) between 2015 and 2018 were limited to the Breakfast cereal category. However, these results are consistent with reduction in volume of products purchased over the same timeframe (Table 17), suggesting that changes in purchasing are contributing to reductions in sugar purchases as opposed to (or most likely in addition to in the case of Breakfast cereal products) changes in sugar content.

These data suggest that while consumers are purchasing certain products regularly and in larger quantities, they are purchasing less of these over time (as shown in the lower volumes of products purchased). It is possible that consumers are changing product choices and moving away from their usual products due to reformulation of these products, but there are alternative equally plausible explanations (expanding choice leading to expanding the number of products purchased, changes in the size of product purchased, for example).

In summary, in products available each year there was evidence of a reduction in sugar purchasing across all products and all sub-categories of products bar unbranded products where there was no change in the amount of sugar purchased increased. With the exception of Breakfast cereal products, which had also reduced sugar content, this was most likely driven by an accompanying reduction (or in the case of unbranded products no change) in the volume of products purchased.

Table 34. Sugar purchases (kg, 000s), by year, by product category, branding and single serve

	Median (IQR)			2015 – 2017		2015 – 2018	
	2015	2017	2018	z	p	z	p
All products	9.368 (1.864, 38.532) n=6073	8.074 (1.570, 36.935) n=6097	8.874 (1.777, 40.011) n=5937	2.373	0.018*	0.210	0.834
Breakfast cereal	10.475 (1.744, 45.949) n=1416	7.972 (1.247, 39.243) n=1473	9.120 (1.311, 45.279) n=1322	2.680	0.007*	1.078	0.281
Chocolate confectionary	7.313 (1.611, 33.273) n=2795	7.066 (1.475, 35.428) n=2708	7.517 (1.632, 36.179) n=2742	0.089	0.929	-0.855	0.393
Sweet confectionary	11.601 (2.366, 40.336) n=1862	9.968 (2.217, 37.124) n=1916	10.820 (2.242, 40.979) n=1873	2.012	0.044*	0.575	0.565
Branded	8.362 (1.447, 38.570) n=3876	6.380 (1.011, 34.484) n=4070	7.233 (1.273, 35.842) n=4078	3.542	0.001*	1.250	0.211
Unbranded	11.056 (2.716, 38.321) n=2197	11.928 (3.148, 39.847) n=2027	13.249 (2.956, 45.841) n=1859	-1.696	0.090	-2.578	0.010*
Single serve only	5.978 (1.093, 24.220) n=1616	4.308 (0.770, 19.757) n=1606	4.797 (0.852, 24.537) n=1524	3.030	0.002*	1.189	0.235

Whilst there are some 0s in the data, as noted previously (see methods section 5.3.5) these were kept in the analysis as they reflected purchases of zero sugar products.

Table 35. Product purchases (kg, 000s), by year, by product category, branding and single serve

	Median (IQR)			2015 – 2017		2015 – 2018	
	2015	2017	2018	z	p	z	p
All products	24.959 (5.546, 100.795) n=6073	21.099 (4.350, 95.443) n=6097	23.300 (4.711, 105.848) n=5937	3.774	0.001*	1.711	0.087
Breakfast cereal	79.089 (13.805, 301.910) n=1416	65.604 (11.146, 269.645) n=1473	85.278 (14.588, 32.713) n=1322	2.041	0.041*	-0.739	0.460
Chocolate confectionary	15.926 (4.169, 69.710) n=2795	14.359 (3.206, 69.096) n=2708	15.115 (3.356, 69.994) n=2742	2.181	0.029*	1.283	0.120
Sweet confectionary	21.640 (5.175, 70.526) n=1862	18.103 (4.168, 65.560) n=1916	19.400 (4.399, 71.910) n=1873	2.881	0.004*	1.315	0.188
Branded	21.834 (4.533, 94.705) n=3876	15.708 (2.952, 83.847) n=4070	18.105 (3.345, 88.266) n=4078	5.478	<0.001*	3.286	0.001*
Unbranded	31.084 (7.592, 108.831) n=2197	34.231 (8.631, 117.308) n=2027	38.086 (8.730, 136.938) n=1859	-1.885	0.060	-2.966	0.003*
Single serve only	12.322 (2.792, 51.167) n=1616	8.803 (1.582, 38.215) n=1606	9.818 (1.825, 49.415) n=1524	4.737	<0.001*	2.691	0.007*

Table 36. Complete case analysis. Sugar purchases (kg, 000s), by year, by product category and branding

	Median (IQR)			2015 – 2017		2015 – 2018	
	2015	2017	2018	z	p	z	p
All products (n=3100)	17.849 (4.214, 61.015)	17.053 (3.924, 61.785)	13.028 (2.554, 53.317)	0.820	0.412	6.186	<0.0001 *
Breakfast cereal (n=769)	20.753 (3.845, 80.565)	19.626 (3.586, 74.811)	16.072 (2.102, 66.797)	0.551	0.581	2.863	0.004*
Chocolate confectionary (n=1400)	13.669 (3.704, 52.422)	14.272 (3.606, 54.982)	11.701 (2.563, 48.115)	-0.151	0.880	3.146	0.002*
Sweet confectionary (n=931)	21.896 (6.330, 62.506)	19.453 (5.054, 61.568)	13.838 (2.892, 50.833)	1.294	0.196	4.976	<0.0001 *
Branded (n=2054)	15.978 (3.568, 63.423)	13.535 (3.088, 58.913)	9.137 (1.655, 47.806)	1.762	0.078	7.005	<0.0001 *
Unbranded (n=1046)	21.666 (5.939, 57.685)	23.194 (6.688, 62.944)	21.198 (5.141, 60.465)	-1.237	0.216	0.602	0.547
Single serve only (n=815)	10.249 (2.693, 37.965)	9.191 (2.199, 38.469)	7.623 (1.636, 33.515)	0.898	0.369	2.603	0.009*

Table 37. Complete case analysis. Product purchases (kg, 000s) by year, by product category, branding, single serve

	Median (IQR)			2015 – 2017		2015 – 2018	
	2015	2017	2018	z	p	z	p
All products (n=3100)	47.275 (11.625, 166.730)	46.547 (10.960, 169.368)	34.689 (6.851, 152.267)	0.571	0.568	5.966	<0.0001 *
Breakfast cereal (n=769)	171.956 (45.080, 512.156)	168.772 (42.601, 523.237)	152.506 (28.566, 510.366)	0.220	0.826	2.153	0.031*
Chocolate confectionary (n=1400)	28.351 (7.934, 103.638)	29.253 (7.693, 108.991)	23.306 (5.264, 94.380)	-0.027	0.978	3.423	0.001*
Sweet confectionary (n=931)	39.304 (10.710, 108.149)	35.366 (9.804, 103.330)	24.532 (6.057, 85.135)	1.010	0.312	4.910	<0.0001 *
Branded (n=2054)	38.811 (8.971, 155.509)	34.280 (7.747, 151.930)	23.459 (4.222, 123.068)	1.528	0.127	7.017	<0.0001 *
Unbranded (n=1046)	62.101 (19.156, 182.841)	67.074 (21.432, 202.456)	64.439 (17.453, 198.430)	-1.209	0.227	0.351	0.726
Single serve only (n=815)	19.936 (5.301, 72.336)	18.317 (4.091, 76.041)	15.791 (3.156, 66.596)	0.612	0.541	2.386	0.017*

8.4.3 Purchases of products with low, medium or high sugar

It was intended to examine change in consumer purchasing through exploring the purchase of low, medium and high sugar products. However, earlier analysis using these categories to examine change in g/100g of sugar showed that the categories were only suitable for Breakfast cereal products as confectionary products are typically high in sugar. As a result, the analysis of change in purchasing of products with low, moderate or high sugar was conducted using the Breakfast cereal category only (see Table 38 below).

To recap: earlier analysis showed an 8.1% reduction ($p < 0.001$) in the proportion of high sugar Breakfast cereal products between 2015 and 2018 and accompanying increases in the proportions of medium (+5.6%, $p = 0.004$) and low sugar (+2.6%, $p = 0.082$) products (Table 24). The g/100g sugar content of Breakfast cereal products reduced by -9.5% (-1.73g/100g, $p < 0.001$) based on an available case analysis during the same time frame (-0.75g/100g, -4.33%, $p < 0.001$ based on complete cases).

Each year, the median volume of low sugar Breakfast cereal products purchased was higher than medium or high sugar products suggesting that more low sugar products were typically purchased. In 2017 a median volume of 96,920kg of low sugar breakfast cereal products was purchased compared with 62,594kg of medium and 52,794kg of high sugar products. Whilst there were some changes over time in the purchases of products by sugar category, none of these changes were significant at conventional levels ($p<0.05$). This is despite the evidence of a reduction in the proportion of high sugar breakfast cereal products available.

Summary: whilst the availability of high sugar Breakfast cereal products was lower in 2018 compared to 2015 as a result of reductions in the mean sugar content of these products; there was no evidence of a reduction in the amount of sugar purchased from high sugar Breakfast cereal products during the same time frame. It is possible that either the sugar content of products not frequently purchased was changed or that purchasing changed following reformulation.

Table 38. Purchases of low, medium and high sugar Breakfast cereal products by year

	Median (IQR) n products			**2015 – 2017**		**2015 – 2018**	
	2015	2017	2018	z	p	z	p
Low sugar	103.126 (14.689, 493.372) n=241	96.920 (14.502, 423.010) n=254	112.408 (19.519, 416.851) n=259	0.295	0.768	-0.281	0.779
Medium sugar	71.915 (13.785, 265.190) n=672	62.594 (10.146, 234.98) n=760	82.131 (16.503, 305.718) n=701	1.380	0.168	-0.851	0.395
High sugar	77.013 (13.961, 292.595) n=503	57.924 (11.146, 255.583) n=459	79.261 (10.917, 314.120) n=362	1.632	0.103	0.129	0.898

8.5 Chapter summary

I analysed product-level changes following initiation of the SRP in England (between 2015 and 2018) focused on Breakfast cereal, Sweet and Chocolate confectionary products within the in home setting. Whilst there was evidence of an initial reduction in the mean sugar content of products between 2015 and 2017 (-0.77g/100g, -1.66%, $p<0.05$) this was not sustained through to 2018 and was mostly likely due to changes in the availability of products rather than product reformulation. There was no evidence of a reduction in the sugar content of products, the portion sizes of single serve products nor sugar purchases between 2015 and 2018. There was evidence of a 10% reduction in the mean sugar content of Breakfast cereal products during that time and an 8% reduction in the proportion of Breakfast cereal products that were high in sugar (>22.5g/100g). Although there was no evidence that the amount of sugar purchased from breakfast cereal products reduced or of any changes in the volume of low, medium or high sugar products purchased. There was no evidence of any reductions in portion sizes of single serve Chocolate or Sweet confectionary products or of reduced sugar or sugar sales in these products (single serve or otherwise).

The expectation was set by PHE that industry should gradually reduce the sugar content or portion size of products already on the market, although it was also acknowledged that some new products may be created to achieve reformulation targets (57). Further analysis of the Breakfast cereal product category showed that a 4% sugar reduction could be accounted for by reformulation, and that the remainder of the reduction in sugar content of products was most likely accounted for by product renewal. One third of all products were new between 2015 and 2018, and the sugar content of new products was higher than that of those available each year. However, the sugar content of discontinued products was also higher than products available each year. Taken alone this could suggest that industry discontinued high sugar products in order to achieve a lower sugar content in their portfolios of products. But given the results for new products, it is likely that products available continuously are lower in sugar for other reasons which is something future research could explore. The same pattern was observed in relation to portion sizes of single serve products.

Examining the extent of change both within and across products can give an indication of the extent of reformulation that is feasible for industry. Overall, one in five products showed a reduction in sugar by 2018 and there was evidence that these products reduced by an average of 10% – in line with the interim targets set by the SRP for 2018. This was higher in Breakfast cereal products, where 29% of products had reduced sugar content. The mean sugar reduction was -17% reduction and as much as -26.2g/100g which suggests a large amount of reformulation is technically feasible within certain products. Interestingly, some Chocolate and Sweet confectionary products had reduced sugar (Chocolate confectionary: 12% of products, Sweet confectionary: 8% of products) including 12% of single serve products with mean reductions ranging from -6% in Chocolate confectionary to -10% in Sweet confectionary. This suggests that it is feasible to modestly reformulate the sugar content of some Chocolate and Sweet confectionary products irrespective of changes to portion size.

The Kantar FMCG data used in this analysis included product data for the in home sector only, and therefore does not consider changes in all products included in the SRP within these categories. Longer term follow up would be needed to determine whether further changes were made during the remaining term of the policy.

9. Discussion: Interpretation of results and critical reflections

9.1 Chapter introduction: recap of research aims and studies that form this thesis

In this DrPH thesis, I set out to critically examine the potential role of voluntary reformulation policy in reducing population consumption of sugar. This was a major policy priority in England between 2015 and 2020 – the Sugar Reduction Programme (SRP) – and other countries around the world have begun to adopt similar policies to the English policy. I conducted three studies:

Study 1 involved a systematic review of global empirical evidence on the effectiveness of sugar reformulation policy in changing the sugar content of products, sugar purchases and sugar intake, examining differential effects for different product categories.

Study 2 involved the use of published evidence to examine implementation of voluntary salt reformulation policy in England with a view to understanding the core components of effective voluntary reformulation policy and application of this to sugar.

Study 3 involved an in-depth, exploratory analysis of changes in sugar content, portion sizes and purchases in three exemplar food product categories following implementation of the SRP in England. It also explored the extent to which existing products were reformulated and new products created. Based on available data the study focused on products purchased for consumption within the home, as opposed to out of home settings.

I have summarised the results of these studies individually in Chapters 6, 7 and 8. This discussion chapter includes a critical reflection and interpretation of key results from across all three studies, and considers implications to the SRP in England and sugar reformulation policy more broadly. It also sets out the strengths and limitations of the studies within my thesis, key considerations for future policy implementation and highlights research gaps that still need to be addressed.

9.2 Impact of voluntary reformulation policy on the sugar content of products, sugar purchases and sugar consumption

Studies 1 and 3 considered the impacts of voluntary reformulation policy on the sugar content of products, sugar purchases and sugar consumption. Study 2 examined policy

impacts in relation to voluntary salt reformulation policy in England, and the results of this study are drawn upon with a view to learning from and applying previous experience from salt to voluntary reformulation policy targeting sugar.

Results of Studies 1 and 3 suggest that **voluntary reformulation policy may lead to small reductions in the sugar content of some products included** in an overall policy. Although still modest, reductions in sugar content were greater in certain product categories and within the in home (compared with out of home) setting, suggesting policies may have a particular impact on certain products and settings. Study 1 reported small overall reductions in sales-weighted mean (SWM) sugar content of products within in home settings ranging between -2.2% and -5.2% (100, 137, 138) with greater reductions reported for breakfast cereal products, yoghurts and fromage frais and pre-packaged milk-based drinks (100, 114, 124, 125, 137). No changes in sugar content were reported overall for food products sold in out of home settings (100). Study 3 (Chapter 8, Section 8.2) showed no evidence of change in sugar content of all products included in the analysis (-0.40g/100g, -0.86%, p = 0.301). However, when broken down by product category, there was evidence of a modest reduction in the mean sugar content of breakfast cereal products (-1.73g/100g, -9.5%, p < 0.001) and in the sugar content of single serve chocolate and sweet confectionary products (-1.32g/100g, -2.43%, p = 0.017).

