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How did the UK Soft Drinks Industry Levy (SDIL) Influence Consumer and Producer Behaviours, and what Aspects of the Policy Contributed to these Impacts? - A Narrative Literature Review

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ABSTRACT

➢ ***Background:***

Many fiscal policies have been implemented worldwide to reduce SSB consumption due to the health implications surrounding SSBs. These usually comprise a tax on soft drinks with added sugar, but the design and structure of the tax vary across jurisdictions. As part of measures to tackle childhood obesity, in 2016, the UK government announced the Soft Drinks Industry Levy (SDIL), which came into effect in 2018. The main aim of the levy was to incentivise producers to reformulate their drinks to contain less added sugar. The SDIL was unique in its design as it adopted a two-tiered tax rate based on the sugar concentration of the drinks and a two-year gap between its announcement and implementation.

➢ ***Aim:***

To provide an up-to-date understanding of the positive and negative impacts of the tax on producer and consumer behaviours and recognise the aspects of the policy which contributed to these outcomes.

➢ ***Objectives:***

Firstly, perform a literature review to identify the impact of the SDIL on purchasing and consumption of SSBs and industry responses to the levy. Next, discuss how the SDIL influenced the behaviours of producers and consumers based on the results of the literature review. Then, explore what aspects of the levy contributed to these changes. Finally, provide recommendations to increase the effectiveness of the SDIL.

➢ ***Methods:***

A narrative literature review was conducted. The electronic databases Google Scholar, PubMed, Embase, and Scopus were systematically searched for relevant literature, which was then screened for inclusion using the eligibility criteria. Data from the ten eligible studies were extracted and summarised in tabular form, which highlighted the study aim, methodology, study period, main outcomes, major findings, and limitations of the chosen studies. This table was then used alongside notes made on the individual studies to identify and group the key outcomes within the literature, which were then organised and presented as a textual description.

➢ ***Results:***

A total of six outcomes were explored in the ten chosen studies. These were changes in sales of soft drinks following the levy, reformulation activities, changes to sugar purchased through SSBs, pricing changes, and changes in domestic turnover of soft drinks companies. The review revealed that the SDIL led to a reduction in sales of taxed drinks and an increase in sales of untaxed drinks. The overall volume of sugar purchased through SSBs decreased. Reformulation was the most common industrial response to the SDIL. Some companies responded with price increases on taxed and diet/no sugar products, but consumers were unresponsive to pricing changes.

➢ ***Conclusion:***

The SDIL was successful in reducing sugar consumption from SSBs. Reformulation by industry contributed more to this outcome than consumer behaviour changes. The tiered design, clear threshold to avoid tax, and the two-year gap between announcement and implementation of levy accelerated the reformulation responses. The research concluded that the SDIL would benefit public health without harming the UK soft drinks industry. However, multiple interventions need to be pursued simultaneously to the SDIL to reduce the health impacts of SSB consumption.

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ABBREVIATIONS

SSBs – Sugar-Sweetened Beverages
T2DM – Type 2 Diabetes Mellitus
HDL - High-Density Lipoprotein
SDIL - Soft Drinks Industry Levy
PE – Physical Education
PHE – Public Health England
WHO – World Health Organisation

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CHAPTER ONE INTRODUCTION

➢ *Sugar-Sweetened Beverages and their Health Impacts*

Sugar-sweetened beverages (SSBs) comprise a wide variety of non-alcoholic drinks that contain added caloric sweeteners (sucrose, high fructose corn syrup, or fruit juice concentrates), including sugar-sweetened carbonated drinks, fruit drinks, sports drinks, and sweet teas (1-4).The consumption of SSBs has increased worldwide in recent decades due to their wide availability and affordability, aggressive marketing, and increased urbanisation.

SSB intake has been linked with several adverse health outcomes, with some associations, such as SSB consumption and weight gain, being better studied than others (5). For example, Ruanpeng et al. (6) conducted a meta-analysis of eleven studies on consuming SSBs and the risk of being overweight/obese, which concluded that there is a statistically significant association between the consumption of SSBs and weight with a 1.18-fold increase in the risk of being overweight and obese. Another meta-analysis of 7 prospective cohort studies conducted by Qin et al. (7) demonstrated the risk ratio of obesity was 1.20 (95% CI 1.10-1.31) between the highest to lowest SSB consumption categories. A systematic review on intake of SSBs and weight gain by Malik et al. (2) concluded a positive association between SSB consumption and weight gain and obesity. As part of an intervention to reduce consumption of carbonated drinks among UK school children, a randomised controlled trial was carried out on 644 7–11-year-old students (8). This study showed that students of the control group had a significantly higher BMI and a 7.7% higher incidence of obesity than the intervention group after one year.

Various mechanisms can explain the association between SSBs and weight gain. Firstly, the added sugars in these drinks increase blood glucose levels and the amount of calorie intake that exceeds energy balance, thereby directly promoting weight gain (2). SSBs, including soft drinks, are examples of isoenergetic liquid food that produce a less satiating effect and lack a compensatory mechanism in comparison to solid food consumption. Hence, consumption of these caloric drinks does not replace other forms of food, causing no reduction in total food intake and subsequently resulting in additional weight gain (2, 9). Behavioural mechanisms such as coupling SSB intake with social reasons and finding other healthy alternatives unappealing due to their low sugar content also promote weight gain among consumers, especially children (5).

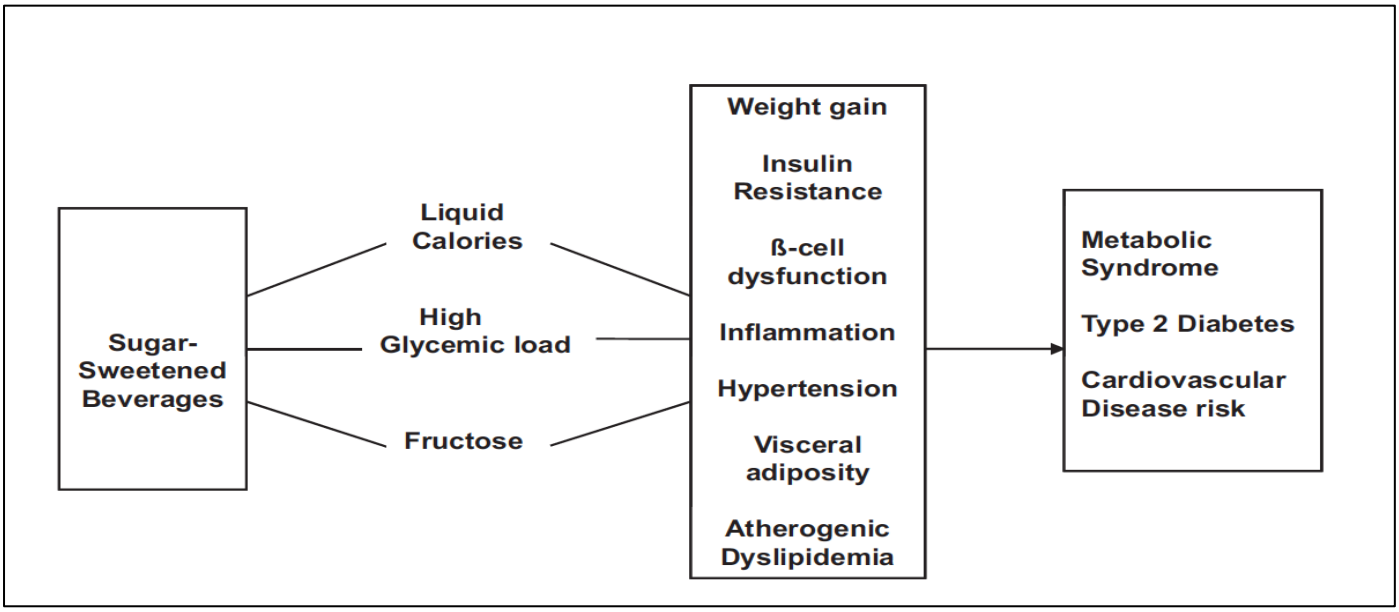

Fig 1 Mechanisms Linking SSBs to Health Outcomes (3)

There is also an increased risk of cardiovascular diseases, metabolic syndrome and T2DM due to the large fructose fraction, high glycaemic load and liquid calories found in SSBs, as shown in figure 1 (3). Daily SSB consumption is associated with an increased risk of T2DM by 19% due to their high glycaemic load, which has direct effects on pancreatic islet cells and causes insulin resistance (5). In addition, fructose leads to greater insulin resistance by increasing plasma triacylglycerol levels and subsequently reducing insulin and leptin production in peripheral tissues (2, 9). Moreover, refined carbohydrates such as sugar in SSBs elevate triglyceride levels and blood pressure whilst lowering HDL cholesterol, thus increasing the risk of cardiovascular diseases (5). Dental caries is also strongly associated with SSB consumption. At pH 6.0, dentine erosion occurs, followed by the development of dental caries at pH 5.5. As most SSBs are acidic with pH ranges from 2.5 to 3.3, the consumption of these beverages can both initiate and progress caries (1).