In relation to **change in sugar purchases or sales** (examined in Studies 1 and 3), results were mixed, although indicative that voluntary reformulation policy may lead to small reductions in sugar purchased. Three studies included in my systematic review (Study 1) examined changes in sugar purchases or sales. Two of these studies reported a reduction in sugar sales per person (or per capita) per day of -3.6% (137, 138) ranging and -7.5% (111) over different timeframes, for different policies and products. A third study reported on total (not per capita) volume purchases (described within the study as sales), and results varied over time (100, 114, 124, 125), however, it is understood that this was due to growth in the Great British population over the timeframe of the analysis as well as changes in purchasing due to health protection measures in place during COVID-19 pandemic and the results are therefore difficult to interpret. My own analysis of sugar purchases conducted within Study 3 found no evidence of change overall in total volume of sugar purchased between 2015

and 2018 but this will also have been impacted by changes in the Great British population over the same timeframe.

Change in intake of sugar resulting from implementation of voluntary reformulation policy is yet to be examined, as no studies with this outcome were identified within my systematic review (Study 1, Chapter 6, Section 6.2). Modelling studies have estimated the potential impacts of reformulation on sugar intake to be between 0.2g/day and 62.1g per day in different reformulation scenarios (83) so it is possible that the changes in sugar content and purchases of products that were observed in England have impacted intake of sugar. This is yet to be empirically tested. As previously reported in Chapter 3, Section 3.2.1, modelling underpinning the SRP estimated a potential reduction in sugar intake of as much as 26g/day, however this was based on a 50% reduction in the sugar content of food products which is considerably higher than the 20% guidelines and the modest reductions in sugar content of products that was observed.

Changes in intake of sugar could be assessed with data from the Health Survey for England or the NDNS as was the case for the salt reformulation policy. The NDNS collects data on intake of free sugars in England and this could have been used to monitor changes in population sugar intake following initiation of the SRP. The most recent results from 2016/2017 to 2018/2019 reported that sugar intake was lower in children and adults than it had been in 2014 to 2016 (181). The NDNS data have also been used to examine change in intake of SSBs (181) reporting reductions intake which likely contributed to the overall reduction in sugar intake (SSBs were targeted through the SDIL rather than the SRP). Changes in sugar intake could also have occurred due to other factors, for example the Change4Life Sugar Smart Campaign that was also launched in 2016 (88) or wider media interest at the time. Further work is needed to determine the explicit contribution of voluntary sugar reformulation policy to changes in population intakes of sugar. Evidence from voluntary salt reformulation policy (as described in Study 2, Chapter 7) estimated that salt intake reduced by up to 16% during implementation of the policy, although the extent to which the policy had an impact on intake varied over time depending on the approach to, and context of, policy implementation. It will be important for both implementation and impacts to be assessed in future policy focused on sugar.

There has been very little consideration of inequalities. The most recent progress monitoring report for the SRP suggested that for the most part any percentage reductions in SWM sugar content of products were similar regardless of a household's socio-economic groupings (100) and this is consistent with the limited studies previously conducted for salt and trans-fats (Chapter 1, Section 1.2). A study of household sugar purchasing between 2014 and 2017 which also used data from Kantar FMCG suggested there had been no changes in socio-economic inequalities relating to sugar purchases during the first two years of policy implementation (182) although the authors also reported that lower socio-economic status households purchased more sugar from less healthy products compared with higher socio-economic groups. With this in mind, if reformulation were to target particular products there could be the opportunity to reduce inequalities in sugar purchasing.

9.3 Expected versus alternative approaches to reformulation

In Study 3 (Chapter 8, Section 8.2) I found that the small reductions in sugar content of products were partly due to reformulation of existing products and partly due to changes in product portfolios (the creation and discontinuation of products). There was evidence of a -9.5% reduction in mean sugar content of breakfast cereal products overall (from 18.21g/100g in 2015 to 16.48g/100g in 2018, -1.73g/100g, $p < 0.001$). When examining products available each year to isolate reformulation of existing products, the reduction in mean sugar content of breakfast ceral products was lower at -4% (from 17.34g/100g in 2015 to 16.59g/100g in 2018, -0.75g/100g, $p < 0.001$). This suggests that the remaining reduction in sugar content was due to changes in product portfolios (i.e. discontinuing higher sugar products or introducing lower sugar products). Similarly, the overall reduction in sugar content of single serve chocolate and sweet confectionary products (from -54.36g/100g in 2015 to 53.04g/100g in 2018, -1.32g/100g, -2.43%, $p = 0.017$) was not apparent when examining products available each year, suggesting the overall sugar reduction was due to changes in product portfolios rather than reformulation. These results are consistent with a French study examining changes in sugar content of breakfast cereals, crisps, biscuits and cakes, and SSBs following industry-led reformulation initiatives (115). This study however, reported that changes in product portfolios contributed to increases in SWM sugar content

of products, counteracting reductions in SWM sugar that had occurred through reformulation (115).

As part of Study 2 (reported in Chapter 7) I identified one study which examined the extent to which existing products had been reformulated (as opposed to changes made to product portfolios) in relation to salt. In their analysis of the sodium content of products during the implementation of salt reformulation policy in England, Gressier et al. (2021) reported that most of the change in sodium content of products was due to reformulation as opposed to changing product portfolios, which contributed to only a small amount of the overall sodium reduction (143). This is contrary to my observations just described in relation to sugar, where a larger proportion of the reduction in sugar was due to changes in product portfolios. There is need to examine this across all product categories, but also to consider why this is the case. For example, it could be due to a lack of technical support or guidance for industry in reformulating the sugar content of products, lack of policy direction towards reformulation (see the paragraph below) or concerns around consumer perspectives towards reformulated products. All of these issues were addressed as part of the salt reformulation policy.

Although the reformulation of existing products was set out as the preferred approach in policy guidance, creation of new lower sugar products in response to the SRP was also anticipated (96). Whilst the results of Study 3 (Chapter 8, Section 8.1) suggested that around one third of products in the dataset were new in either 2017 or 2018, my analysis showed that these products were higher rather than lower in sugar when compared with continued products. I also found that one fifth of products were discontinued in 2017 or 2018, and that these were higher in sugar than continued products. The reason for this is unclear as the opposite might have been expected if industry were looking to bring down the sugar content of their products overall.

The concern here is that the impacts of product reformulation are overridden by concurrent changes in product portfolios, where new higher sugar products are created and / or lower sugar products discontinued. Certainly, this has impacted on the extent to which sugar is available in products purchased overall. However, the impact on sugar purchased and consumed is heavily dependent on consumer preferences. If new higher sugar products are created, consumers would still need to switch away from their usual purchases of

reformulated products to purchase a new higher sugar product. This may occur if a product is marketed or promoted by industry or there are changes in relative prices.

Whilst industry may engage in reformulation to meet their social responsibilities (30, 120), the commercial sector is ultimately driven by profits. Industry may therefore respond to reformulation policy by creating and marketing new lower sugar products in order to increase profits. On the other hand, in considering the commercial determinants of health as set out in Chapter 1, Section 1.4, industry may make minimal changes to existing products in order to suggest they are responding to the policy to avoid further legislative or mandatory policies.

9.4 Implementation of voluntary reformulation policy

Implementation of voluntary reformulation policy was primarily explored within Study 2 of this thesis and in relation to salt (see Chapter 7 for results of this study). Some of the primary studies included in my systematic review (Study 1, Chapter 6) included information about implementation and these results are also drawn upon within this section.

9.4.1 Intake targets, reformulation targets and progress monitoring

Study 2 (Chapter 7) described the role of intake and reformulation targets within England's salt reformulation policy and monitoring of progress against these. The policy was underpinned by scientific evidence on the associations between high intake of salt and high blood pressure collated by SACN, data on the excess population intake of salt in England and analysis of the products that contributed to this. A population intake target was set initially at 6g salt per day in 2003, then changed to 7g per day in 2019. Reformulation targets were set across a range of products and product categories, developed through consultation with stakeholders and published. Each of these elements also underpinned the SRP although they were used in slightly different ways. The population intake target for sugar was set as a proportion of total dietary energy intake (less than 5%), and a reduction in SSB consumption was recommended. It is unclear specifically what role the intake targets have in policy implementation, and whether the different approaches used might impact on this. It is likely that they are more important in making the case for policy action and setting an overall

vision for change although they do also allow for progress to be assessed and provide a clear and measurable outcome for evaluating policy success in the longer term. Neither intake targets for salt nor sugar have been met, and this does not appear to have been used to prompt any further government intervention, however the reduction in population salt intake observed following the FSA phase of the policy was considered a success.

Salt reformulation targets were set for 48 product categories (Chapter 7.3) using both average and maximum targets, and these were revised during the course of policy implementation. Within the SRP (Chapter 2, Section 2.2) sugar reformulation targets were set for ten food product categories initially, increasing to 21 with the inclusion of milk-based drinks and juices in 2018 (Box 1, p.29). Sugar reformulation guidelines differed to salt, in that mainly average guidelines for sugar reduction were established. Maximum guidelines were proposed only for calories in single serve products, and this was combined with an average target. Gradual reformulation targets were set at the outset of the policy (5% reductions each year, up to 20% after four years) and these were not re-assessed during policy implementation. In their study of voluntary policy to reduce the sugar content of SSBs in Germany (reported on in Study 1 of this thesis, Section 6.1.4), one target was set for a 15% reduction in the sugar content of SSBs over 6 years (138). It is worth considering if there is an optimal approach to the setting of targets, for example if they are more useful when set incrementally and revised over time as per the approach taken with salt (66) (although this really only happened during the FSA phase of the policy) and for a large number of specific product categories or a smaller number of broad product categories. Most likely, it is more important that they are an active component of policy implementation and used to engage with industry and to encourage broader engagement and further reformulation.

Targets also enable progress monitoring. Progress monitoring was embedded in delivery of the salt reformulation policy and is a central feature of the SRP, although with a focus on reformulation as opposed to intake targets. With the exception of the RD phase where industry progress was self-reported, progress against salt targets was monitored by the arms-length body responsible for policy implementation using independent data. This approach has also been adopted within the SRP to monitor progress against sugar reduction guidelines. Independent and transparent monitoring of progress reduces the potential for

bias and can provide detailed insight into where progress is, or is not, being made in relation to products and businesses. Beyond this, it would be helpful to understand if or how progress monitoring is or could be used to inform further government intervention and what that might be. My analysis of salt reformulation policy (Study 2, Chapter 7) suggested that, in the FSA phase of implementation at least, progress reports were used to 'name and shame' businesses making insufficient progress and this approach was described as an important implementation strategy (66). Although it was unclear how this was conducted and whether it increased the extent of salt reformulation. Within the SRP progress monitoring reports businesses could only be named with their permission so business-level progress was only partially reported. This could have hindered the potential for progress monitoring reports to encourage further engagement by industry, although not if PHE were to use the information for less public encouragement and the type of 'soft regulation' used by the FSA in implementing their salt reduction targets.

9.4.2 Legislative approach to delivery of reformulation policy

Study 2 (Chapter 7, Section 7.2) also considered the legislative approach to delivery of the salt reformulation policy, suggesting that voluntary reformulation policy is most effective when targeting a single nutrient and when other policies to encourage reformulation are also in place. Salt reformulation policy in England was initially implemented as part of a structured salt reduction programme which also included a marketing campaign and food labelling policy. Evidence considered within Study 2 (Chapter 7, Section 7.3) suggests that this phase of the policy was effective in reducing population salt intake and that the combination of policies in place were an important driver of this. During the RD phase, when salt reformulation policy was absorbed into a much wider programme focused on a range of public health topics, the reduction in population salt intake slowed. During the PHE phase it became part of a wider reformulation policy which focused on calories and sugar as well as salt, but where the priority focus shifted to sugar. This phase has not been evaluated.

Evidence examining implementation of salt reformulation policy was lacking across all phases, so it is difficult to determine with any certainty the extent to which the legislative approach was important over and above any other factors. For example, when the policy was absorbed into the RD there were changes in leadership and governance of the programme that may also have reduced policy impacts. That said, the policies implemented

alongside salt reformulation policy during the FSA phase are complimentary and there is sound logic that the combination of policies would lead to a greater combined impact. Studies have shown that food labelling can lead to product reformulation and improved diet (183). Mass media campaigns lead to consumer awareness which can improve demand or acceptance of the policy. This is also consistent with prior studies described in Chapter 3, Section 3.2 of this thesis which suggest that reformulation policies are more effective when implemented alongside other policies (26, 119). It is likely that the coordinated delivery of several policies focused on salt reduction contributed to the success of that phase. It is also possible that initial reformulation is easier to achieve and that other implementation factors were important, including wider political context and the exclusive focus on salt.

Chapter 2, Section 2.1 describes the broader policy landscape in relation to sugar reduction in England. The SRP was also implemented alongside a multi-component marketing campaign (Change4Life) to build public awareness of sugar as a public health issue and products contributing to sugar intake, although with a focus on children (salt policy focused on the population) as per policy context at the time. An evaluation of the marketing campaign reported an initial 2% reduction in the total contribution of sugar to energy intake among children although this was not maintained at 12 month follow up (88) (the sugar content of products was not examined as part of the study). Legislative policy was also used concurrently to reduce the amount of sugar in SSBs via the SDIL and there were also additional reformulation policies in place targeting calories and salt. It is possible that these multiple expectations on industry (from the reformulation policies and the SDIL) inhibited progress in sugar reduction for products included in the SRP. Although, as noted in Chapter 3, Section 3.3.2 of this thesis, industry participants in an evaluation of a reformulation policy in Norway had valued the coordination that came with focusing on multiple elements of diet at one time and from an industry perspective there would be efficiencies in reviewing the nutrient content of a product as a whole at one point in time rather than having to make changes to different products at different time points. It is more likely that the legislative approach used for SSBs is more effective than the voluntary approach used within the SRP in reducing the sugar content of products.