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➢ *The UK Soft Drinks Industry Levy*

Based on the evidence surrounding the health implications of consuming SSBs and the excess health care costs generated, the Scientific Advisory Committee on Nutrition (SACN) recommended minimising the consumption of SSBs in adults and children (10). Following on from this, as part of the UK government's 'Childhood obesity: a plan for action' commitments, HM Revenue and Customs introduced the Soft Drinks Industry Levy (SDIL) Regulations 2018 (commonly known as the sugar tax) to the public in 2018 (10). The levy was introduced with the objective of tackling childhood obesity by encouraging beverage manufacturers to reformulate their overall product ranges to contain less added sugar. This was expected to help consumers choose lower/no sugar alternatives and reduce portion size (11, 12). Companies that don't alter the sugar content of their products would pay the levy, which was predicted to raise a revenue of £530 million per year, later changed to £240 million per year (13). The government announced that the generated revenue would be used to fund healthy school breakfast clubs and upgrade PE equipment and sports facilities in schools through a Healthy Pupils Capital Fund (12, 13). The tax structure, design and primary objectives of the UK SDIL are illustrated further in table 1 (11-14).

Table 1 Characteristics of the UK SDIL (11-14)

Tax Design	**Specific (unit-based) - Volume tax based on sugar concentration threshold.**
Who the tax is levied on	Distributors, importers, and manufacturers of soft drinks containing added sugar will be levied. The levy does not apply to small businesses with a low production volume of <1 million litres/year or importers from the smallest producers.
Dates implemented	Announced: March 2016 Public consultation: August 2016 Laid before the House of Commons: 17th January 2018 Implemented: 6th April 2018
Taxable categories	All soft drinks that contain added sugar of at least 5g per 100ml during production.
Exempted categories	• Milk replacement drinks and drinks that contain 75% milk or more • Alcohol replacement drinks (less than 0.5% alcohol by volume) • Liquid drink flavouring added to drinks/food • 100% vegetable/fruit juices • Powders mixed in liquids and served in open containers
Tax rate	Multi-tiered tax design as follows: <u>No levy category</u> No charge on drinks with sugar content less than 5g/100mL. <u>Low levy category</u> £0.18 per litre on drinks with a sugar content between 5-8g/100mL. <u>High levy category</u> £0.28 per litre for drinks with a sugar content greater than 8g/100mL.
Stated purpose	• Reduce childhood obesity through the removal of added sugar from soft drinks. • Encourage producers to reformulate their beverages to contain less added sugar. • Reduce portion sizes of drinks with added sugar. • Encourage importers to import reformulated products with less added sugar. • Encourage consumers to switch to healthier alternatives.
Framing	Reformulations in the soft drinks industry. Reduce sugar consumption from soft drinks. Revenue generation to fund healthy school breakfast clubs and school sports.

➢ *Existing Sugar Taxes*

Several fiscal policies have been implemented globally in recent years to discourage the consumption of SSBs due to their associated health risks, which place a significant burden on health systems worldwide (4, 5). These taxes are very different to 'sin taxes' implemented for other unhealthy products such as alcohol and tobacco (15). Sin taxes involve the consumer facing the tax in the price they pay for the product when purchasing it, helping to reduce consumption levels by directly impacting consumer decisions. However, the tax on SSBs works in different ways. In countries such as Mexico (16), Portugal (17), France (18), and Chile (19), the tax was implemented on a national level. In contrast, it was implemented locally in the US cities of Philadelphia (20) and Berkeley (21). Most taxes, such as in Mexico, Catalonia (22), and Berkeley, were only levied on drinks with added sugar, whereas some countries, such as France (18, 23), taxed all soft drinks despite containing sugar or not. The tax rate and how the tax is levied also differ across jurisdictions (24). Some taxes are based on the sugar content and volume of the beverage, whereas other taxes do not vary with either. The impacts of sugar taxes worldwide differ based on the nature of the tax, but most have proven to affect consumption levels as intended. For example, in 2014, Mexico implemented an excise tax on SSBs, of one peso per litre, which led to a decrease in purchases of taxed SSBs and an increase in purchases of healthier alternative drinks such as bottled water (25). Additionally, a tax on SSBs in Berkley resulted in a significant reduction in SSB sales by 9.6% and an increase in untaxed drinks and bottled water by 3.5% and 15.6%, respectively, one-year post-implementation (26, 27). Similar deterrent effects on consumption trends were expected from the UK SDIL; however, these depend heavily on industry responses to the levy.

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➢ *Expected Outcomes of the SDIL*

A health impact assessment of the UK SDIL by Briggs et al. (28) developed a conceptual model of the possible industry responses to the SDIL (figure 2), which include reformulation to reduce the sugar content of their products, an increase in price to pass on the tax to consumers, and activities to change the market share of low-sugar, mid-sugar, and high-sugar drinks. The authors claimed that these responses would contribute to a reduction in the quantity of SSBs purchased and liquid calories consumed.

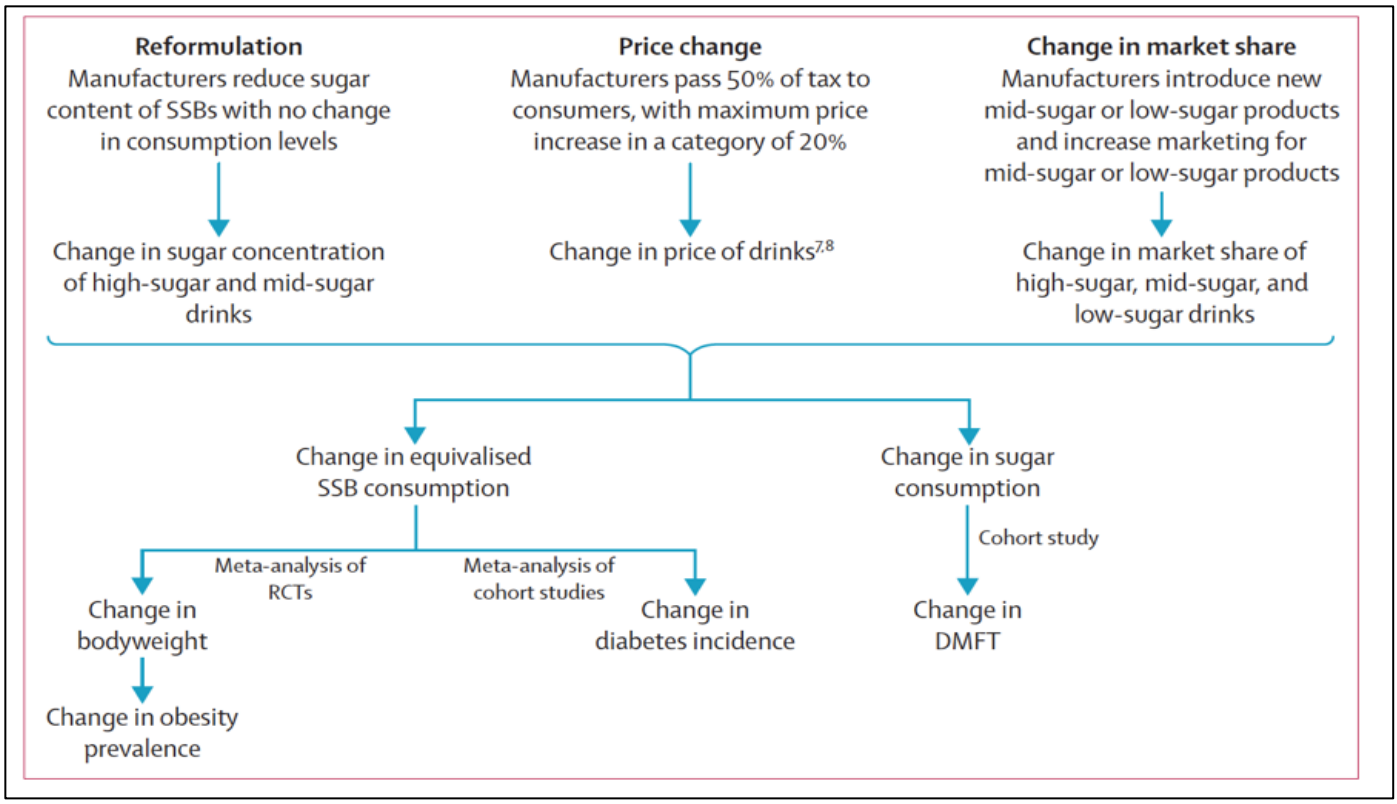

Fig 2 Conceptual Model of Possible Industry Responses (28)

The UK government stressed that the sugar tax is a tax on the beverage industry and not on the consumers; therefore, companies should reformulate their products instead of passing on the levy to consumers (12, 13). Most previous taxes on SSBs had a flat rate (24) and did not provide sufficient incentive for manufacturers to reformulate their drinks. In contrast, the tiered nature of the UK SDIL is expected to prompt reformulation by industry (12, 28). However, some companies would choose to do otherwise as reformulation is a challenging and risky move that could significantly alter the taste of their product and push consumers towards competing alternative brands (29). In situations such as this, it is expected that manufacturers would opt not to reformulate and pass on the levy to consumers through price increases (28, 29). Price changes can lead to reduced consumption, but the size of the reduction and who will be most affected by prices depends on the consumers' price elasticity of demand (the %change in the quantity demanded that results from the price increase) (26). Data collected from various countries showed that as the % change in soft drink prices increased, there was an increase in the % change in consumption too. This data was used to estimate the elasticity of the demand for SSBs to be around -1.2, meaning that for each 10% increase in SSB price, SSB consumption will decrease by 12% (26). Additionally, the pooled own-price elasticity of demand for SSBs in 9 studies included in a meta-analysis on SSBs and obesity rates by Escobar et al. (30) was -1.30. Another meta-analysis by Powell et al. (31) on the potential effectiveness of beverage taxes found an overall mean price elasticity on demand for SSBs to be -1.21. Similarly, Andreyeva et al. (32) concluded the price elasticity of demand for SSBs to be -0.79. Therefore, it is expected that UK soft drink consumers would respond to price increases by substituting taxed drinks for other beverage types or no sugar alternatives (26).

Reduced consumption rates are expected to offer the potential for health improvements in obesity, diabetes, and dental caries, according to Briggs et al., as shown in figure 2 (28). However, Lean et al. (33) projected a minimal reduction in total calories consumed in UK children ages 11-18 if sugar is removed from SSBs, which could result in reduced weight gain if maintained over several years (figure 3). Therefore, the study concluded that although taxation will reduce SSB consumption, the reduction produced will not be sufficient to impact obesity levels substantially. Similarly, using a demand model, Tiffin et al. (34) concluded that the overall impact of SSB taxation on calorie consumption is likely to be small despite the relatively large changes in SSB household demand produced by the tax. On the contrary, a narrative review on the impact of taxation on dental caries demonstrated an association between SSB taxes and a significant decrease in dental caries and dental care costs based on modelling and simulation studies (1). Despite the conflicting evidence and an inadequate number of studies attempting to model the impact of a sugar tax on population health outcomes, PHE and WHO have concluded that taxing SSBs would be beneficial to population health (10, 35).

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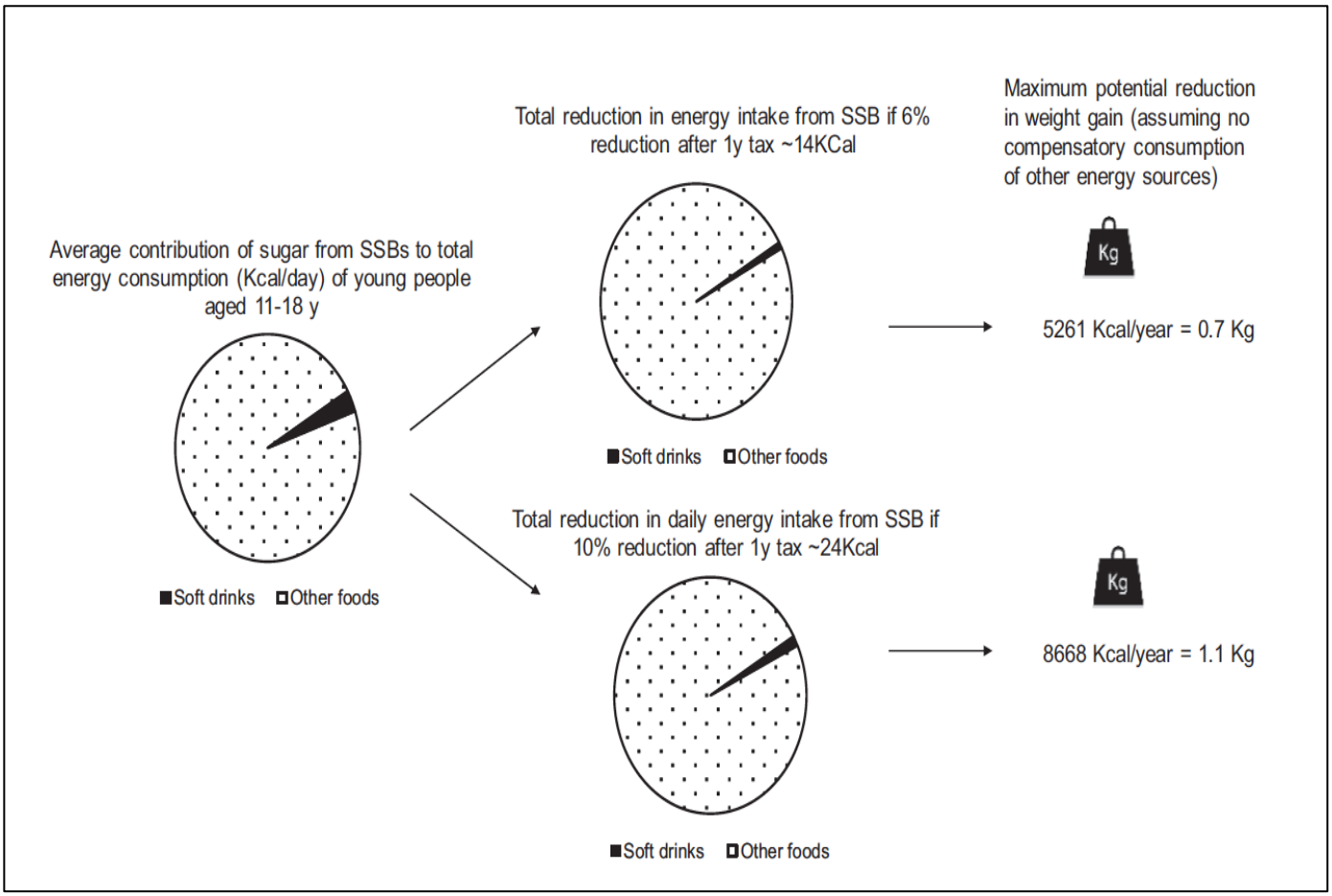

Fig 3 Projected Maximal Impact on Energy Intake and Weight Gain in UK Children (33)

Furthermore, low socioeconomic status populations face a disproportionate burden of illnesses related to poor diets fuelled by increased consumption of SSBs through targeted marketing (27, 34). A latent class analysis on beverage purchases in British households concluded that households that purchase high volumes of SSBs were more likely to be of low socioeconomic status (36). When introducing the policy, there were expectations among the policymakers that the SDIL would be most beneficial to these communities. As these populations are the most price sensitive, they would be expected to switch to an alternative such as water available at little or no cost, thus improving their health and cutting spending on beverage purchases (5). Although there are concerns regarding the regressive nature of sugar taxes, the expected progressive benefits to the health of low-income groups are supposed to alleviate the regressive effects (37).

➢ *Rationale, Aims and Objectives*

There is plenty of existing research dated before the implementation of the SDIL exploring the potential outcomes of the levy (28, 29, 33, 34, 37), which demonstrated promising results in terms of reduced consumption and reformulation. However, these models don't account for any unintended consequences that could occur. Moreover, several predictions have been made based on case studies from SSB taxing in other countries. Although previous SSB taxes in other countries have proven to be successful in lowering SSB consumption (18-20, 22, 24, 25, 27), the taxation structure adopted by the UK SDIL is unique in design and was conducted over a different period (11-14). In addition, several population-level contextual factors contribute to the success of a policy. Therefore, findings from one country cannot be generalised to another (1). Additionally, manufacturers and importers had several options available, as demonstrated above (28, 29), creating significant uncertainty surrounding how the industry would respond to the levy. Therefore, a thorough review of how manufacturers responded to the levy and how consumer purchasing behaviours changed following the SDIL is required.