In Study 1, Chapter 6, I did not identify any studies involving mandatory reformulation policies for reducing sugar. As policies currently being developed in other countries are

following similar voluntary approaches to the SRP (see Chapter 1, Section 1.3 of this thesis) it is unlikely that new evidence will be generated in coming years. This is despite studies on salt and trans-fats suggesting that mandatory approaches are more likely to be effective than voluntary alternatives (26, 28, 117, 119) (Chapter 3, Section 3.2.1) and the increased preference for mandatory policies in relation to salt and trans-fats globally (35). It has previously been suggested that mandatory or regulatory reformulation policies may be viewed as 'unacceptable' from a commercial or political perspective, due to opposition from industry and other stakeholders (28). A qualitative study involving small to medium food companies, however, revealed support for the use of regulation to help 'create a level playing field' (110). The study suggested it can be difficult for companies to reformulate when others do not, for example due to concerns that consumers might switch products, and in fact the use of regulation by government can support industry reformulation efforts (110). The study also reported that voluntary agreements were seen by industry to have limited effect on reformulation within companies. That said, evidence I examined as part of Study 2, Chapter 7, Section 7.3) suggested there is a point whereby voluntary reformulation policy can almost become mandatory for industry due to regulatory approaches in place (the FSA phase of policy implementation) and that under these conditions industry will respond to the policy.

9.4.3 Technical considerations

As part of Study 2 (Chapter 7, Section 7.2) I found evidence to suggest that gradual reductions in the salt content of products was considered technically feasible and that variations in salt content of products showed the extent of salt reduction that could be achieved. With this in mind, the primary mechanism encouraged for reformulation was salt reduction, with a view to gradually reducing the 'saltiness' of products. At the request of industry, government commissioned an independent expert committee to consider the potential for replacement strategies (in particular, the use of potassium in place of salt) reporting that benefits of these would outweigh risks. Whilst not the preferred mechanism from a public health perspective, an increase in replacement strategies for salt was reported by PHE in 2015 (specific strategies and extent of this not reported) (113).

Different technical approaches to reformulation have been proposed for different nutrients. In relation to salt, guidance has focused on salt reduction citing evidence that large

reductions in salt content can be made (as much as 40% to 50%) without being detected by consumers if this is done gradually, as taste receptors will adjust over one to two months (38). In relation to trans-fat, guidance has focused on replacement and the optimal approaches to this for different products (37). Clear guidance on the preferred approach to sugar reformulation has not been released, and guidance underpinning the SRP acknowledges that multiple approaches may be needed (96, 113). Prior to initiation of the SRP, PHE examined evidence on 'sweetness' considering a broad body of literature. The evidence highlighted that preference for sweet products is innate, however no conclusions were drawn regarding the potential to adjust consumer tastes through gradual sugar reductions due to a lack of evidence (113). PHE also noted the environmental differences between salt and sugar, in that artificial sweeteners were already commonly used to replace sugar as means of calorie reduction (113). A recent systematic review suggested it is feasible to reduce the sugar content of certain products (an example was fruit juices, by up to 20%) without replacement strategies and without affecting consumer preferences (184). There is a need to examine this fully across all product categories.

In relation to sugar, successful reformulation involves the removal of sugar whilst retaining other key attributes such as texture, taste and cost (184, 185). It is possible to replace sugar whilst retaining sweetness through the use of alternative sweeteners however further product formulation is needed alongside this to ensure that other functional and sensory functions are retained (184). With that in mind, it has been suggested that replacing sugar is easier for liquid than for solid products (184). The soft drinks industry has successfully replaced sugar with the creation of low or no calorie soft drinks. This has likely contributed to the success of the SDIL in England where by 2020 the SWM sugar content had reduced by almost half (100), although an evaluation of voluntary sugar reformulation policy focused on SSBs in Germany (identified and reported in Study 1 of this thesis, Chapter 6) reported a much smaller sugar reduction in sugar content resulting from the policy (a -2% reduction in g/100ml SWM sugar content between 2015 and 2021, compared with a -29% reduction in g/100ml SWM sugar content of SSBs in England) (138). This could corroborate evidence from salt and transfats that legislation is more effective than voluntary policy, although there was already consumer acceptance of low-sugar SSBs before the policy was initiated.

As introduced in Chapter 1, it is important to recognise the concerns that have been raised in relation to artificial sweeteners (42), and the potential health harms that may result from their over-consumption. There is a risk that continued and increased use of artificial sweeteners as a replacement strategy for sugar reduction by industry may lead to future health issues, and that health risks from artificial sweeteners could outweigh the risks associated with sugar consumption. There is also a risk that the potential health harms associated with artificial sweeteners could be used as a reason for industry to evade further reformulation. Industry will need to develop alternative reformulation strategies that enable sugar reduction without the use of artificial sweeteners, and government will need to implement policy and guidance that encourages this. Future research will need to consider the extent to which sugar is replaced with artificial sweeteners as a means to reduce sugar content and the potential health implications of this.

The SRP proposed reductions in portion sizes as a reformulation mechanism for single serve confectionary products, acknowledging that it would be technically difficult to reformulate sugar content of these products, but set guidance (and monitored progress) using calories. I examined change in portion sizes within Study 3 of this thesis (Chapter 8, Section 8.3) and found no evidence of a change in the portion sizes of single serve products based on their weight (in grams) per serving. My results were consistent with SRP progress monitoring reports (reported in Study 1, Section 6.1.4) which showed no change in SWM calorie content of single serve products, despite targets having been set for calorie reductions (100, 114, 124, 125). In my systematic review (Study 1) one study had examined change in the sugar content per portion of products reporting a large reduction in the sugar content per portion of ice-cream products sold in restaurants. Pepper et al. described how a particular technique had been used to reduce the gram weight of the portion (and thus the amount of sugar per portion) whilst maintaining the visual size of the portion (136). This suggests that some novel techniques may exist for reducing the sugar content of products, although there is a further need to consider the impact on sugar intake.

9.4.4 Wider contextual factors influencing policy implementation

Study 2 (Chapter 7, Section 7.2.2) highlighted the importance of leadership and governance in implementation of salt reformulation policy. This included, for example, the role of 'influential politicians' and advocacy groups in policy initiation. It also showed that changes

in government impacted on how the policy was governed and implemented, which most likely contributed to reductions in impact (in relation to population salt intake) that were reported over the longer term. Whilst there have been no changes in political party since the announcement of the SRP, there have been multiple changes in leadership within government (described in Chapter 2, Section 2.4). These changes bring different views, priorities and perspectives which could have influenced the level of support for the SRP and its delivery or distracted teams involved in policy implementation.

There have also been major changes to the public health landscape resulting from the COVID-19 pandemic, and the public health issues being prioritised. Public Health England (PHE), the national public health authority and the organisation responsible for delivery of the SRP was dissolved, and the SRP was moved into the Department of Health and Social Care (DHSC). Whilst these changes largely occurred following the completion of the SRP timeline (it was due to finish in 2020) they could lead to major changes in how the SRP is delivered in future. Government priorities have shifted. A Major Conditions Strategy is currently under development focused on cancers, cardiovascular disease, chronic respiratory disease, dementia, mental ill health and musculoskeletal disorders. Whilst this makes the case for action on primary prevention it also focuses on secondary prevention as well as early diagnosis, early intervention and treatment. Work with industry on sugar reformulation is mentioned in an interim report setting out government's strategic case for action (186), but the extent of commitment will be made clearer when the strategy is published in Summer 2024.

England's salt reformulation policy, particularly in the early phases, was accompanied by broader support in the form of advocacy work from CASH, NICE guidance for cardiovascular disease which included a recommendation on salt reduction and global leadership from the WHO, who in collaboration with the FSA convened an expert meeting on salt reduction (including food industry representation) which resulted in technical guidance being published on effective salt reduction. In 2013, WHO member states committed to achieving a "…30% relative reduction in mean population sodium intake by 2025, with a goal of <2000mg/day sodium" (187). This wider context may have contributed to the sustained implementation of salt reformulation policy in England. There has been some advocacy work in relation to sugar via CASSH which was launched in 2014 as an expansion of the

action on salt group 'CASH' previously described (188), Sustain (a recent sugar smart campaign for example (189)) and the Food Foundation.

There has also been some global leadership from WHO in the form of intake guidelines issued in 2015 (11, 12). In January 2022, the WHO announced the launch of a new sugar and reduction network to be led by the UK over the first three years (190). A first meeting was held in October 2022 where five elements of sugar reduction were discussed (191). This included the use of targets for industry reformulation, fiscal levers, marketing and advertising, front-of-pack labelling, and the out-of-home sector. A detailed discussion on UK experiences of implementing voluntary reformulation policy is not described, and no further information on progress with the network is publicly available. Further advocacy and leadership for sugar reformulation may provide some support for further implementation.

9.5 Strengths and limitations of the studies included in this thesis

This DrPH thesis involved three studies using different research designs to critically examine the potential role of voluntary reformulation policy. It is the first in-depth study of this type of policy with a focus on sugar, and the results can be used to inform future policy in this area. There are a number of strengths and limitations with my work, described here in relation to each study.

Study 1 provided an up-to-date synthesis of global evidence with a specific focus on reformulation policies targeting sugar in real world settings across all potential outcomes and publication types. Building on previous systematic reviews ensured that my work added to the existing evidence base, and focusing exclusively on reformulation policy and sugar-related outcomes enabled a detailed examination of the evidence base specific to the policy of interest. The inclusion of empirical studies only (with modelling studies excluded) ensured that the results reflect the impacts of sugar reformulation policy in the real-world as opposed to the outcomes that could potentially be achieved under certain conditions.

That said, this study did have some limitations. Had I included modelling studies, I may have identified more recent studies that provided new evidence that has yet to be examined, for example comparing the potential impacts of voluntary reformulation policy including in

comparison with mandatory policies. There may have been value in including studies of industry-led reformulation to draw comparisons between industry- and government-led approaches, although there is the potential for multiple forms of bias towards showing positive impacts of industry-led reformulation. In applying GRADE, I focused on overall results which meant that results specific to certain categories of products (for example, where there were larger and statistically significant effect sizes as described in Section 9.2 of this Chapter) were not considered. That said, the application of GRADE to product category sub-groups is unlikely to have affected the certainty ratings. Results would have been rated very low certainty due to the small number and quality of studies, regardless of effect size.

Study 2 utilised evidence on the implementation of voluntary reformulation policy targeting salt intake in England to overcome the lack of evidence exploring this in relation to sugar policy. The use of existing published evidence allowed me to examine the policy approach without replicating prior research. Given the similarities between the salt and sugar policies in England, and the lack of implementation evidence on the SRP, understanding of salt reformulation policy implementation was a useful way of understanding potential issues or enablers in implementing the SRP and related policy approaches.

In considering limitations, I relied on studies focused exclusively on the salt reformulation policy and accompanying references and did not draw on the wider available evidence, for example on the effectiveness of the Responsibility Deal (RD) more broadly or on the role of industry partnerships in government policy. My search, whilst structured, was not systematic meaning that some key studies may have been missed. Although a systematic search was not appropriate for this study due to its exploratory nature and the snowballing approach helped to identify studies or records not identified via electronic database searches. There were limitations with available evidence. The majority of studies were focused on the FSA phase of the policy which concluded in 2010, and all published papers describing implementation were written as narratives without any methodology. No formal process evaluation appears to have been conducted. Many of the authors of included papers were involved in CASH, or organisations involved in policy delivery. There have been no evaluations of the PHE or OHID phases of the policy so my insight from these phases was limited.

Study 3 built on existing studies focused on the impacts of the SRP through examining the extent of changes in sugar content of products within product categories, in terms of the number of products reformulated and levels of reformulation. This is important for understanding the extent of reformulation efforts but also the potential feasibility of reformulation in certain products. I explored whether industry had followed the expected or an alternative approach to reformulation of products (39) through looking at new, continued and discontinued products. Based on the levers proposed for industry in SRP guidelines, this study included a detailed analysis of the portion sizes of single serve products. This had been monitored by PHE based on calorie content, but the portion sizes and sugar content of these products had not previously been examined.

This study also had methodological limitations. The Kantar FMCG datasets used within this study are 'shopping basket' data, meaning they only include data for products that have been purchased by the consumer panel, so it is possible that some reformulated products were not included in the dataset. This is an issue for all studies relying on consumer panel data and is likely a minor issue as the panel is so large. The collection of nutrition information by fieldworkers was dated only when nutrition information had changed, so it was not possible to identify product data that had been checked and had not changed or was not checked. This could have affected results in either direction. I used product code to identify new, discontinued and continued products. Product code is based on product barcodes which can change when changes are made to a product (for example, a change in packaging or due product reformulation). If major reformulation of sugar content did lead to a change in product code, this would have been captured as a new product as opposed to reformulation of an existing product. My analysis used data from 2015, 2017 and 2018 based on availability of data when I started this study and more recent data are now available. My study does not consider the full timeframe of SRP implementation so may not capture the full extent of changes (or any slowing or reversal of these) in the longer term. On the one hand it is possible that two years was insufficient to capture the full extent of product reformulation which may have continued over time. On the other, it is possible that immediate response to the policy was not sustained. In addition, I examined products purchased for in home consumption only. As the policy also includes the out of home sector, this provides only a partial perspective on SRP impacts.

9.6 Considerations for implementation of voluntary sugar reformulation policy

There are number of considerations for the future implementation of voluntary sugar reformulation policy:

i) Evidence on the associations between sugar and health, population sugar intake and the contribution of certain products to sugar intake is needed to support initiation of voluntary reformulation policy and the setting of targets to reduce the sugar content of these products. Whilst not the sole (and perhaps not the most important) driver of policy initiation, this evidence can help to make the case for action.

ii) Reformulation targets are considered a central feature of voluntary reformulation policy and have previously been set based on data as described in point 1 above and with input from stakeholders. The latter helps to ensure buy in from stakeholders and that the targets are feasible. Targets should enable the gradual reformulation of sugar over time, whilst also being ambitious enough to impact on population sugar consumption. It may be necessary to set different targets for different product categories and sub-categories (based on technical feasibility) and to revise these regularly based on progress.

iii) Progress monitoring ideally involves the use of independent data and analysts (as opposed to industry self-reporting for example) to assess the extent to which the sugar content of products is reducing and check progress against targets. The data should also be analysed to determine the extent to which existing products are being reformulated, new lower sugar products are being created and higher sugar products discontinued. Identification of the extent of reformulation within product categories and the levels of business engagement can be used to develop further implementation strategies. Population intake of sugar should also be monitored.

iv) It is important to determine what strategies might be used to reformulate the sugar content of different product categories whilst maintaining key product features. It is also important to consider the maximum amount of reformulation that is possible. Reformulation of existing products should be encouraged. Strategies may include sugar

reduction, sugar replacement or combinations of these. Guidance could be developed to enable the use of similar reformulation approaches across product categories. It is important to consider potential unintended consequences, for example in the use of replacement strategies bearing in mind growing concerns around the use of artificial sweeteners.

v) Consumer acceptance of a reformulated product is important to ensure there are no changes in purchasing. Gradual reduction was considered feasible for salt based on evidence that consumer taste would quickly adjust to products being less salty. This also needs to be examined further in relation to sugar.

vi) Where voluntary reformulation policy is implemented, it is important to consider the potential for other complimentary policies to be used in addition to this or to ensure alignment with other policies or programmes already in place – particularly those such as food labelling and consumer awareness policies that can also lead to product reformulation. Impacts of voluntary reformulation policy are likely to be greater when supporting policies are in place.

vii) Political support is important in initiation and sustained implementation of voluntary reformulation policy, and this can be influenced by a range of stakeholders. Appropriate framing can help to harness political support. For example, the SRP was framed as tackling childhood obesity based on political interest at the time, however its approach targets sugar consumption among children and adults. That said, the policy should ideally be led from outside of central government to ensure clear and transparent governance and protection from the influence of industry and other stakeholders.

viii) It is important that a suitably resourced policy team is in place to deliver the policy, working to a transparent implementation plan. This should set out when and how routine progress monitoring will take place, but also the ways in which progress monitoring will be used to encourage reformulation across a sufficient breadth of products, product categories and businesses. This could include, for example, examination of the technical feasibility of reformulating certain products or

identification of effective reformulation approaches that have been used. Continuous engagement with stakeholders should be built into policy implementation and informed by progress monitoring.

ix) The potential role of mandatory reformulation policy for targeting sugar consumption is unclear. On the one hand, concerns have been raised that a mandatory approach could be rejected by industry but on the other a mandatory approach can help to ensure a level playing field for industry. It is possible that a mandatory approach may be useful to build on progress following voluntary guidelines, and where it is clear what levels of reformulation are feasible and the technical approaches that can be used. The use of fiscal policies should also be considered.

x) It is essential that evaluation is embedded within policy implementation. In addition to examining policy impacts, it is important to evaluate implementation strategies described above and to learn from policy implementation. Suggestions for research and evaluation are described below in Section 9.7.