Several jurisdictions across the globe, such as Ireland, Portugal and South Africa, have decided to implement the unique tiered design of the SDIL (38). Additionally, there are gaps in the literature on why the policymakers allowed a two-year lead time between the date of announcement and implementation of the policy (12, 13) and how this affected the outcomes of the policy. Hence, it is vital to establish what aspects of the policy contributed to its impacts on producers and consumers of SSBs.

Since the tax was only introduced a few years ago, it is too early to establish the health outcomes that resulted from it. Determining the specific contribution made by SSBs to differences in health outcomes is likely to be challenging due to the

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complexity of the diseases involved. For instance, several other diet and lifestyle factors contribute to cardiovascular health and T2DM and adjusting for confounding factors as such will be highly time-consuming (39).

The overall aim of this literature review was to provide an up-to-date understanding of the positive and negative impacts of the SDIL on producer and consumer behaviours and recognise the aspects of the policy which contributed to these outcomes. Therefore, the research question is, "How did the UK Soft Drinks Industry Levy (SDIL) influence consumer and producer behaviours, and what aspects of the policy contributed to these impacts?". This research can determine if a tax on SSBs was sufficient to address the health concerns associated with SSBs or if there is a need for additional action from the government.

➢ *Objectives:*

- Perform a literature review to identify the impact of the SDIL on purchasing and consumption of SSBs and industry responses to the levy.
- Based on the results of the literature review, discuss how the levy influenced the behaviours of the producers and consumers.
- Explore what aspects of the levy contributed to these changes.
- Provide recommendations to increase the effectiveness of the SDIL.

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CHAPTER TWO METHODOLOGY

➢ *Methodological Approach*

A literature review was required to describe the impact of the UK SDIL on consumer and producer behaviours. The purpose of this review was to provide a descriptive account of the evidence available on the outcomes of the SDIL; hence a narrative review was deemed the most suitable among the variety of review types presented by Kastner et al. and Xiao and Watson (40, 41). As the SDIL is a recently implemented policy, the literature available on the impacts of the levy is limited. This highlights the importance of using a methodology that widens the scope of literature that can be included, such as a narrative literature review. For example, a narrative review allows the integration of both quantitative and qualitative evidence, whereas many other types of review focus heavily on qualitative data (41). Also, choosing a narrative review favoured this dissertation's available time and resource limitations (40, 41). There were no ethical considerations involved in this dissertation.

This literature review process was guided by the eight steps proposed by Xiao and Watson, shown in figure 4 (40).

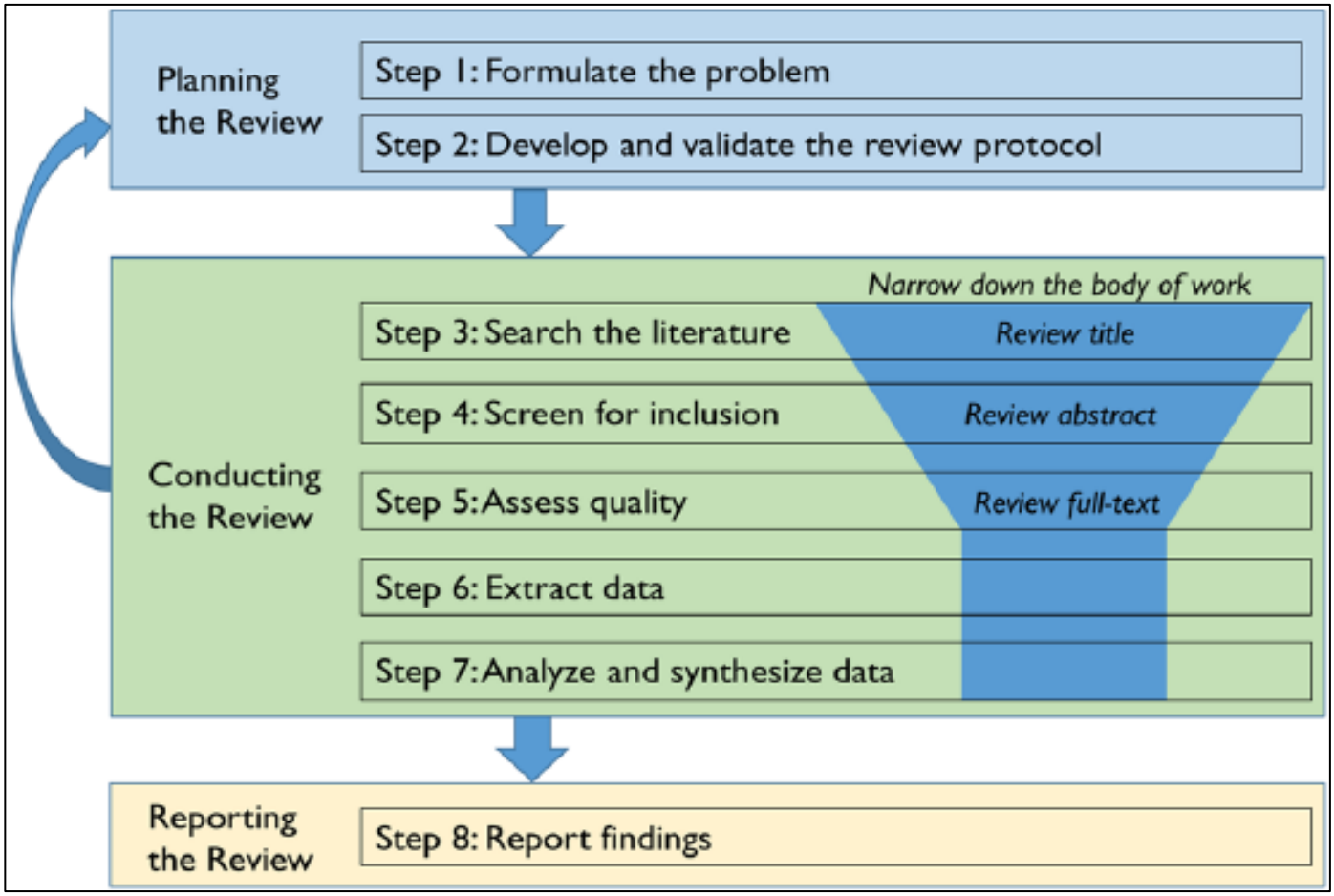

Fig 4 Process of Literature Review by Xiao and Watson (40)

➢ *Search Strategy*

The electronic databases used in this search were Google Scholar, PubMed, Embase, and Scopus. Various databases were used to ensure multiple disciplines were covered, reducing the risk of relevant articles being excluded from the review. Google Scholar and PubMed are free search engines that contain a vast amount of literature. Embase and Scopus were included as they usually contain journals not found on Google Scholar and PubMed. The search for this review was conducted between 24th – 30th June 2022. Numerous combinations of keywords and phrases were trialled in all four databases to determine the amount of literature available before confirming the final set of key terms. In order to verify that the keywords were appropriate, the search results from the trial search were then checked against already known primary studies. The search terms used in the final search in all four databases were: (UK SDIL OR UK sugar tax OR UK soft drinks tax OR UK levy) AND (impact OR effect) AND (SSB purchasing OR SSB consumption OR soft drinks purchasing OR soft drinks consumption OR industry response OR producers response OR manufacturers response). As seen above, several synonyms were included in the search to avoid excluding relevant articles. The search results were limited to articles published since 2016 (the announcement of the SDIL) and in English only. Moreover, due to time constraints, searches were restricted to titles and abstracts in databases such as Google Scholar, where a large number of articles were generated. The search was ended when repeated searches resulted in the same articles and no new results.

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➢ *Study Selection and Eligibility Criteria*

After identifying records through the database search, duplicates were removed after checking for matching date, title, and author. This narrowed down the results, which were then screened individually to remove articles with content not applicable to the research question and eligibility criteria. The screening followed a three-step process. Firstly, the articles were screened for inclusion based on their titles, followed by an assessment of their abstracts if the titles did not reveal sufficient information for exclusion. Finally, a full-text review of the articles was carried out to confirm eligibility. The overall process was inclusive as studies were included if in doubt. It is suggested that at least two reviewers work independently in appraising if the studies match the eligibility criteria (40). However, this was not possible as the review was performed individually due to the restrictions of the dissertation task.