It is also important to consider the opportunity costs of reformulation policy implementation and the evidence relating to this type of policy. The results of my thesis suggest that voluntary reformulation policy may lead to only modest reductions in the sugar content of products included in the policy although there is the potential to improve this using certain implementation strategies. Wider evidence set out in Chapter 3, Section 3.2 suggests that mandatory reformulation and fiscal approaches are likely to be more effective than voluntary reformulation. Directing resources towards implementation of voluntary reformulation policy instead of these other approaches may be determinantal to population health. Clear messaging around the likely impacts of voluntary reformulation policy is needed to ensure appropriate and efficient policy decisions can be made.

9.7 Future research

Further research is needed to strengthen the evidence base relating the potential impacts of voluntary sugar reformulation policy, and to fill evidence gaps relating to policy implementation. In particular:

i) Comprehensive and rigorous research studies are needed to evaluate the impacts of voluntary reformulation policy based on current, or recent, policy implementation. Outcomes of interest would include changes in the sugar content of all categories of products included in the policy, consumer purchases of sugar from these products and sugar intake.

ii) Evaluations of implementation are needed, embedded within impact evaluation as described in point 1 above, and used to understand the reach of policies, implementation strategies (by government and industry) that work well or less well and satisfaction with these, and acceptability of reformulation policy among industry and consumers. An existing process evaluation framework such as the MRC framework for process evaluation of complex interventions (192) should be used to ensure implementation is comprehensively examined.

iii) In relation to policy implementation, as well as standard process evaluation described in point 2 above, more detailed research would be useful in relation to:
   - Understanding the technical feasibility of reducing the sugar content of certain product categories and types of reformulation strategies used,
   - Extent to which sugar is replaced with artificial sweeteners as a reformulation approach and the potential health harms of this,
   - Government implementation strategies to encourage further and sustained reformulation by industry,
   - Perspectives on voluntary versus mandatory approaches to delivery of sugar reformulation policy.

iv) Studies have estimated the potential impacts of reformulation on population intake of sugar. There would be value in conducting further research to estimate the impacts of

sugar reduction achieved through implementation of policies, specifically as observed within the SRP, on population sugar intake and associated health gains.

v) There would be value in examining the relative investment in voluntary reformulation policy as compared with other policy approaches targeting sugar, to ensure that funding and resources are being spent in the most cost-effective way.

In conducting this thesis, I have also uncovered a lack of robust evidence underpinning current voluntary reformulation policy in England targeting salt. The areas of research proposed here could also benefit further implementation of salt reformulation policy in England as well as reformulation policies targeting other nutritional issues.

10. Conclusions

This thesis has identified evidence to suggest that voluntary reformulation policy has the potential to achieve modest reductions in the overall sugar content of food or drink products in Great Britain. Robustly implemented reformulation in a few, selected product categories may close to, or exceed, the 20% reduction guidelines of the SRP. Available evidence globally on the impacts of reformulation remains limited due to the small number of studies and methodological weakness in these. This thesis did not analyse primary data on sugar intake. The existing literature, which mostly reports on modelling studies, suggests that the effect of voluntary reformulation in isolation is likely to be modest, and consistently smaller than several other policy interventions. Product categories (within the in home sector only) with largest (albeit still modest) reductions in sugar content include breakfast cereal products, yoghurts, sweet spreads and sauces and certain milk-based drinks categories. Other product categories (chocolate and sweet confectionary for example) made only small reductions in sugar content although there were examples of relatively large sugar reductions in small numbers of products. There is now a need to understand how and why sugar reformulation has been possible for certain product categories and not for others, with a view to expanding reformulation policy impacts.

From a public health perspective, reformulation should involve the gradual replacement of sugar in existing products as opposed to the creation of new, lower sugar products. The former requires industry to make gradual sugar reductions whilst maintaining other important product features, such as texture and taste, and ensuring that consumers continue to purchase the reformulated product. The latter requires consumers to change their behaviour in order to benefit from the lower sugar product. No previous studies have examined the approach to reformulation in relation to sugar. My exploratory analysis (Study 3) suggested that changes in sugar content of products were only partially due to the reformulation of existing products, with some changes due to the creation and discontinuation of products. Further research is needed to determine the extent of this across a broader range of product categories, as the approach is likely to impact on any further changes in sugar intake.

There are some explicit strategies involved in the implementation of voluntary reformulation policy. For example, reformulation targets for products with the greatest contribution to intake of a particular nutrient, and transparent progress monitoring of these. These were described in reformulation frameworks that underpinned the implementation component of this thesis and could also be identified within the delivery of both the salt and sugar reformulation policies in England. Attention needs to be given to the optimal approach to setting targets and the use of these to drive further reformulation. For example, to look at product categories that are not being reformulated, work with stakeholders to understand why this is, and consider technical approaches that might enable reformulation. Or, to identify and work with specific businesses or sectors of industry that are not engaged. Application of the regulatory approaches used by the FSA during the initial phase of England's salt reformulation policy should be considered.

Evidence from implementation of salt reformulation policy and from previous studies of policies targeting salt and trans-fats suggests that voluntary reformulation policy will have the greatest impact when implemented alongside other policies focused on reformulation. This needs to be considered during policy development. Multiple policies were proposed at the same time as the SRP, and as per England's approach to salt reformulation policy a marketing campaign focused on sugar was implemented during the early stages of the SRP and guidance to support nutrition labelling. Reformulation policy is also influenced by wider factors, for example political support, leadership and resourcing, and these will also need to be managed during the course of policy implementation. Policy focus in England has changed since the COVID-19 pandemic, and this is likely to influence the level of commitment for continued implementation of the voluntary sugar reformulation programme. Certainly, no further targets have been set since the SRP concluded in 2020.

Despite the emergence of voluntary sugar reformulation policies globally, and five years of implementation in England, evidence on the implementation and impacts of this type of policy remains limited. The lack of any comprehensive, independent evaluation of the SRP is a missed opportunity to generate new evidence based on policy implementation. The reasons for this omission are perplexing given the resourcing that is available for evaluation of similar policies via the National Institute for Health and Care Research (NIHR), and the ready availability of data both on products and population intake of sugar in England. In

conducting a systematic review as Study 1 for this thesis I had expected there to be more studies globally examining the impacts of their sugar reformulation policies over recent years. That said, it is likely that the COVID-19 pandemic impacted both on implementation timelines for some policies, and on planned policy evaluations, and it is possible that additional studies of policy implementation will emerge in time.

Voluntary reformulation is just one potential policy option, directed towards the voluntary reformulation of the sugar content in products by industry. As described in the introductory chapters of this thesis, there are multiple policy options for tackling the food environment and a combination of policies are needed to improve diet and population health in the longer term. Where industry does engage in voluntary reformulation this could be a strategy to avoid legislation. Whilst voluntary reformulation policy may have a role to play in reducing population consumption of sugar, it is very possible that mandatory reformulation and legislation would have a greater impact and that these should be implemented alongside other complimentary policies.

11. Integrating statement

The DrPH course at LSHTM is aimed at future public health leaders. It aims to provide its students with experience in *"understanding and adapting scientific knowledge in order to achieve public health gains, as well as the analytical and practical skills required by managers and leaders in public health"*. The DrPH therefore has a dual focus on developing both expertise to conduct and evaluate research, and skills crucial for leadership roles in public health policy and practice. This chapter describes my learning and experience in relation to all components of the DrPH.

11.1 Taught component

I completed the taught component of the DrPH full-time whilst working at Public Health England (PHE). Having spent a number of years working in government, and training public health decision makers in, evidence-informed public health I was able to use the 'Evidence-based public health' module to consolidate my knowledge across that topic. The 'Understanding leadership and management in organisations' was a new topic for me, where I gained new knowledge and skills through the lectures, the residential and the practical assignment. I found I was able to integrate this knowledge quickly into my role at PHE, for example using stakeholder analysis tools to inform my work.

11.2 Organisational policy analysis (OPA)

I did my Organisational Policy Analysis (OPA) whilst still working at Public Health England, as this was the most feasible and practical way for me to complete this whilst undertaking the DrPH part-time. My OPA focused on the roles and responsibilities of two teams within PHE in supporting the provision of evidence-based public health advice and supporting evidence-informed decision. I examined the internal organisation of these two teams ('Knowledge and Intelligence' and 'Research, Translation and Innovation'), their positioning within PHE and their roles and responsibilities to determine the extent to which these either enhanced or constrained PHE's ability to use or support the use of evidence. This built on my interest and experience in evidence-based public health and knowledge mobilisation and allowed me to continue applying my new knowledge gained through the taught component of the DrPH.

I used knowledge mobilisation theory and organisational management theory to analyse the two teams' combined support for evidence used and developed recommendations to increase PHE's effectiveness in its mandate for evidence-based public health. I focused on a topic that I knew well and already had internal contacts in – obesity prevention – and used a qualitative approach, as I wanted to develop my skills in qualitative research. I shared the results of my work with participants and internal stakeholders and was later able to implement some recommendations in a new role as Head of Evidence and Evaluation in the Research, Translation and Innovation division of PHE.

11.3 Research project and final thesis

My research project provided a further opportunity to consolidate existing research skills and develop new ones whilst maintaining a focus on my interests of public health nutrition and evidence-based public health practice. I examined the role of voluntary reformulation policy in potentially reducing population consumption of sugar – this was a major policy priority in England when I started my thesis planning in 2018/2019. At that time, there was no externally funded evaluation in place and analytical resources within PHE were heavily focused on monitoring policy progress against guidelines. My DrPH research provided me with an opportunity to explore the policy in more depth, examining the existing evidence base focused on the effectiveness of these types of policy, exploring implementation of a similar policy focused on salt reduction, and examining the product datasets used by PHE in a more in-depth way.

In my roles, originally at PHE and now OHID, I have both managed or worked collaboratively with a range of colleagues with different backgrounds. This includes teams of analysts conducting quantitative analysis of large datasets (often at pace) and using particular types of software; teams of evidence reviewers conducting systematic and rapid evidence reviews; and teams working on policy implementation. The studies I conducted allowed me to build new knowledge and skills, or consolidate my existing knowledge and skills, across all of these areas and I hope that this will improve my ability to manage these types of programmes and work collaborations in future. In particular I was keen to improve my quantitative analytical skills. I did this through study 3, learning Stata to analyse Kantar FMCG (formally Kantar Worldpanel). It was also useful to conduct my own systematic

review from scratch again, which I did for Study 1, to apply a structured approach to policy analysis in order to examine how the salt reformulation policy had been implemented (Study 2), and to draw comparisons between the salt and sugar policies in England.

11.4 Personal reflections

It has been challenging working on my DrPH part-time whilst also working in national public health organisations. Although I have been able to tailor my learning to fit with my work, in reality this has not been as straightforward as I had expected. I have changed jobs several times since I started the DrPH, and from March 2020 I spent two years working full time on the national COVID-19 response (which ultimately delayed the completion of this thesis by 2 years). Despite not working in an academic setting, having a doctorate is important for my career progression and I have found the approach taken within the DrPH more appropriate to my style of applied learning. Being able to break the DrPH down into its three components, and then further sub-dividing my thesis into three research studies, helped to make it manageable, kept me interested and focused in a way that I would have struggled with if doing a more traditional PhD. I have found working on my final thesis to be my biggest challenge, pushing me to think about issues in more depth than I am required to (or have time to) in my work. I am also much more accustomed to writing very short policy briefs than an in-depth research project, so I found it hard writing up the thesis and have had to develop new writing skills.

As an employee of PHE / OHID – the organisation responsible for implementing the SRP, but also a colleague of the team leading on policy implementation, there is an inherent conflict of interest that I have needed to manage in conducting this research. On the one hand my role has affected certain choices relating to research design, for example, it would have been infeasible and inappropriate for me to conduct my own qualitative research examining SRP implementation. But it may also have affected my interpretation of results. It was easier to take an unbiased view when analysing the salt reformulation policy (Study 2) as I had not been involved in that work and had very limited prior knowledge of its implementation. For the SRP, I had worked both with and within the team responsible, and perhaps felt more of a need to be careful with my interpretation of results relating to this (in Study 1 and Study 3). Working in government there is always a need for caution when handling evidence and

making recommendations, and this is even more so when dealing with a government policy. Having spent almost ten years now as a civil servant, it was difficult to adopt a more direct, perspective. Discussions with my supervisory team helped with this, as did the discussion with and comments from examiners.

Overall, I have developed my knowledge and skills in research and research methods and the application of these in public health policy and practice. Completing this DrPH is an important step in my career progression.

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Appendices

Appendix 1. Sugar reduction programme guidelines

Table A1a. Guidelines set in 2016 for all ten food product categories included in the policy (adapted from Tedstone et al. (96) Table 2 p.23)

Category	**Baseline sales weighted mean for total sugar (g sugar per 100g)**	**5% sugar reduction guideline (SWM g per 100g)**	**20% reduction guideline (SWM g sugar per 100g)**	**Portion guideline – kcals per serve (single serve only)**	
				SWM	**Maximum**
Breakfast cereals	15.3	14.6	12.3	n/a	400kcal
Yoghurts	12.8	12.3	11.0	120kcal	175kcal
Biscuits	32.8	31.2	26.2	100kcal	325
Cakes	32.8g	31.2g	26.2g	220	325
Morning goods	12.5g	11.9	10	220	325
Puddings	18.8	17.9	15.1	220	450 / 550
Ice-cream, lollies & sorbets	23.2 (13.7)	22.1 (12.8)	18.6 (10.8)	220	325
Chocolate confectionary	54.6	51.9	43.7	200	250
Sweet confectionary	60.6	57.5	48.4	125	150
Sweet spreads & sauces				*Portion size guideline (grams per serve, SWM*)	
Chocolate spread	*54.8*	*52.0*	*43.8*	*15g*	*n/a*
Peanut butter	*4.9*	*4.7*	*3.9*	*15g*	
Dessert toppings / sauces	*48.3*	*45.9*	*38.7*	*15g*	
Fruit spreads	*43.2*	*41.1*	*34.6*	*15g*	

Table A1b. Guidelines set in 2018 for milk-based drinks and juices (adapted from Tedstone et al. (193) Table 1 p.5)

Category	Baseline (g sugar per 100ml)	20% reduction guideline (g sugar per 100ml)*	Sugar allowance (g sugar per 100ml)	Calorie (kcal) guidelines – single serve products
Milk-based drinks				
Milk based drinks (pre-packaged drinks, milkshake powders and syrups[1,2])	9.7g	8.8g	5.2g	300kcal maximum
Coffee and tea powders, syrups and pods[1]	3.7g	3.3g	1.5g	n/a
Hot chocolate and malt drink powders[1]	6.4g	5.6g	2.8g	n/a
Pre-packaged drinks – flavoured milk-substitute drinks	7.1g	6.1g	2g	300kcal maximum
Out of home milk based drinks (including coffee, tea, and hot chocolate)[3]	6.2g	5.7g	3.8g	300kcal maximum
Juice-based drinks		**5% reduction guideline (g sugar per 100ml)**		
Juice based drinks except mono-juice[4]	9.3	8.9		150kcal maximum
Mono-juice such as orange, apple, grape, carrot, tomato (Kantar Worldpanel data only)	9.7	n/a		150kcal maximum

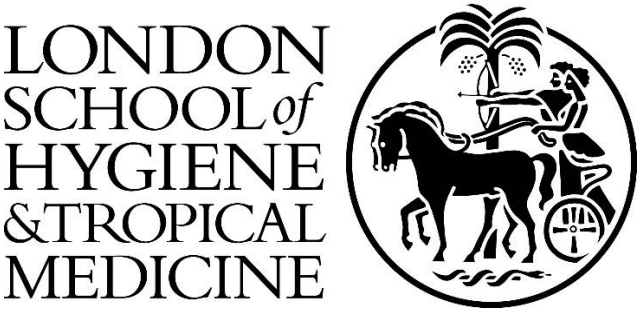
*figures include sugar allowance, [1]made up to manufacturer's instructions, [2]includes out of home milkshakes, [3]includes drinks in scope made with milk and milk substitute drinks, [4]includes blended juice and juice with water combination drinks but excludes juice with added sugar which are included in the SDIL.

Table A1c. Guidelines set in 2019 for fermented (yoghurt) drinks (adapted from Owtram et al. (194) Table 1 p.8)

Baseline (SWA, g sugar per 100ml)	20% reduction guideline (SWA g sugar per 100ml)[1]	Sugar allowance (g sugar per 100ml)	Calorie (kcal) guidelines – single serve products
9.7g	8.5g	3.8g	300kcal

[1]Includes sugar allowance for lactose,

Appendix 2. Data management plan prepared for DrPH review



Data Management Plan for Research Students

Project title	DrPH Thesis: The role of food reformulation and portion size interventions in reducing the availability and consumption of sugar
Author name	Rachel Clark
Supervisor	Karen Lock
Contact email	rachel.clark@lshtm.ac.uk
Date of last edit	29th August 2019

Guidance on writing a Data Management Plan can be found at

https://lshtm.sharepoint.com/Research/Research-data-management/

and http://servicedesk.lshtm.ac.uk

Advice and feedback can be obtained from:

researchdatamanagement@lshtm.ac.uk

DESCRIBE YOUR RESEARCH

1. What digital resources – data, code, collection tools, etc. - will you collect/obtain and use?

Relevant details to mention: topics covered, type (e.g. survey), source (collected by self or others), format (e.g. STATA) and amount (e.g. 10 interviews). Draw attention to human or other data that require additional protection.

a. Systematic literature review

- Collected via database searches, web-searches, hand-searching and contact with experts
- Stored in EPPI-reviewer and Endnote X9
- Data extraction conducted using Microsoft Excel
- Files will be saved on a secure server at Public Health England

b. Case studies

- Collected via database searches, web-searches, hand-searching and contact with experts
- Stored in Endnote X9
- Files will be saved on a secure server at Public Health England

b. Quantitative analysis

- Data provided by PHE, originally collected by Kantar Worldpanel. The data represents household purchase information from a continuously reporting panel of approximately 30,000 people. The dataset has been coded and cleaned by analysts at PHE.
- To be provided in Excel and transferred to Stata. Three datasets will be combined (from three years – 2016, 2017 and 2018). The dataset includes data on approximately 150,000 products with 70 variables.
- The dataset does not contain any personal identifiable information about members of the public, however it does contain identifiable information for businesses and brands.
- The dataset will be stored on secure PHE servers, and the analysis will be conducted using PHE (STATA) and equipment.

2. What hardware and software will be used in your research?

List any hardware and software to be used, their intended purpose (e.g. collection, analysis), and (if relevant) the number needed. E.g. 20 Samsung 10" tablets, LSHTM's Open Data Kit software, STATA and MS Access for analysis.

- This research will only involve the analysis of secondary data.
- The literature review components will require Endnote, Excel and EPPI-reviewer 4 for storage and management. This is already available via PHE and held on a PHE laptop.
- STATA will be needed for the quantitative analysis. This will be accessed via Public Health England.
- No additional hardware is required.

3. What data related activities will be performed during the research?

List key data-related activities that you and/or others will perform during the research. For instance, trial draft survey in month 6, collect data in month 8-10, clean and anonymise data in month 11, analyse data in month 12-18.

Note: the detail provided here and in section 4 refer to the quantitative project only.

Task	Description
Identification of relevant data	The dataset provided by PHE contains all data items used by PHE across multiple programmes of work (for example, salt reduction work). This study will focus on three sugar reformulation categories – the first step will be to identify this sub-set of data. Some data will not be used (for example, products where nutrition values have been imputed) – these data will need to be excluded. This stage will be completed using Excel.
Transfer of data	Data will be transferred into STATA.
Data cleaning and checks	The datasets have already been cleaned and coded by PHE analysts. However, additional checks will be conducted. For example, descriptive statistics will be produced to check for extreme outliers and implausible values.
Creating new variables	Some new variables will be created, for example to identify 'new' products and to classify products as high, med, low sugar.
Conduct analysis	One the preparatory work has been complete, the main analyses will be run.

4. What quality checks will you perform to ensure resources are fit for purpose?

Outline any quality checks to be performed before, during and after the above activities, e.g. to ensure data are captured correctly, remain accurate and complete, or ensure you avoid recognised problems. The UK Data Services offers guidance at http://ukdataservice.ac.uk/manage-data/format/quality.aspx.

- Quality of the data has been ensured by Kantar Worldpanel and quality of the data coding has been ensured by PHE.
- Additional quality checks, such as checking for outliers, will be completed prior to starting the analysis.

5. How will you address ethical & legal issues within your research?

- What permissions are needed? E.g. to collect data in country, analyse data for specific purpose, share data
- From whom must approval be obtained? E.g. study participant, ethics committees, data provider
- How will permissions be provided? E.g. ask participants to sign a consent form, sign a Data Transfer Agreement

Permissions are needed from PHE. Permission has already been granted and will be provided in writing by the Deputy Director at PHE with responsibility for the work and a data sharing agreement will be made. No further permissions are required from businesses as no identifiable information will be reported.

Ethical approval will be sought from LSHTM ethics committee.

6. What documentation will be created to ensure resources can be understood?

What aspects of the research will be documented and how? E.g. processes could be documented in Standard Operating Procedures, workflows applied described in a lab book, a codebook written to describe variables, etc.

A codebook to describe variables will be provided by PHE along with the data. When new variables are created a separate document will be created to describe variables.

A decision log will be created specifying key decisions that have been made in conducting the analysis.

STORAGE AND SECURITY

7. Where will resources be stored at key stages of your research?

Identify where resources will be held during capture, processing, analysis and other stages, and who will have access to them. Consult https://lshtm.sharepoint.com/Services/IT-Services/ServiceDesk/LSHTM-data-storage-options.pdf

All data and documentation pertaining to the research will be stored securely on PHE systems. Only the researcher will have access. Data processing will be completed using software and hardware already provided by PHE.

8. What labelling conventions will you apply to manage your resources?

Briefly describe any naming conventions or classification systems you will apply to resources. E.g.

- Filenames: key characteristics you will record to group files, e.g. FG1_transcript_2018-10-01
- Variable: conventions to be used for question IDs, completed responses & missing variables

- Versions: how will you identify changes to resources over time (e.g. v1.1, v1.2)

Filenames will follow a standard approach, including a file name and date. Versions will be captured numerically (e.g. v1, v2, v3) and using dates.

Naming of new variables within the quantitative dataset will follow existing variable naming formats within the dataset.

9. How will you keep data safe and secure

Only anonymised data will be used - personal, sensitive, or otherwise confidential data is not needed for the research	X	Store personal details in a separate secure location & link it via an identifier	n/a	Delete personal & confidential details at earliest opportunity (specify when below)	n/a
Use digital storage that require a username/password or other security feature	X	Physical security (such as locked cabinet or room)	n/a	Protect portable devices using security features, e.g. biometric	X
Encrypt storage devices	X	Encrypt during transfer	n/a	Avoid cloud services located outside EU	X
Take 'Information Security Awareness training'	X	Ensure backups are also held securely	X		
Notes:	All of these security features are already in place.				
Identify additional steps you will take to avoid, reduce, or eliminate risks that may affect your resources.					

ARCHIVING & SHARING

10. What resources should be kept as evidence of your research?

Research often has value beyond the lifespan of the project that produced it. For this reason, many researchers are required to keep data for a set time period, typically 10 years following completion, to comply with funding or journal publication requirement. List the resources in Q1 that will be kept and for how long. If some resources can't be retained for some reason (e.g. it contains personal data), state the reason that this is not permitted.

The dataset will be held by the researcher and by PHE for 10 years following completion of the analysis. No additional resources will be developed.

11. Where will these resources be hosted?

Identify where each resource will be hosted following research completion. E.g.

- Files intended for sharing may be hosted in the LSHTM data repository (http://datacompass.lshtm.ac.uk) or a 3rd party repository, such as UK Data Service, ArrayExpress, Zenodo, etc.
- Internal and confidential files can be held on the LSHTM Secure Server
- My supervisor will look after them

All resources and files used / created for this research will be held on a PHE secure server that can only be accessed by the researcher.

12. When will the resources be made available? (choose one or more)

During the research life		At the same time as findings are published in an academic journal		A set time after research end, e.g. 12 months. Specify below	
Resources already available (provide details below)		On completion of my thesis		Other (provide details below)	
Further information / Other					
Any new resources developed for the purpose of this work (e.g. new variables) will be available only to PHE as the data owner. No resources will be made available. The data will only be used to conduct this research and for the purpose of the thesis. Academic papers will also be submitted for publication.					

13. How will you make other researchers aware that the resources exist?

Publish a metadata record describing the resources in a repository or other catalogue		Obtain a Digital Object Identifier (DOI) or other permanent ID	
Cite resources in future research papers, e.g. in the data access statement or reference list		Cite resources in project reports	
Publish a description for the project website		Write and publish a Data Paper	
Add resources to a list of your academic outputs			
Other measures / Further details			
Not applicable			

14. What steps will you take to ensure resources are easy to analyse and use in future research? (choose one or more)

Prepare a codebook or other documentation that provides an accurate description of content	X	Store resources in open file formats such as CSV, Rich Text, etc. See https://www.ukdataservice.ac.uk/manage-data/format/recommended-formats	

Write a user guide that provides a high-level overview of research		Apply a standard licence that allows a broad range of uses (e.g. Creative Commons, Open Data Commons)	
Designate a corresponding author / data custodian who will handle data-related questions		Use domain-specific standards that make it easy to import and analyse data	
Other / Further information			
Any new variables will be added to the existing code-book to support future use by PHE.			

15. If resources can be made available, but not openly, what conditions on access/use must be met?

E.g. data can be used for specific types of research only. Leave blank if not applicable.

Requirement:	**To be addressed by:**
Not applicable	

RESOURCING

16. What are the primary data management challenges in your research?

E.g. uncertainty on data management practice, data security, data-related costs, staff resources, etc.

No major challenges are anticipated.

17. How can LSHTM & others help you to better manage your data?

Support from advisory committee.

Appendix 3. Search strategy for EMBASE, Study 1

1 sugar* adj10 (diet* OR nutrition OR food* OR intake OR consum*)
2 sugar* adj10 (reduc* OR less OR target* OR cutback* OR decreas* OR limit)
3 1 OR 2
4 beverage* AND industry
5 drink* AND industry
6 food* AND industry
7 4 OR 5 OR 6
8 (adjust* OR alter* OR change OR changing OR control* OR decreas* OR limit* OR modify OR modified OR new OR reduce OR reducing OR reduction* OR redevelop OR restrict) adj10 (recipe* OR food* OR drink* OR beverage* OR formula* OR ingredient*)
9 7 AND 8
10 (food OR drink OR beverage*) AND (formulat* OR reformulat*)
11 9 OR 10
12 3 AND 11
13 3 AND 11 AND [2015-2023]/py
14 3 AND 11 AND [2015-2023]/py AND [english]/lim

Appendix 4. Quality Criteria Checklist questions and scoring, Study 1

1. Was the research question clearly stated?

1.1 *Was the specific intervention(s) or procedure (independent variable(s)) of interest identified?
1.2 *Was the outcome(s) (dependent variable(s)) clearly indicated?
1.3 *Were the study context and setting specified?

2. Was the selection of study subjects/units free from bias?

2.1 *Were inclusion/exclusion criteria specified with sufficient detail and without omitting criteria critical to the study?
2.2 Were criteria applied equally to all units of observation and all study groups?
2.3 *Was the source and other relevant characteristics of units of observation described?
2.4 *Were the selected units a representative sample of the context and setting for the application of study findings?

3. Were study groups comparable? [N/A unless comparison group is used]

3.1 Was the method of assigning subjects/units of observation described and unbiased? (Method of randomization identified if RCT)
3.2 Was the distribution of relevant characteristics similar across subjects/units of observation and study groups at baseline?
3.3 Were concurrent controls used? (Concurrent comparison data preferred over historical data.)
3.4 If cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?

Note: criterion 3 is NA if only one group was studied, comparison groups were not constructed for analysis, and a comparison to a reference standard not made.

4. Were methods of handling losses from the original sample (withdrawals) described?

4.1 Were follow up methods described and the same for all subjects / units of observation or groups?
4.2 *Were the number, characteristics of withdrawn units (i.e., damaged specimen, dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group?
4.3 Were all enrolled subjects/units of observation (in the original sample) accounted for?
4.4 Were reasons for withdrawals similar across groups?
4.5 If diagnostic test, was decision to perform reference test not dependent on results of test under study?