The inclusion and exclusion criteria used in the screening process are presented in table 2. These criteria covered the study type and methodology, study topic, publication date, and setting. This review was about the levy's influence on consumer and producer behaviours. Hence, studies that assessed changes in consumer purchasing patterns, industry marketing responses, and industry production responses were eligible for inclusion. Studies on the perceived or anticipated effectiveness of the levy were excluded because this review focused solely on the actual impacts of the SDIL that took place since its announcement. Moreover, studies assessing public opinions, industry opinions and portrayal of the SDIL in the media were excluded too. The review included both primary and secondary research, but commentaries, opinion pieces, conference abstracts and editorials were excluded. Articles using both qualitative and quantitative methods were included in the report to provide a broader understanding of the topic. For example, quantitative research will measure the direct impacts of the levy, such as changes in SSB sales, whilst qualitative research will explore the experiences of consumers and producers when responding to the SDIL. Although the SDIL was only implemented in 2018, studies published since the announcement of the SDIL in 2016 were included. Furthermore, there were no restrictions on study population type or size, although only studies done in the UK were included.

Step 5 of Xiao and Watson's literature review process (figure 4) to assess quality was not carried out in this review. Quality assessment is not a crucial step because the chosen type of review is a narrative review (40). Kastner et al. (41) described narrative reviews as being "less concerned with assessing evidence quality and more focused on gathering relevant information". In addition, the SDIL is a recently implemented policy, therefore, the research available on its impacts is limited. Therefore, excluding research due to methodological quality would significantly minimise the scope of literature that can be included.

Table 2 Inclusion and Exclusion Criteria

Inclusion criteria	**Exclusion criteria**
Type of study and methodology Primary or secondary research Published literature Qualitative, quantitative, and mixed methods.	Type of study and methodology Editorials, commentaries, conference abstracts, and opinion pieces. Unpublished and grey literature
Topic Studies assessing the impact of the levy on one or more outcomes associated with consumer behaviours and industry responses.	Topic Studies assessing consumer and industry opinions or media responses. Studies about anticipated impacts of the tax. Studies concerning sugar taxes in countries other than the UK.
Published in or after 2016	Studies done outside the UK

➢ *Data Extraction and Analysis*

Following Xiao and Watson's (40) guidelines on conducting a narrative review, an informal data extraction process was carried out. Each chosen paper was read individually at least twice to allow familiarisation with the content, notes were made on each paper, and key findings were highlighted. The data from the eligible studies were then extracted and summarised in tabular form in Appendix 1, as Green, Johnson, and Adams suggested (42). This table highlights the study aim, methodology, study period, main outcomes, major findings, and limitations of the chosen studies. This table was used alongside the notes to identify and group the key outcomes of the selected studies (Appendix 2), which were then reviewed and refined prior to data synthesis. Xiao and Watson described the data synthesis process of narrative reviews as a "narrative juxtaposition of evidence" (40). Hence, when writing the synthesis, the grouped findings elicited from the table and note-taking process were organised and presented as a textual description.

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CHAPTER THREE RESULTS

A flow diagram of the study selection process is illustrated in figure 5. The literature search conducted in the four databases yielded a total of 934 results, from which 243 duplicates were removed. From the remaining 691 articles, 625 were removed after reading the titles. Most studies were excluded because their study question was about the sugar tax in countries other than the UK, or outcomes related to the impact of the SDIL were not assessed. The abstracts of the remaining 66 articles were read, and 15 of those were suitable for full-text screening. Following the full-text screening of the 15 articles, ten studies were eligible to be included in the review. The reasons for the exclusion of articles at this stage have been outlined in figure 5.

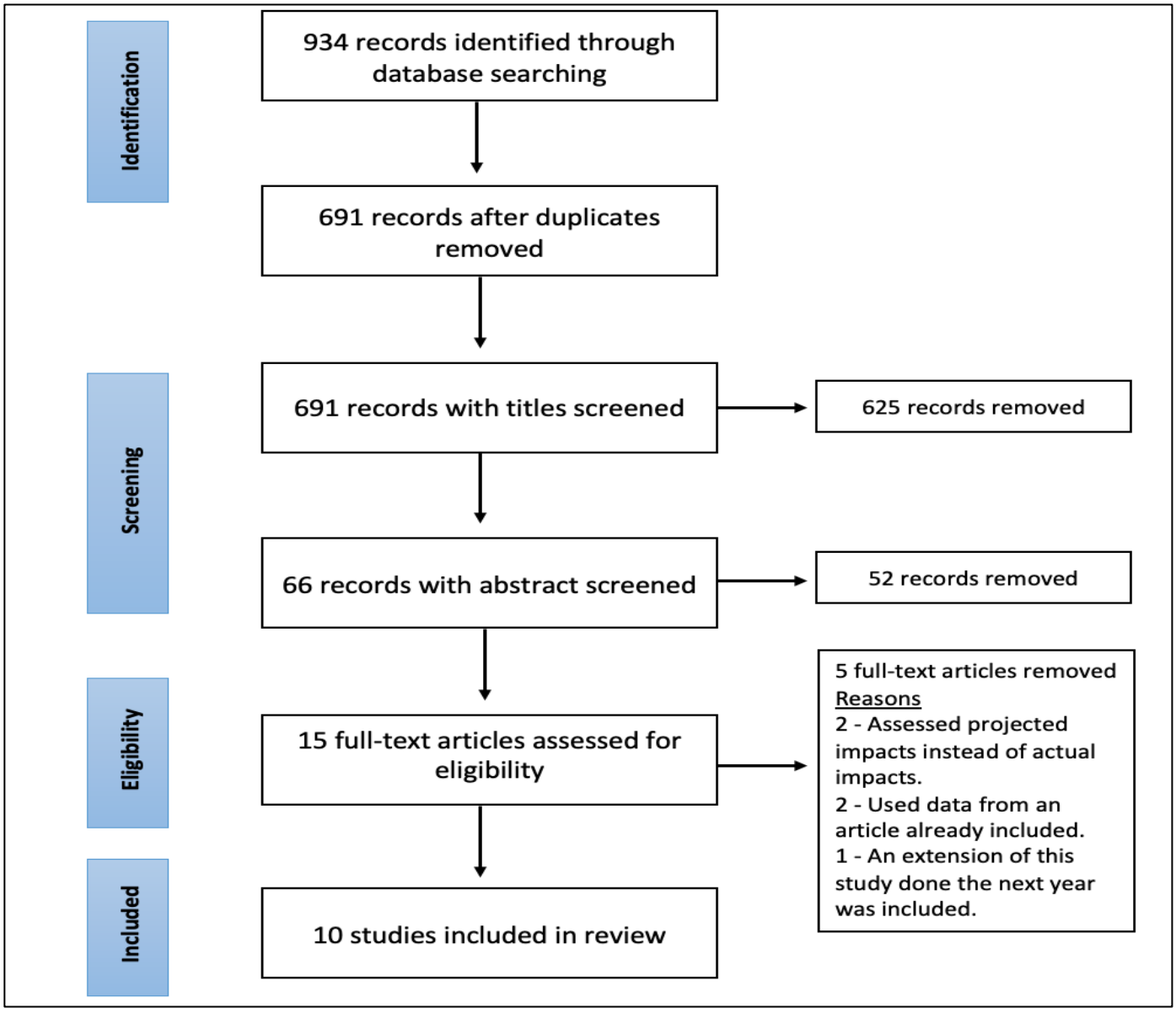

Fig 5 Flow Diagram of the Study Selection Process.

➢ *Study Characteristics*

Appendix 1 summarises the main characteristics of the eligible studies. Nine studies used quantitative methods, whereas one study used qualitative methods. Quantitative methods include analysis of data on sales, domestic turnover, nutrient composition information, and household purchasing data (38, 43-50). The study using qualitative methods involved semi-structured telephone interviews (51). Of the ten chosen studies, five explored outcomes related to changes in sales of soft drinks (43, 45-47, 50). The other common outcome outlined by the studies was reformulation, and six of the ten chosen studies investigated reformulation activities following the SDIL (38, 43, 46, 48, 49, 51). Three selected studies also explored changes to sugar purchased through SSBs (43, 47, 50), whilst another three explored pricing changes to soft drinks following the levy (38, 46, 51). Only one study investigated the impact of the SDIL on the domestic turnover of soft drinks companies (44). Although packaging alterations and portion size changes were expected outcomes, the studies included did not cover these to a sufficient degree to be included in the review results. The key findings identified in the literature review are explained in detail below.