Note: this may be not applicable, for example, if examining the food supply as not accounting for withdrawals shows industry response to the intervention

5. Was blinding used to prevent introduction of bias? [N/A]

5.1 Were field and research staff blinded to treatment group, as appropriate?
5.2 Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)
5.3 In cross-sectional study, were measurements of outcomes and risk factors blinded?

5.4 In case control study, was case definition explicit and case ascertainment not influenced by exposure status?
5.5 In diagnostic, reliability or validity study, were test results blinded to patient history and other test results?

6. Was the intervention/treatment regimen/exposure factor, procedure, process or product of interest and any comparison(s) described in detail? Were intervening factors described?

6.1 Were protocols described for all alternatives studied?
6.2 *Was the context (study setting, intervention or exposure details or process, involved personnel, etc) described?
6.3 *Was the intensity and duration of the treatment or exposure factor sufficient to produce a meaningful effect?
6.4 *Was fidelity to the research plan documented and the actual amount of exposure, if relevant, measured, and are data free from bias?
6.5 *Were co-interventions (e.g., concurrent ancillary treatments or procedures, other therapies) described?
6.6 *Were extra or unplanned interventions or environmental influences during the study period described?
6.7 Was the information for 6.4, 6.5, and 6.6 assessed the same way for all units of observation and all groups?
6.8 In diagnostic, validity or reliability study, were details of test administration and replication sufficiently described?

7. Were outcomes or condition or status of interest clearly defined and the measurements valid and reliable?

7.1 Were key outcomes (including primary and secondary endpoints, if applicable) described and relevant to the question?
7.2 Were nutrition-related outcomes measures, if included, appropriate to the study question and outcomes of concern?
7.3 *Was the period of follow-up long enough for important outcome(s) to occur?
7.4 *Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?
7.5 Was the measurement of outcomes or effect at an appropriate level of precision?
7.6 *Were other factors that could affect outcomes (e.g., confounders) measured or accounted for?
7.7 *Were the measurements conducted consistently across units of observation, groups and time periods?

8. Was the statistical analysis appropriate for the study design and type of outcome indicators?

8.1 Were statistical analyses adequately described the results reported appropriately?
8.2 Were correct statistical tests used and assumptions of test not violated?
8.3 Were statistics reported with levels of significance and/or confidence intervals?
8.4 Was there a clear description of subjects/units observed included in each analysis? If appropriate, was there a dose-response analysis?
8.5 *Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?
8.6 Was clinical or pragmatic significance as well as statistical significance reported?
8.7 Was a power calculation reported to address adequate sample size to measure effect and avoid type 2 error? (This is especially important if findings are negative.)

9. Are <u>conclusions supported by results</u> with biases and limitations taken into consideration?

9.1 Is there a discussion of findings?
9.2 Are biases and study limitations identified and discussed?

10. Is bias due to study's <u>funding or sponsorship</u> unlikely?

10.1 Were sources of funding and investigators' affiliations described
10.2 Was there no apparent conflict of interest?

Scoring: yes, no, unclear, not applicable

Total score:

MINUS/NEGATIVE (-) (WEAK)
If most (six or more) of the answers to the above validity questions are "No," the report should be designated with a minus (-) symbol on the Evidence Worksheet.

NEUTRAL (Ø)
If the answers to validity criteria questions 2, 3, 6, and 7 do not indicate that the study is exceptionally strong, the report should be designated with a neutral (Ø) symbol on the Evidence Worksheet.

PLUS/POSITIVE (+) (POSITIVE)
If most of the answers to the above validity questions are "Yes" (including criteria 2, 3, 6, 7 and at least one additional "Yes"), the report should be designated with a plus symbol (+) on the Evidence Worksheet.

Appendix 5. Example search terms – salt reformulation policy, Study 2

Search terms 1:

(salt OR sodium) AND

(reformulat* OR reduc*) AND

England AND

Policy

Search terms 2:

'responsibility deal' AND

salt

Search terms 3:

(salt OR sodium) AND

(reformulat* OR reduc*) AND

policy AND

'systematic review'

Appendix 6. List and definitions of variables, Study 3

Table 6a: Variables available in the PHE dataset

Variable name	Description	Composite[6]	Categorical[7]
Product information			
Product code	Unique product code created by Kantar	-	-
Product name	Name of product	-	-
Product description	Short description of product	-	-
Unit of sale[8]	Unit volume of product is measured in (e.g. grams, millilitres, kilograms)	-	-
Branded / Private	Whether the product is branded or private label (1=branded, 2=private label)	-	✓
Pack size	Total weight of a whole product (pack)	-	-
Number in pack[9]	Number of items (single serve portions) in one product (pack)	-	-
Size of portion	Weight of one portion. Calculated from: Volume weight of a whole product / number of items within a product	✓	-
Single serve flag[10]	Flags any products available as single serve (1=single serve, 0=not single serve)	-	✓

[6] Composite variables had been produced by PHE using combinations of variables available in the Kantar dataset
[7] All variables were provided in string format, some were changed to categorical variables to enable analysis
[8] All products in the categories selected were available in grams or kilograms
[9] There may be more than one single serve portion in a pack if it is a multipack. The multipack will be counted as one product.
[10] These 'items' are individual products that can be consumed on a single occasion and could be single serve products (for example a chocolate bar available as a single item) or a product within a multi-pack (for example, a pack of 4 chocolate bars individually wrapped)

Variable name	Description	Composite[6]	Categorical[7]
Product category	PHE sugar reformulation product categories (selected only, 1=breakfast cereal, 2=chocolate confectionary, 3=sweet confectionary	-	✓
Purchase information			
Household (HH) purchases – volume	Total annual reported volume in kg, 000s[11]	-	-
Household (HH) purchases – packs	Total annual reported number of packs in kg, 000s[6]	-	-
Purchases per serving	Number of portions sold – single serve portions only. Calculated from: Household purchases – packs * Number in pack	✓	-
Data collection information			
Date NI updated	Specifies the date the nutritional information was last updated	-	-
Real / Cloned / Imputed	Specifies if nutritional data is real, cloned or imputed (1=real/cloned, 2=imputed). Data available product and each specific nutrient.[12]	-	✓
Nutritional information			
Sugar g/100g	g/100g sugar content in a product	-	-
Sugar per serving	Sugar per serving. Calculated from: Sugar g/100g / 100 * Number in pack.	✓	-
Sugar purchases	Total sugar purchased for that product in kg, 000s[6]. Created from: Sugar g/100g*HH purchase – volume / 100	✓	-

[11] Take Home 30,000 households, 52 weeks, weighted up to Great Britain

[12] Real = found , cloned or McCance and Widdowson. Imputed = not found so given a production category average

Table 6b: New variables created to enable this study

Variable name	Variable description
Outcome variables[1]	
Changes in sugar content	Two categorical variables to identify products as having changes in sugar content between two years using the Sugar g/100g variable (years: 2015 and 2017, 2015 and 2018; categories: no change, increase, decrease)
Changes in portion size	Two categorical variables to identify single serve products as having changes in portion size between two years (years: 2015 and 2017, 2015 and 2018; categories: no change, increase, decrease)
Changes in sugar purchases	Two categorical variables to identify products as having changes in total purchases of sugar from products between two years (years 2015 and 2017, 2015 and 2018; categories: no change, increase, decrease)
Category based on sugar content ('sugar category')	A categorical variable to identify products as low (≤5g/100g), medium (>5 and ≤22.g/100g) or high (>22.5g/100g) sugar
Sub-group analysis	
Product availability	A categorical variable to group products based on their availability within each data collection year (2015 only; 2015 and 2017; 2015 and 2018; 2017 only; 2017 and 2018; 2018 only; all years) to examine discontinued, new and continued products and enable complete case analyses
Exploratory analysis	
Amount of sugar reduction	To explore the extent of change in those products that had reduced sugar content, a new continuous variable was created to show the amount of sugar reduction in g/100g

[1]Some outcome variables were also used for sub-group analysis

Additional variables to enable required analysis

- A series of binary variables to group products based on their availability in two years where change was being examined (2015 and 2017; 2015 and 2018) to enable available case analysis
- Binary variables created from categorical variables to enable certain statistical tests, for example, binary variables of 'not high sugar' and 'high sugar' (based on the sugar categories already described for low, medium or high sugar categorisations – high sugar >22.5g/100g, not high sugar ≤22.g/100g) for the purpose of conducting proportion tests.

Appendix 7. Studies excluded at full-text review and reasons for exclusion

Studies from databases

Intervention (n = 24)

Bandy LK, Scarborough P, Harrington RA, Rayner M, Jebb SA. Reductions in sugar sales from soft drinks in the UK from 2015 to 2018. BMC medicine. 2020;18(1):20.

Berger N, Cummins S, Smith Richard D, Cornelsen L. Have socio-economic inequalities in sugar purchasing widened? A longitudinal analysis of food and beverage consumer data from British households, 2014-2017. Public health nutrition. 2021;24(7):1583-94.

Bernstein Jodi T, Christoforou Anthea K, Weippert M, L'Abbe Mary R. Reformulation of sugar contents in Canadian prepackaged foods and beverages between 2013 and 2017 and resultant changes in nutritional composition of products with sugar reductions. Public health nutrition. 2020;23(16):2870-8.

Chepulis L, Hill S, Mearns G. The nutritional quality of New Zealand breakfast cereals: an update. Comment in: Public Health Nutr 2018 Jun;21(8):1583-1585 PMID: 29277172 [https://wwwncbinlmnihgov/pubmed/29277172] Comment in: Public Health Nutr 2018 Jun;21(8):1586-1587 PMID: 29444727 [https://wwwncbinlmnihgov/pubmed/29444727]. 2017;20(18):3234-7.

Crino M, Sacks G, Dunford E, Trieu K, Webster J, Vandevijvere S, et al. Measuring the Healthiness of the Packaged Food Supply in Australia. Nutrients. 2018;10(6)

Dotsch-Klerk M, Kovacs Eva MR, Hegde U, Eilander A, Willems Julie I. Improving the Nutrient Quality of Foods and Beverages Using Product Specific Standards for Nutrients to Limit Will Substantially Reduce Mean Population Intakes of Energy, Sodium, Saturated Fat and Sugars towards WHO Guidelines. Nutrients. 2022;14(20).

Encarnacao R, Lloyd-Williams F, Bromley H, Capewell S. Obesity prevention strategies: Could food or soda taxes improve health? Journal of the Royal College of Physicians of Edinburgh. 2016;46(1):32-8.

Estruch R, Vendrell E, Ruiz-Leon Ana M, Casas R, Castro-Barquero S, Alvarez X. Reformulation of Pastry Products to Improve Effects on Health. Nutrients. 2020;12(6).

Gontijo de Castro T, Eyles H, Ni Mhurchu C, Young L, Mackay S. Seven-year trends in the availability, sugar content and serve size of single-serve non-alcoholic beverages in New Zealand: 2013-2019. Public health nutrition. 2021;24(7):1595-607.

Graca P, Gregorio MJ, De Sousa SM, Bras S, Penedo T, Carvalho T, et al. A new interministerial strategy for the promotion of healthy eating in Portugal: Implementation and initial results. Health Research Policy and Systems. 2018;16(1):102.

Hashem KM, He FJ, Macgregor GA. Cross-sectional surveys of the amount of sugar, energy and caffeine in sugar-sweetened drinks marketed and consumed as energy drinks in the UK between 2015 and 2017: Monitoring reformulation progress. BMJ Open. 2017;7(12):018136.

Jahn JL, Cohen JFW, Gorski-Findling MT, Hoffman JA, Rosenfeld L, Chaffee R, et al. Product reformulation and nutritional improvements after new competitive food standards in schools. Public health nutrition. 2018;21(5):1011-8.

Khoshtinat K, Koohy-Kamaly P, Komeili-Fanood R, Sohrabvandi S, Khosravi-Darani K, Mohammadi M, et al. Comparative study of salt, total fat and sugar contents of mayonnaise and salad dressings from the Iranian market. Eastern Mediterranean health journal = La revue de sante de la Mediterranee orientale = al-Majallah al-sihhiyah li-sharq al-mutawassit. 2021;27(5):452-8.

Luger M, Winzer E, Schatzer M, Damon S, Moser N, Blagusz K, et al. Gradual reduction of free sugars in beverages on sale by implementing the beverage checklist as a public health strategy. European journal of public health. 2018;28(5):961-7.

Pinho-Gomes AC, Dunford E, Jones A. Trends in sugar content of non-alcoholic beverages in Australia between 2015 and 2019 during the operation of a voluntary industry pledge to reduce sugar content. Public health nutrition. 2023;26(1):287-96.

Pombo-Rodrigues S, Hashem Kawther M, He Feng J, MacGregor Graham A. Salt and sugars content of breakfast cereals in the UK from 1992 to 2015. Public health nutrition. 2017;20(8):1500-12.

Russell C, Dickie S, Baker P, Lawrence M. Does the Australian Health Star Rating System Encourage Added Sugar Reformulation? Trends in Sweetener Use in Australia. Nutrients. 2021;13(3).

Santos M, Matias F, Rito Ana I, Castanheira I, Torres D, Loureiro I, et al. Breakfast Cereals Intended for Children: Opportunities for Reformulation and Potential Impact on Nutrient Intake. Foods (Basel, Switzerland). 2021;10(8).

Spiteri M, Soler L-G. Food reformulation and nutritional quality of food consumption: an analysis based on households panel data in France. European journal of clinical nutrition. 2018;72(2):228-35.

Tassy M, Rytz A, Drewnowski A, Lecat A, Jacquier Emma F, Charles Veronique R. Monitoring improvements in the nutritional quality of new packaged foods launched between 2016 and 2020. Frontiers in nutrition. 2022;9:983940.

Ter B, Sovianne, Steenbergen E, Milder Ivon EJ, Temme Elisabeth HM. Evaluation of Nutri-Score in Relation to Dietary Guidelines and Food Reformulation in The Netherlands. Nutrients. 2021;13(12).

Van Dam I, Vandevijvere S. Benchmarking the nutrition-related commitments and practices of major French food companies. BMC public health. 2022;22(1):1435.

Vergeer L, Ahmed M, Vanderlee L, Mulligan C, Weippert M, Franco-Arellano B, et al. The relationship between voluntary product (re) formulation commitments and changes in the nutritional quality of products offered by the top packaged food and beverage companies in Canada from 2013 to 2017. BMC public health. 2022;22(1):271.

Vlassopoulos A, Masset G, Charles VR, Hoover C, Chesneau-Guillemont C, Leroy F, et al. A nutrient profiling system for the (re)formulation of a global food and beverage portfolio. European Journal of Nutrition. 2017;56(3):1105-22.

Outcome (n = 6)

Bandy LK, Hollowell S, Harrington R, Scarborough P, Jebb S, Rayner M. Assessing the healthiness of UK food companies' product portfolios using food sales and nutrient composition data. PLoS ONE. 2021;16(8 August):e0254833.

Eyles H, Trieu K, Jiang Y, Mhurchu CN. Reducing children's sugar intake through food reformulation: Methods for estimating sugar reduction program targets, using New Zealand as a case study. Journal of Biochemistry. 2020;167(1):622-34.

Gressier M, Privet L, Mathias KC, Vlassopoulos A, Vieux F, Masset G. Modeled dietary impact of industry-wide food and beverage reformulations in the United States and France. American Journal of Clinical Nutrition. 2017;106(1):225-32.

Jensen Jorgen D, Sommer I. Reducing calorie sales from supermarkets - 'silent' reformulation of retailer-brand food products. The international journal of behavioral nutrition and physical activity. 2017;14(1):104.

Rosewarne E, Huang L, Farrand C, Coyle D, Pettigrew S, Jones A, et al. Assessing the Healthy Food Partnership's Proposed Nutrient Reformulation Targets for Foods and Beverages in Australia. Nutrients. 2020;12(5).

von Philipsborn P, Stratil Jan M, Heise Thomas L, Landgraf R, Hauner H, Rehfuess Eva A. Voluntary industry initiatives to promote healthy diets: a case study on a major European food retailer. Public health nutrition. 2018;21(18):3469-76.

Study design (n = 12)

Basto-Abreu A, Braverman-Bronstein A, Camacho-Garcia-Formenti D, Zepeda-Tello R, Popkin BM, Rivera-Dommarco J, et al. Expected changes in obesity after reformulation to reduce added sugars in beverages: A modeling study. PLoS Medicine. 2018;15(10):e1002664.

Bernstein Jodi T, Christoforou Anthea K, Ng Alena P, Weippert M, Mulligan C, Flexner N, et al. Canadian Free Sugar Intake and Modelling of a Reformulation Scenario. Foods (Basel, Switzerland). 2023;12(9).

Coyle DH, Shahid M, Dunford EK, Louie JCY, Trieu K, Marklund M, et al. Estimating the potential impact of the Australian government's reformulation targets on household sugar purchases. International Journal of Behavioral Nutrition and Physical Activity. 2021;18(1):138.

Crino M, Herrera Ana Maria M, Ananthapavan J, Wu Jason HY, Neal B, Lee Yong Y, et al. Modelled Cost-Effectiveness of a Package Size Cap and a Kilojoule Reduction Intervention to Reduce Energy Intake from Sugar-Sweetened Beverages in Australia. Nutrients. 2017;9(9).

Federici C, Detzel P, Petracca F, Dainelli L, Fattore G. The impact of food reformulation on nutrient intakes and health, a systematic review of modelling studies. Erratum in: BMC Nutr 2019 Feb 4;5:9 PMID: 32154802 [https://wwwncbinlmnihgov/pubmed/32154802]. 2019;5:2.

Goiana-da-Silva F, Cruz ESD, Allen L, Gregorio Maria J, Severo M, Nogueira Paulo J, et al. Modelling impacts of food industry co-regulation on noncommunicable disease mortality, Portugal. Comment in: Bull World Health Organ 2019 Jul 1;97(7):442-442A PMID: 31258209 [https://wwwncbinlmnihgov/pubmed/31258209]. 2019;97(7):450-9.

Grieger Jessica A, Johnson Brittany J, Wycherley Thomas P, Golley Rebecca K. Comparing the Nutritional Impact of Dietary Strategies to Reduce Discretionary Choice Intake in the Australian Adult Population: A Simulation Modelling Study. Erratum in: Nutrients 2017 Aug 09;9(8): PMID: 28792462 [https://wwwncbinlmnihgov/pubmed/28792462]. 2017;9(5).

Lehmann U, Charles VR, Vlassopoulos A, Masset G, Spieldenner J. Nutrient profiling for product reformulation: Public health impact and benefits for the consumer. Proceedings of the Nutrition Society. 2017;76(3):255-64.

Ma Y, He Feng J, Yin Y, Hashem Kawther M, MacGregor Graham A. Gradual reduction of sugar in soft drinks without substitution as a strategy to reduce overweight, obesity, and type 2 diabetes: a modelling study. Comment in: Lancet Diabetes Endocrinol 2016 Feb;4(2):86-7 PMID: 26777598 [https://wwwncbinlmnihgov/pubmed/26777598]. 2016;4(2):105-14.

Muth Mary K, Karns Shawn A, Mancino L, Todd Jessica E. How Much Can Product Reformulation Improve Diet Quality in Households with Children and Adolescents? Nutrients. 2019;11(3).

Vercammen KA, Dowling EA, Sharkey AL, Johnson Curtis C, Wang J, Kenney EL, et al. Estimated Reductions in Added Sugar Intake among US Children and Youth in Response to Sugar Reduction Targets. Journal of the Academy of Nutrition and Dietetics. 2022;122(8):1455-64.

Yeung Chris Ho C, Gohil P, Rangan Anna M, Flood Victoria M, Arcot J, Gill Timothy P, et al. Modelling of the impact of universal added sugar reduction through food reformulation. Scientific reports. 2017;7(1):17392.

No full text (n = 6)

Cushen M, Rogers N, Barron R, Wonik J, Stanek B, Pigat S, et al. The impact of food industry reformulation, innovation and consumer preference on dietary intakes in Ireland: A probabilistic intake model. 13th European Nutrition Conference, FENS 2019 Dublin Ireland. 2020;79(OCE2).

Gressier M, Mathias KC, Drewnowski A, Vlassopoulos A, Masset G. Modeled impact of food and beverage reformulations on added sugars intake and its social gradient in the US. Experimental Biology 2017, EB Chicago, IL United States. 2017;31(1 Supplement 1).

Maillot M, Privet L, Masset G. Modeled industry-wide food and beverage reformulations reduce the gap between current and nutritionally adequate dietary intakes among French adults. European Journal of Nutrition. 2020;59(3):1123-34.

Molenberg F, Vlassopoulos A, Masset G, Lehmann U. Improving the food supply by product reformulation: Using nutrient profiling to evaluate foods consumed in the USA. Experimental Biology 2016, EB San Diego, CA United States. 2016;30(Meeting Abstracts).

Winzer E, Luger M, Schatzer M, Moser N, Schatzer J, Putzhammer C, et al. Gradual reduction of free sugars in beverages on sale by implementing the beverage checklist as a public health strategy. 25th European Congress on Obesity, ECO 2018 Vienna Austria. 2018;11(Supplement 1):232-3.

Zupanic N, Pravst I. Trends in free sugar content of slovenian pre-packaged foods and non-alcoholic beverages. 13th European Nutrition Conference, FENS 2019 Dublin Ireland. 2020;79(OCE2).

Studies from grey literature searches

Intervention (n = 3)

Croisier E, Hughes JA-O, Duncombe SA-O, Grafenauer SA-O. Back in Time for Breakfast: An Analysis of the Changing Breakfast Cereal Aisle. LID - 10.3390/nu13020489 [doi] LID - 489. (2072-6643 (Electronic)).

McMenemy D, Kelly F, Sweeney MR. An exploration of food industry led reformulation on fortified food staples in Ireland. Journal of Public Health. 2022;44(2):342-8.

Taillie LS, Ng SW, Popkin BM. Gains Made By Walmart's Healthier Food Initiative Mirror Preexisting Trends. Health Aff (Millwood). 2015;34(11):1869-76.

Outcome (n = 1)

Elliott T, Trevena H, Sacks G, Dunford E, Martin J, Webster J, et al. A systematic interim assessment of the Australian Government's Food and Health Dialogue. Medical Journal of Australia. 2014;200(2):92-5.

Language (n = 1)

Oqali. Bilan des premiers resultats des suivis des evolutions: Etude de l’évolution des produits transformés disponibles sur le marché français par secteur entre 2008-2010 et 2010-2013. 2016.

Appendix 8. Tables of results from the Sugar Reduction Programme (SRP) progress monitoring reports (80, 89, 99, 100), Study 1

Table A8a: Percentage change in sales weighted mean sugar (g/100g) and mean sugar (g/100g) of food products reported in SRP progress monitoring reports for the in home sector, by year and product category

	SWM sugar				Mean sugar			
	2020	**2019**	**2018**	**2017**	**2020**	**2019**	**2018**	**2017**[2]
Overall	-3.5	-3	-2.9	-2	-2.9	-2.2	-0.2	-
Biscuits	-3.1	-1.6	-0.6	0	-0.9	+0.6	+1.6	-
Breakfast Cereals	-14.9	-13.3	-8.5	-5%	-14.4	-13.6	-9.1	-
Chocolate Confectionery	-0.9	-0.4	-0.3	0	-1.6	-1.2	-0.5	-
Ice Cream, Lollies & Sorbets	-7.2	-6.4	-0.3	-2	-6.2	-5	-0.2	-
Puddings	-2.3	+2	+0.5	+1	-1.8	+0.9	-0.2	-
Sweet Spreads & Sauces	-10.1	-5.6	-4.6	-5	-19.2	-17.7	-16.7	-
Sweet Confectionery	-2.8	-0.1	+0.6	-1	-3.4	-2.2	-1.1	-
Yogurts & Fromage Frais	-13.5	-12.9	-10.3	-6	-17	-13.8	-9.1	-
Cakes[1]	-3.2	-4.8	-4.8	-	-0.2	-1.5	-1.4	-
Morning Goods[1]	-4.9	-5.6	-3.6	-	-4.2	-1.8	-0.5	-

[1]due to issues with 2015 data the baseline for Cakes and Morning goods is 2017, [2]mean sugar was not assessed in 2017

Table A8b. Percentage change in volume sales, % in sugar sales and % contribution to overall sales for food products reported in SRP progress monitoring reports for the in home sector, by year and product category

	% change from baseline								% contribution to overall sales				
	Sugar sales				Sales								
	2020	2019	2018	2017	2020	2019	2018	2017[2]	2020	2019	2018	2017	2015
Overall	7.1	2.6	2.6	-1.0	8.1	3.4	3.8	-	-	-	-	-	-
Biscuits	9.5	5.7	3.1	-1.0	12.3	6.8	4.6	-	18.8	18.6	18.3	-	18.1
Breakfast Cereals	-11.3	-13.9	-7.5	-6.0	4.2	-0.5	0.7	-	17.3	17.2	17.5	-	17.9
Chocolate Confectionery	26.9	16.3	10.4	5.0	27.8	16.3	11.0	-	13.2	12.6	12.1	-	11.2
Ice Cream, Lollies & Sorbets	10.2	0.8	16.3	3.0	18.7	8.0	16.5	-	13.5	12.9	13.3	-	12.7
Puddings	-7.5	-4.0	-10.1	-1.0	-3.1	-3.0	-6.7	-	12.7	13.3	12.7	-	14.2
Sweet Spreads & Sauces	24.5	6.1	6.4	-2.0	32.0	12.0	11.0	-	1.7	1.5	1.5	-	1.4
Sweet Confectionery	9.6	7.2	4.9	-2.0	12.2	7.3	5.3	-	5.6	5.6	5.5	-	5.4
Yogurts & Fromage Frais	-8.4	-15.9	-8.7	-8.0	-5	-3.3	0.6	-	17.2	18.3	19.1	-	19.5
Cakes[1]	-	-	-	-	-	-	-	-	-	-	-	-	-
Morning Goods[1]	-	-	-	-	-	-	-	-	-				-

Table A8c. Percentage change in mean sugar (g/100g) reported in SRP progress monitoring reports for food products in the out of home sector, by year and product category

	% reduction in mean sugar g/100g		
	2020	**2019**	**2018**
Overall	-0.2	-0.3	-4.9
Biscuits	0.3	-3.9	-0.4
Breakfast Cereals	-	-17.1	-17.1
Chocolate Confectionery	-	10.7	3.6
Ice Cream, Lollies & Sorbets	0.5	-2.3	-12.9
Puddings	0.3	2.4	-15
Sweet Spreads & Sauces	-	-	-
Sweet Confectionery	-	-	-
Yogurts & Fromage Frais	-	2.4	-23.5
Cakes	-8.2	-6.8	-6.9
Morning Goods	-3.5	-0.4	-9.1

Table A8d. Percentage change in mean sugar (g/100ml) and SWM sugar (g/100ml) of drink products, reported in SRP progress monitoring reports for the in home and out of home sectors, by year and product category

	% change in mean sugar		% change in SWM sugar	
	2020	**2019**	**2020**	**2019**
In home product categories				
Pre-packed milk-based drinks	-27.8	-21	-20	-11.2
Pre-packed flavoured milk substitute drinks	-32.5	-21.7	-8	-2.9
Pre-packed fermented (yogurt) drinks	-28.4	-26	-2.3	-4.1
Coffee and tea powders, syrups and pods as consumed	-20.3	-17.8	-	-
Hot chocolate and malt powders, syrups and pods as consumed	5.1	0.2	-	-
Milkshake powders, syrups and pods as consumed	-34.2	-12.1	-	-
Pre-packed mono juices	-1.7	-1.2	-3.4	-3.6
Pre-packed blended juices	-3.8	-4.5	-8.8	-6.1
Out of home product categories				
Open cup milkshakes	12.7	7.8	-	-
Open cup hot or cold drinks	-10.2	-6.8	-	-
Blended juices	-9.4	1.5	-	-

Appendix 9. GRADE analysis, Study 1

Outcome	Judgement	Concern
Mean sugar content (g/100g) of products	**Description:** One of the four studies examined this outcome. This encompassed three of the four progress monitoring reports for the SRP (2017 onwards) (QCC rating: neutral) (100, 124, 125). The study reported an overall -2.9% reduction in mean sugar content for the in home setting (from 34.1g/100g to 33.1g/100g), and no change for the out of home setting between 2015 and 2020.	
	Methodological limitations The study rated neutral on the QCC. There was limited information on sampling and product numbers and no statistical tests nor provided confidence intervals were provided.	Very serious
	Indirectness The study is directly relevant as it was conducted in England focusing on the voluntary sugar reformulation policy.	Not serious
	Imprecision Sample sizes are provided for the panel providing purchase data but not for the number of products included in the analysis. No confidence intervals are provided so precision is unknown.	Very serious
	Inconsistency It is not possible to give this a rating as only one study assessed this outcome.	n/a
	Likelihood of publication bias	Not serious

Outcome	Judgement	Concern
	Comprehensive search strategy and identified studies with no effect, so no serious concerns regarding publication bias.	
Mean sugar content (g/portion) of products	**Description:** One study examined this outcome (136) based on food products sold in the out of home setting. Mean sugar per portion reduced from 30.5g/portion in 2017 to 27.1g/portion in 2020 (-3.4g/portion, -11%, p=0.001). Timeframe: 2017 – 2020. **Methodological limitations** Scored neutral on risk of bias, but potential issues with data source and sampling. **Indirectness** The study is directly relevant as was conducted in England based on the SRP. **Imprecision** No issues with sample sizes, but CIs are not provided for overall results (only category specific results, box plots in suppl. material). Statistical significance was reported overall (non-significant result). **Inconsistency** It is not possible to give this a rating as only one study assessed this outcome. **Likelihood of publication bias** Comprehensive search strategy and identified studies with no effect, so no serious concerns regarding publication bias.	Serious Not serious Serious n/a Not serious