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➢ *Findings*

- *Sales of Soft Drinks*

The literature review revealed a decrease in the sales of taxed beverages and an increase in the sales of untaxed beverages following the announcement and implementation of the SDIL. A study conducted by Bandy et al. revealed that the sales of soft drinks with sugar content >5g/100ml, belonging to the low levy and high levy categories, decreased by 16% between 2015 and 2018. On the contrary, sales of soft drinks with sugar content <5g/100ml increased from 43% in 2015 to 48% in 2018. Overall, the total volume sales of soft drinks increased by 7% between 2015 and 2018 (43). PHE also described the same trend as it reported a 22% decrease in the proportion of sales of drinks in the low levy and high levy categories whilst showing a 30% increase in sales of drinks with no levy attached between 2015 and 2019 (47). Moreover, Dickson et al. studied the sales of levied, reformulated, and non-levied brands. The study concluded that brands that reformulated did not experience significant reductions in volume sales, but an 18% decrease in sales volumes was seen in brands that did not reformulate and remained subject to the levy upon implementation of the SDIL. On the other hand, the volume sales of diet/no sugar products increased by approximately 50% between 2015 and 2020 (46). Considering sales in the eating out of home sector, Cornelsen et al. concluded that SSBs sold per customer decreased by 11.04% at 12 weeks and 9.34% at six months post-implementation of the levy (45). The study by Pell et al. concluded that the volume of purchased high levy tier and low levy tier drinks decreased by 41.6% and 85.9%, respectively, after the implementation of the SDIL. The study established that there was no statistically significant reduction in the volume of total soft drinks purchased as the decrease in sales of taxed drinks was offset by increased sales of other soft drinks (50).

- *Sugar Purchased Through SSBs*

The literature review revealed a negative trend in the amount of sugar purchased through SSBs following the announcement and implementation of the SDIL. Pell et al. concluded that the sugar consumption from all soft drinks decreased by 30g per household per week, one year after the implementation of the levy, despite some increases in sugar purchased from untaxed drinks (50). In addition, PHE concluded that total sugar sold from SSBs decreased by 35.4% between 2015 and 2019 (47). The results from Bandy et al.'s study were consistent with these findings as they showed a 29% decrease in the total volume of sugars sold from SSBs, although there was a 24% increase in the volume of sugars sold from untaxed soft drinks between 2015 and 2018. The greatest decrease in mean sugar content of SSBs was seen in 2017-2018 (43). Furthermore, PHE's sugar reduction progress report added that the average sugar content of drinks sold in the eating out of home sector decreased by 38.5% between 2017 and 2019 (47).

- *Domestic Turnover of Soft Drinks Companies*

Law et al. revealed a statistically significant negative impact on the level (-5.6%) and trend (-0.5%) of domestic turnover of soft drinks companies in the two-year gap between the announcement and implementation of the SDIL. However, the soft drinks turnover returned to its pre-announcement growth rate after the levy was implemented in April 2018. There was no evidence of a loss in GDP contribution from the industry. As these values were controlled for changes in prices and trends in manufacturing, the study concluded that the decrease in the volume of drinks sold due to reasons not related to price fuelled the short-term negative impact on domestic turnover (44).

- *Reformulation*

The literature reviewed highlighted several ways the SSB industry made changes to their product portfolios in response to the SDIL, and reformulation was the most described. Most soft drink brand owners reformulated their products by substituting other non-caloric sweeteners for sugar or reducing the total sugar concentration of their products. Dickson et al.'s study on the top 100 soft drink brands illustrated that reformulation was responsible for 83% of the total decrease in consumption of calories induced by the UK SDIL, leading to a reduction of 4.9 billion calories per week among the drinks studied by the end of January 2020. It was revealed that calorie intake from a brand reduces by 50% six months after it is reformulated compared to what it would have been if not reformulated. However, this study also showed a modest reduction in calorie consumption in these brands prior to the announcement. Dickson et al. clarified that these trends were a result of the lower calorie content of drinks and not due to a reduction in drink consumption (46).

According to a study conducted by Scarborough et al., the proportion of drinks to be included in the levy fell by 19.5% just 50 days prior to the implementation and by 30.7% 50 days after the SDIL was implemented. They concluded that the announcement of the levy led to reformulation changes only slowly at first but very rapidly just before the implementation (38). Hashem et al. added that the proportion of soft drinks in the high levy category (>8g/100mL) decreased from 71% to 18% between 2014 and 2018, whilst the proportion of soft drinks in the no levy category (<5g/100mL) increased from 16% to 63%. The proportion of drinks in the low levy category (5-8g/100mL) increased slightly from 13% to 19%. Overall, there was a 42% reduction in the mean sugar content of soft drinks between 2014 and 2018 (49). Another study by Bandy et al. concluded that the announcement and implementation of the SDIL accelerated the rate of change in the sugar content of SSBs. This study demonstrated a 28% reduction in the mean sugar content of soft drinks between 2015 and 2018, with annual changes of -7%, -10%, and -13%. Six of the top ten soft drinks companies included in this study reformulated over 50% of their products eligible for the sugar tax by 2018 (43). The reviewed studies also revealed that most reformulation activities by the companies took place between the announcement and implementation of the levy, and the trend in these activities flattened off after the implementation of the levy (38, 43, 46, 49). Additionally, Scarborough et al. and Dickson et al. suggested that most manufacturers opted to reformulate their products to just

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below the threshold shown by a peak in the proportion of SSBs with sugar content between 4.0g/100mL and 5.0g/100mL seen following the implementation of the SDIL (38, 46).

Although some manufacturers reformulated all their products, some resorted to paying the levy in order to maintain the sugar content of their key brands. Forde et al. identified that customers of stronger brands preferred to pay more than to consume a reformulated product, especially if the brand's strength was oriented around the product's taste. On the contrary, health-oriented brands found reformulation more feasible. Also, large companies with pre-existing lower sugar alternatives in their portfolio were less likely to reformulate. It was also revealed that most companies explored other options before resorting to reformulation or waited to observe the outcomes of their competitors' reformulation. Overall, this study concluded that the choice to reformulate was influenced by consumer interests, competitors' reactions, brand identity and previous positive experiences when responding to a policy (51).

Furthermore, the literature review demonstrated that there were no reformulation activities among the brands exempt from the SDIL despite their high sugar content. For example, Chu et al. revealed that products targeted at children, such as fruit juices and smoothies, which were exempt from the levy had a mean sugar content of 10.07g/100mL and 11.6g/100mL, respectively. The study highlighted that there were no changes in their sugar content due to a lack of incentive to reformulate (48).

- *Pricing Changes*

The study by Dickson et al. explored the pricing changes made by the industry in response to the SDIL. Levied soft drinks experienced a sharp increase in their price once the SDIL was enacted in April 2018. The price of levied soft drinks increased by 48ppl to 50ppl, although the sugar tax only accounted for a charge of 28.8ppl on a full sugar drink (a 46% price increase). This shows that the tax was over-shifted by a factor of almost two. Also, diet and zero sugar products experienced price increases by 8ppl to 10ppl a few weeks following the implementation of the SDIL, although these products are not eligible for the levy. Reformulated brands and other levy-exempt products showed no statistically significant price increases. The authors of the study added that it is likely that the demand for SSBs is inelastic as only a 20% decline in sales was reported when the price of levied drinks went up by 25% (46). Scarborough et al. also highlighted changes in the pricing of branded and own-brand levied drinks, which differed significantly. This study showed an 11.8ppl price increase on branded higher levy tier drinks but a 62.5ppl decrease on own-brand higher levy tier drinks. On the other hand, there was a 17.4ppl decrease in branded lower levy tier drinks but a 68.6ppl increase on own-brand lower levy tier drinks. No significant changes were made to own-brand no levy tier drinks prices, but the price of branded no levy tier drinks increased by 2.6ppl (38). According to Forde et al., increasing the price of levy-eligible products was a typical response by strong brands with the least price-sensitive consumers, but some companies chose to maintain price uniformity among high and low sugar variants within their brand due to the challenges in running price promotions and communicating with consumers (51).

➢ *Limitations of Results*

There were several limitations among the studies included in the review, but the authors made maximal efforts to avoid the impact of these limitations on the study results. The limitations for each study are outlined individually in Appendix 2 and will be explained briefly in this section.

Most studies included in the review conducted analyses on secondary data obtained from various sources, including Euromonitor (43) and EPOS (45, 46) for volume sales data, Brandview (43), supermarket webpages (38, 48), and product packing (46, 49) for nutrient composition data, and ONS for data on domestic turnover of companies (44). Although the use of secondary data provides larger samples, maximises resources, and accelerates the pace of research, the accuracy of the study findings will be heavily dependent on the validity of the data provided by these secondary sources (52, 53). For example, although supermarket webpages and product labels are expected to provide up-to-date and accurate information on the contents of the products, this might not always be the case as manufacturers could claim that their products do not contain sugar whilst adding ingredients that already have sugar within themselves. Similarly, with sales and purchasing data obtained from Euromonitor and EPOS, there is insufficient transparency on the data collection methods used as the researcher did not participate in the data collection process and lacks knowledge of the intricacies involved (52, 54). Additionally, these secondary datasets did not include population demographic factors. Hence analyses of this data could not include the distribution of SSB sales based on geographic and socioeconomic factors. This type of limitation is commonly associated with secondary analysis as the data is not necessarily collected with a purpose that aligns with the researcher’s objectives (54). Although data sources such as Euromonitor and EPOS are anticipated to attract researchers from various disciplines, it is not feasible for their data to be appropriate for all purposes of the analysis.