Outcome	Judgement	Concern
Sales-weighted mean sugar content (g/100g) of products	**Description:** Three of the four studies examined change in SWM sugar content (100, 114, 124, 125, 137, 138). Two focused on in home settings only, one included both in home and out of home settings. Results ranged from a -5.2% (-1.5g/100g, -95% CI −9.1%, −1.4%, p=0.52 – Bandy et al) reduction to a -3.2% reduction (5.4g/100 mL to 5.2g/100 mL, Von Phil et al), with the third study reporting a -3.5% reduction (from 25.8g/100g in 2015 to 24.9g/100g in 2020, OHID). The studies used different timeframes – Bandy et al: 2015 – 2018, SRP reports: 2015 – 2020 (interim results also available), Von Phillipsborn: 2015 – 2021. The SRP reports showed the largest reduction after the first year of implementation (in 2017).	
	Methodological limitations One of the studies rated positive using QCC and two of the studies rated neutral. The latter two studies did not include details of sample sizes, confidence intervals or statistical tests.	Serious
	Indirectness Two of the studies are directly relevant as they were both conducted in England with a focus on the SRP. The third study may have relevance as it was conducted in a European OECD country, however it was focused on SSBs which may be different to food products and non-SSB drinks from a reformulation perspective.	Not serious
	Imprecision Where reported, there are no issues with sample size or confidence intervals. However only one of the studies reported this.	Serious
	Inconsistency	Potentially serious

Outcome	Judgement	Concern
	All studies reported a reduction in SWM g/100g sugar content of products over the timeframe. There are differences, potentially most likely due to the use of different data sources and the inclusion of different product categories. When comparing the results from the same timeframe for the two studies focused on the SRP, the reduction reported by Bandy et al (-5.2%) was almost double that reported by Coyle et al (-2.9%). **Likelihood of publication bias** Comprehensive search strategy and identified studies with no effect, so no serious concerns regarding publication bias.	Not serious
Sugar sales (per person or capita per day)	Two of the four studies examined change in sugar sales of products, per person (or per capita) per day, including both in home and out of home e settings (137, 138). Results ranged from a -28.5% reduction in sugar sales in the German study focused on SSBs (21.2g/capita/day in 2015 to 15.1g/capita/day in 2021) to a -7.5% reduction in sugar sales (Bandy et al, -1.6g/person/day between 2015 and 2018). **Methodological limitations** One of the studies rated positive using QCC and one of the studies rated neutral. The latter study did not include details of sample sizes, confidence intervals or statistical tests. **Indirectness** One of the studies is directly relevant as it was conducted in England with a focus on the SRP. The second study may have relevance as it was conducted in a European OECD country, however it was focused on SSBs which may be different to food products and non-SSB drinks from a reformulation perspective.	Serious Serious

Outcome	Judgement	Concern
	Imprecision Where reported, there are no issues with sample size or confidence intervals. However only one of the studies reported this. **Inconsistency** Both studies reported a reduction in sugar sales, however there was a big difference in the scale of reduction. As no statistical tests are included it is difficult to determine the importance of this difference. **Likelihood of publication bias** Comprehensive search strategy and identified studies with no effect, so no serious concerns regarding publication bias.	Serious Serious Not serious
Mean volume sugar sales	One of the four studies examined change in mean volume sugar sales of products without any adjustments, reporting +7.1% increase in sugar sales between 2015 and 2020 (100). Earlier SRP progress reports also reported increased sugar sales (+2.6% in 2018 and 2019) (124, 125) although a -1% reduction in sugar sales was reported in the first year (114). The analysis focused on in home sector only and in the years where sugar sales increased, confounding reasons were reported including COVID-19 restrictions in 2020 which resulted in increased in home purchases and increased population sizes in 2018 and 2019. **Methodological limitations** The study rated neutral on the QCC. There was limited information on sampling and product numbers and no statistical tests nor provided confidence intervals were provided. **Indirectness**	Serious Not serious

Outcome	Judgement	Concern
	The study is directly relevant as it was conducted in England focusing on the voluntary sugar reformulation policy. **Imprecision** Sample sizes are provided for the panel providing purchase data but not for the number of products included in the analysis. No confidence intervals are provided so precision is unknown. **Inconsistency** It is not possible to give this a rating as only one study assessed this outcome. **Likelihood of publication bias** Comprehensive search strategy and identified studies with no effect, so no serious concerns regarding publication bias.	Very serious n/a Not serious
Sugar intake	No studies	n/a

Appendix 10. Timeline of key events in England's salt reformulation policy, Study 2

	Date	Event
Pre-policy implementation		
	May 2003	SACN report on salt and health published
FSA Phase		
	2003	FSA and DH commit to FSA salt reduction programme
	Feb 2004	FSA begins stakeholder meetings to discuss salt reduction targets
	Feb 2005	FSA salt model published
	Jul 2005	FSA / DH publish summary of industry progress
	Mar 2006	FSA published first set of salt reduction targets (2006 – 2010)
	Sept 2006	FSA stakeholder meetings to discuss self-reporting framework
	Aug – Nov 2007	FSA published self-reporting framework
	Jan – Feb 2008	FSA stakeholder meetings to review progress and consider targets
	Jul 2008	FSA runs public consultation on revised salt targets
	Dec 2008 – Jan 2009	Stakeholder meetings – costs of proposed targets
	May 2009	FSA published revised salt reduction targets (2006/10 – 12)
Transfer of policy		
	Oct 2010	Salt reduction programme transferred from FSA to DH
RD Phase		
	Mar 2011	RD launched with salt reformulation policy incorporated
	2012	Existing salt targets accepted into the RD and salt pledge published
	Mar 2014	New salt reduction targets published by DH (2014 – 2017)
	2015[1]	RD dissolved
Unclear policy ownership: 2015 – 2017		
PHE Phase		
	2017[2]	Salt reformulation policy formally moved to PHE
	Mar 2017	2014 targets re-published by PHE
	Dec 2018	PHE published progress monitoring of 2017 salt targets
	May 2019	PHE published an update on the full reformulation programme
	Feb 2020	PHE runs stakeholder consultation
	Sept 2020	New targets set prior to closure of PHE (2020 – 2024)
	Sept 2020	Summary of stakeholder feedback published by PHE
	30th Sept 2021	PHE dissolved
	1st Oct 2021	Salt reformulation policy moves to OHID, DHSC

[1] Unable to establish exact date but reports suggest it was following the general election in May 2015 which resulted in a change in government

[2]Unable to establish exact date, there are mixed reports suggesting the move occurred in either 2016 following publication of the Childhood Obesity Plan or later during 2017

Appendix 11. Histograms showing product availability, Study 3

Figure 11a. Availability of all products, by product category (%)

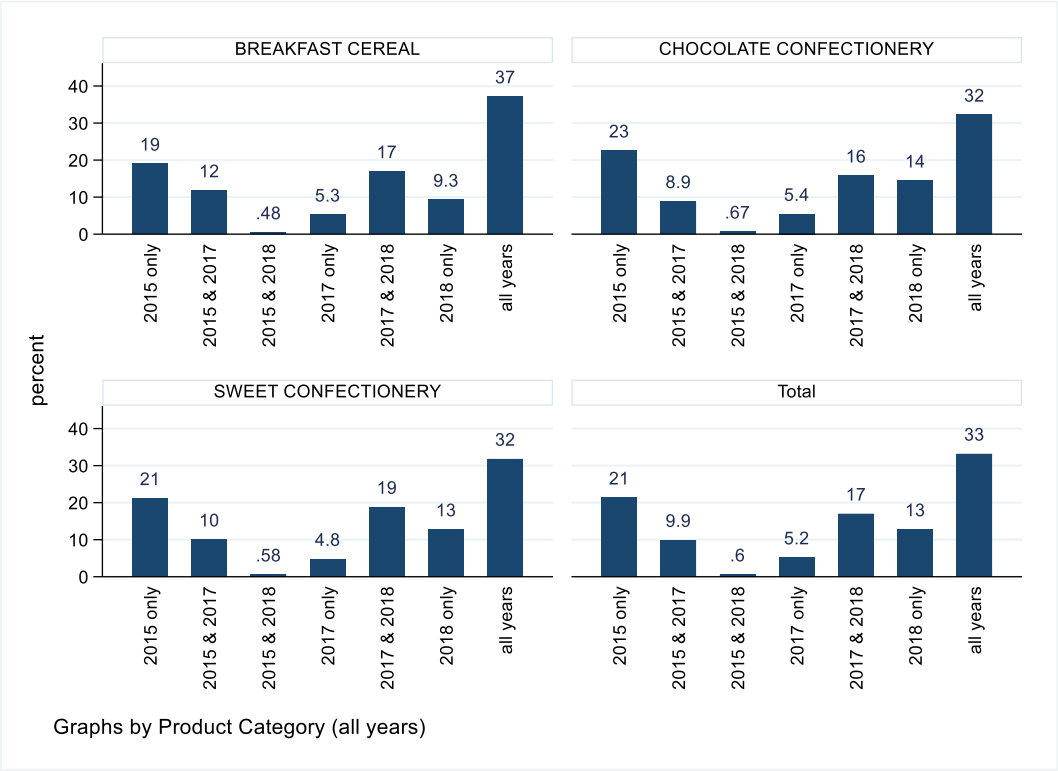


Figure 11b. Availability of single serve products, by product category (%)

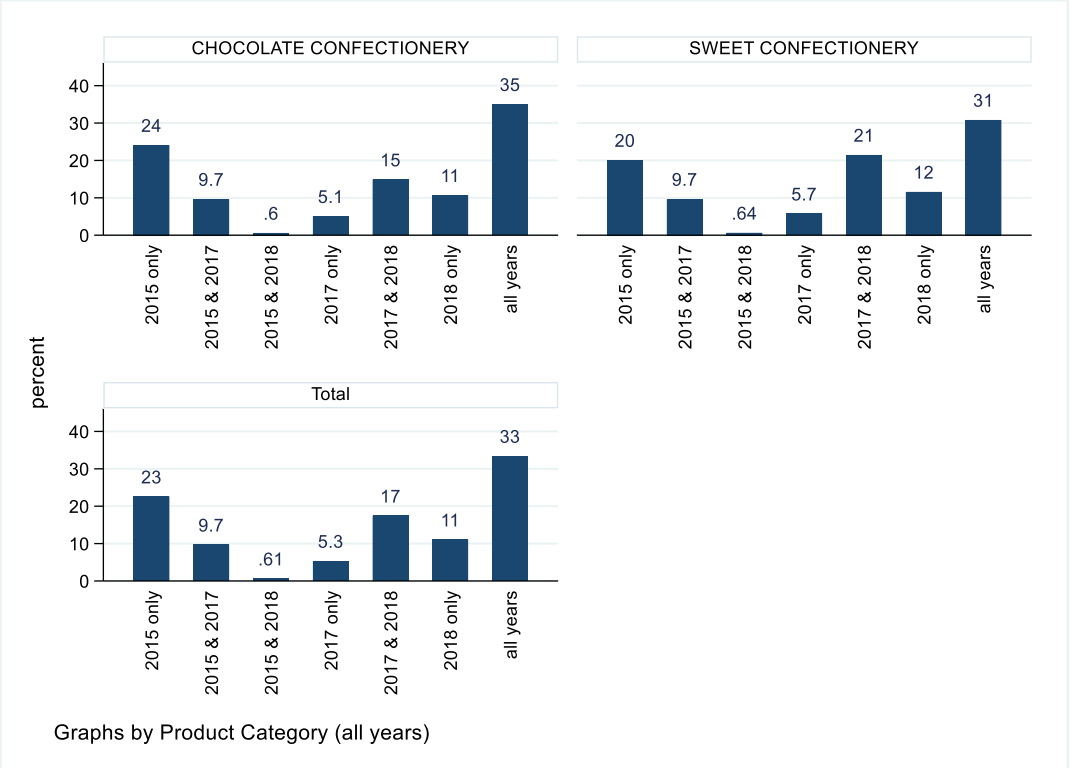


Figure 11c. Availability of all products, branded or unbranded (%)

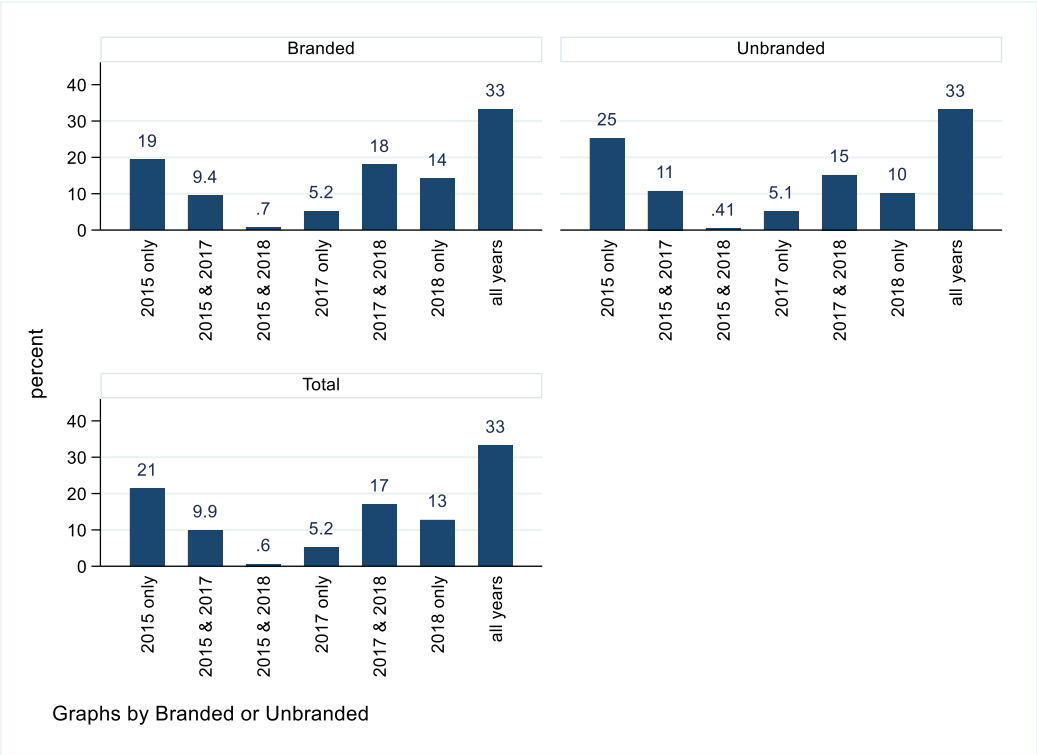


Figure 11d. Availability of single serve products, branded or unbranded