On the other hand, Forde et al. (51) used semi-structured interviews to collect qualitative data on industrial marketing responses to the SDIL. These interviews were held over the telephone, lacking a good interview ambience and social cues (55). More importantly, the interviews happened one year after the implementation of the SDIL, which would have introduced recall bias. Similarly, recall bias may have been introduced in the two studies (47, 50) that investigated purchasing behaviour from data collected through consumer panels. These panels involved participants self-reporting their purchases which risks underreporting or overreporting purchases. Also, the households that participated in these panels are more likely to be from low socioeconomic statuses, leading to the over-representation of these groups of people in relation to others in the general population. This is an

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example of selection bias and makes the sample less representative of all soft drink consumers in the UK (56). Some of the other studies included in the review experienced sampling bias as the samples were too small to represent the target population. This limited the ability of the studies to produce generalisable results, thus compromising the validity of the studies (53, 56). For example, in the study by Chu et al. (48), only 7 of the drinks included were affected by the levy, and Hashem et al. (49) only analysed data collected from 9 supermarkets. Cornelsen et al. (45) only conducted their study in 1 chain of restaurants, so changes in sales could be due to menu changes and availability of drinks in that particular restaurant.

There were also limitations in the analyses of the studies included. For example, Pell et al. (50) estimated the size of the effect based on a counterfactual model, which involves an assumption that the pre-announcement trends would have continued, hence compromising the validity of the results. Also, as the SDIL was implemented amongst other sugar reduction strategies, changes observed could be due to other complementary activities that occurred as part of the strategies or due to the general trend in sugar reduction at the time. However, PHE (47) explored the impacts of the strategies that were implemented simultaneously to the SDIL and concluded that most changes made in that period were, in fact, attributed to the SDIL, hence minimising the impacts of this specific limitation.

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CHAPTER FOUR DISCUSSION

➢ *Summary of Findings*

The implementation of the SDIL led to a decrease in the sales of drinks in the low levy and high levy categories and an increase in the sales of drinks in the no levy category. Overall, there were no significant decreases in the volume of total soft drinks purchased. The volume of sugar purchased through all SSBs declined following the implementation of the tax, although there were some increases in the sugar purchased from untaxed drinks. The domestic turnover of soft drinks companies was negatively affected between the announcement and implementation of the levy but returned to its pre-announcement rate after the levy was implemented. Most companies responded to the SDIL by reformulating their products or paying the levy and passing it on to consumers. Most reformulation activities took place in the two-year period between announcement and implementation, and to sugar concentrations just below the threshold. It was also revealed that levied drinks and diet/zero sugar products experienced price increases following the implementation of the levy. However, this did not significantly affect purchasing patterns as the demand for SSBs was found to be inelastic.

➢ *Interpretation of Findings*

- *Consumer Behaviours in Response to the SDIL*

The studies exploring change in sales of SSBs following the SDIL unanimously agreed that there was a decrease in the sales of taxed beverages and an increase in the sales of untaxed beverages (43, 45-47, 50). The abovementioned trends are mostly due to changes in consumer purchasing behaviour. The decrease in purchasing of taxed drinks could have been a consumer response to the SDIL-induced price increases by the soft drinks industry (38, 46) or the increased awareness of the health impacts of SSBs following the announcement of the levy. Although it was expected that most consumers would reduce purchasing of taxed drinks due to price increases (57), the results of the review illustrated that consumers of SSBs weren't price-responsive. Literature produced before the implementation of the tax modelled elasticities of demand for SSBs to be -1.2 (26), -1.3 (30), -1.21 (31), and -0.79 (32). The studies reviewed did not provide a value for the elasticity demand but concluded that the demand for SSBs is most likely to be inelastic (38, 46), in contrast to literature published pre-implementation. The prices of taxed drinks increased by about 25%, but sales decreased by less than 20% (46), which means that the relative change in the quantity of SSBs demanded by consumers was lower than the relative change in the price of SSBs, thus illustrating the inelasticity in demand for SSBs (58). Therefore, the reduction in sales could have been mostly due to informed decisions made by consumers following the extensive media attention received by the SDIL (59, 60), making consumers more aware of the health impacts of SSB consumption through a signalling effect (61). In this specific case, the signalling effect refers to the implementation of the SDIL implicitly or explicitly signalling to consumers that SSB consumption should be reduced regardless of any price changes. In the UK, signalling was not achieved by the government as the SDIL did not intend to influence consumer behaviour but instead aimed to prompt supply-side responses. However, media portrayal of the SDIL could have helped achieve the signalling effect by making the public more aware of the tax and the health impacts of SSB consumption (59, 60). This is evident as a cross-sectional study conducted in the UK stated that among 92% of parents that were aware of the tax, 41% intended to reduce their household's SSB consumption (62). Although the signalling effect has also been effective in reducing SSB consumption in other countries that implemented a sugar tax (63, 64), a causal relationship between awareness of SSBs' health impacts and SSB consumption is yet to be established.

The reduction in taxed SSB purchases could have also been fuelled by other complementary activities that occurred alongside the levy, such as beverage menu redesign in restaurants, the introduction of new beverages, and food and health campaigns (45, 47). Additionally, due to the awareness and as a component of corporate social responsibility programs, retailers could have shown their support for the levy by reducing the visibility and availability of taxed products in their stores. These retailer actions could have driven the volume reductions in purchases (43, 45-47, 50). This highlights that multidimensional interventions occurring besides a fiscal measure, such as the SDIL, would have a more significant impact on consumer behaviours than a fiscal measure acting by itself.

Consumers who had reduced purchasing taxed drinks replaced them with their closest substitutes, diet/no sugar drinks and drinks exempt from the levy, hence the increase in sales of untaxed beverages (46, 50). It could be argued that this substitution effect has reduced the effectiveness of the SSB tax in reducing sugar consumption, which is made more apparent when compared to the tobacco tax (65). The tobacco tax was aimed at reducing tobacco consumption, and due to the demand satisfied by the product (nicotine) being narrow, there wasn't an apparent substitution effect. On the other hand, for SSBs, the demand targeted by the tax (sugar/calories) is broader and available through several other products. This provides many opportunities for substitution for SSB consumers. Although substitution towards diet/no sugar drinks are not detrimental to the aims of the tax, substitution towards levy-exempt drinks led to slight increases in the volume of sugar consumed through untaxed drinks (43, 47, 50). Following the implementation of the SDIL, the amount of sugar purchased through SSBs decreased, which marks the success of the tax in terms of lowering the amount of calories consumed. The decrease in sugar purchased could be directly attributed to the reduction in sales or reformulations made by the soft drinks industry.

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- *Producer Behaviours in Response to the SDIL*

Literature produced prior to the announcement of the levy predicted that most producers of SSBs would respond to the levy by either reformulating their products to avoid the tax or opting not to reformulate and pay the tax (28, 29). The narrative review confirmed these predictions as most producers did respond to the levy in either of those ways (38, 43, 46, 48, 49). Reformulation is the most extensively described response among the literature currently available on the impacts of the SDIL on producer behaviours, as reformulation was most responsible for the reduction in calorie consumption driven by the SDIL. This could be either because of the vast number of brand-owners that reformulated their products (38, 43, 46) or due to the fact that reformulation by itself decreases calorie consumption from an individual drink by 50% (46). Although there were modest decreases seen in calorie consumption through SSBs due to reformulation before the announcement of the SDIL, these consumption trends experienced a massive decrease following the announcement (46). Moreover, there was no evidence for reformulations in drinks exempt from the SDIL(38, 43), which concurrently indicate that the SDIL was the motivating factor behind the reformulation that occurred. The industry made its decision on how to respond to the levy based on several factors, as explored by Forde et al. (51), but consumer preferences played a considerable role in it. Firstly, reformulation involves substituting sugar for an alternative sweetener or removing sugar from products, which alters the taste of the product massively (66). As sugar is considered the 'queen of sweeteners', any alternate sweetener used in the drinks would not suffice the taste element provided by sugar. Consumers' perception of taste has a significant impact on product choice. Hence reformulation must be done skilfully not to compromise the taste of the brand (29, 66). If a brand lacks the expertise and resources to reformulate without compromising the taste of its products or has an identity strongly tied to the taste of its products, it is more likely to choose not to reformulate (51). On the other hand, health-oriented brands found reformulation more feasible as most of their consumers were interested in health and removing sugar from their diets already.

Manufacturers who chose not to reformulate their products paid the levy and passed it on to consumers. Our review revealed that in doing so, the tax was over-shifted to consumers (38, 46). This was unexpected as SSB taxes in jurisdictions such as France, Philadelphia, and Berkeley were found to be under-shifted (20, 21, 67). Bonnet and Villas-Boas's structural model of supply and demand explained that asymmetries in demand in markets could lead to an asymmetric pass-through (68). This could be a potential explanation for the over-shifting. When the demand for levied SSBs changed substantially following the implementation of the tax, as shown by the drop in sales (43, 45-47, 50), producers increased the price of their products by passing on more than what they were taxed to the consumers. Increasing the price of their products did not reduce the demand further because the demand for SSBs was inelastic (consumers were not price-responsive) (38, 46). Hence, the industry was able to mitigate the effects of the tax on themselves through over-shifting without facing any further demand reductions. As diet/no sugar drinks are considered the closest sugar-free substitutes for the levied drinks, these products saw an increase in sales (46, 50). Brand owners responded strategically to this substitution by increasing the price of these products despite them being not subject to the levy (38, 46). However, price increases in levy-exempt drinks as such were not seen in other jurisdictions (19, 23, 25, 69), which suggests that the design of the SDIL has prompted more industrial changes than sugar taxes in other jurisdictions.

Although the SDIL's motive was to prompt reformulation by industry, the UK government estimated that more companies would choose to pay the levy and pass it on to consumers through price increases instead of reformulating their products. Therefore, the UK Treasury initially expected to raise a revenue of £530 million (13). However, the levy revenue raised in 2019/20 and 2020/2021 only amounted to £337 million and £301 million (70), respectively, which illustrates that more companies than expected opted for reformulation. Additionally, one year after the SDIL was announced, the UK Treasury decreased its estimation to £240 million, which highlights that manufacturers had already started reformulating even before the levy was implemented (13). It could be argued that these reformulations were accelerated but not precipitated by the SDIL as some companies such as Tesco and Asda had already declared their intentions to reformulate their products prior to the announcement of the SDIL (71, 72). However, most companies only announced that they were reformulating in the two-year window between the announcement and implementation of the tax (49). Hence, despite some brand owners already moving towards producing lower calorie products voluntarily, the SDIL acted as an incentive to reformulate among the remaining majority.

- *Aspects of the Levy that Contributed to the Changes*

The literature review has revealed that the SDIL led to higher reformulation levels than expected, leading to decreases in sugar consumption from SSBs as intended by the policymakers. This section will elaborate on what aspects of the policy would have had a positive influence on the results achieved.

Firstly, the tax was implemented at a national level (12) which means consumers could not avoid the tax by purchasing the product from neighbouring regions where the tax is not in place, as was the case in the US cities of Philadelphia (20) and Berkeley (21, 64) that implemented the tax locally. Therefore, nationally implemented taxes produce a higher incentive for the industry to reformulate their products and take supply-side actions to avoid the levy. Moreover, the policymakers also set a clear target sugar level below which the tax can be avoided (12, 14). This prompted reformulation by the industry by allowing the levy to be avoided entirely if the sugar content is lower than the target. In addition, the tiered structure of the SDIL (12, 14) allowed producers to reduce the sugar content of their products to a moderate level that doesn't compromise the taste of the product massively whilst not paying the full tax. This unique design introduced by the UK government has proven to be successful in prompting more manufacturers to reformulate their drinks in comparison to taxes with a flat rate (16, 18, 20, 67, 69). If all concentrations of sugar are taxed the same, there is insufficient incentive to reformulate among companies. In cases like this, more manufacturers would choose to pay the levy

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and pass it on to consumers. In a non-price-responsive market such as the UK (38, 46), this would make the tax unsuccessful as consumption levels will not decrease due to price changes.

Furthermore, allowing a two-year gap between announcement and implementation gave brand owners adequate time to make reformulation changes to avoid the levy entirely. This is evident from the review results, which showed that most reformulation activities occurred in the two-year gap between the announcement and implementation of the SDIL (38, 43, 46, 49). Also, the SDIL was framed as a tax on the industry, and it was publicly announced that the revenue generated would be used to fund new sports facilities in schools and healthy school breakfast clubs (13). This action gathered the support of the public remarkably (73), which contributed to its success in educating people on the health impacts of SSB consumption, thus contributing to the reduction in sales of taxed SSBs (43, 45-47, 50). This is consistent with the findings of a study on the framing and signalling effects of SSB taxes by Cornelsen et al., which concluded that a tax framed as a health-related measure would be more effective at reducing SSB purchases than an unframed tax (74).

As the UK soft drinks industry was already working towards lowering calories in their products prior to the announcement of the levy, they already had the skill and supplier relationships to produce reformulated beverages that satisfied consumer taste preferences (46). Hence, when implementing similar levies in other states or product categories, policymakers should be aware that the impact of a tax would differ depending on the conditions under which the industry works too.

- *Recommendations to Policymakers*

Although the SDIL has achieved its intended objective of reducing sugar consumption from SSBs, there is so much potential for the levy to be made more effective. Some recommendations to policymakers to increase the effectiveness of the policy have been explained below.

Currently, the SDIL only applies to a small proportion of soft drinks available in the UK (14, 38, 48). For example, although the SDIL was introduced as a component of the 'tackling childhood obesity' plan (10), most products targeted at children are not eligible for the levy, despite their sugar content being higher than the recommended levels (48). Therefore, the levy should be extended to other categories such as milk-based drinks, 100% juices, and smoothies. Including these products in the levy would make consumers more aware of the sugar content of these products and help them make informed decisions when purchasing them. In addition, substitution to levy-exempt products has been responsible for the increases in sugar consumption from untaxed beverages seen following the SDIL (43, 47, 50). Therefore, including these products in the levied categories will minimise the substitution effect and contribute to increasing the effectiveness of the SDIL in reducing calorie consumption.

Additionally, the results of the review highlighted that most producers reformulated their drinks to sugar concentrations just below the threshold to avoid the levy (38, 43, 46, 50). In order to produce greater reductions in sugar purchased through soft drinks, the lower levy sugar threshold could be lowered further to drive more reformulations. Since the SDIL currently has a much higher sugar threshold than most jurisdictions that implemented a sugar tax (38), lowering it would not gain much opposition from the industry. The gradual lowering of salt targets in the UK has been proposed to have several public health benefits (75). In the same way, the lower levy sugar concentration threshold could also be lowered gradually. Furthermore, despite most companies reformulating their products, some manufacturers still produce drinks with high amounts of sugar (49). The tax rate could be increased further to push these manufacturers to reformulate. An optimal soda tax implemented nationally was estimated to be around 33ppl, according to Allcott et al. (76), but the UK SDIL levied drinks at 28ppl. Also, tax rates must be updated regularly to keep in accordance with inflation to avoid the impacts of the tax on price changes and revenue collection being diminished over time.

Although taxing a specific group of products such as SSBs makes the administration processes behind taxing more convenient, taxing sugar as an ingredient would act on a broader base making substitution to untaxed products more difficult. Sugar is found in a wide range of products; hence such a tax would increase the price of all products containing sugar or remove sugar from products that don't necessarily need it, decreasing calorie consumption to a much lower level (77). More importantly, the SDIL needs to work alongside other health promotion strategies that would help consumers make informed decisions, such as using front-of-packaging food labels that are easy to understand and education campaigns that promote healthier choices (48).

- *Strengths and Limitations of Research*

Although there are some existing studies done on the outcomes of the SDIL, to the author's knowledge, this study is the first literature review attempting to combine the impacts of the levy on both consumer and producer behaviours whilst providing an assessment of which aspects of the levy contributed to these impacts. It was crucial that both supplier and consumer responses are studied to identify which side was influenced most by the SDIL, thus helping to understand what components of the levy contributed most to its success. The findings of this review have policy implications for the UK government on how to maximise the impact of the SDIL and for other governments looking to implement SSB taxes on what aspects of the UK SDIL they could adopt. However, this review had some limitations.

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As the SDIL was only implemented in 2018, there is still minimal literature available on the impacts of the levy. The literature search yielded over 934 studies, among which only ten were eligible for inclusion, despite conducting an inclusive study selection process. Most literature available focussed on the expected and modelled outcomes of the SDIL and were dated between the announcement and implementation of the tax. In contrast, very few studies were conducted on the outcomes of the SDIL after it was implemented. Therefore, the number of studies that could be included in the review was limited to ten. In addition, due to the short period of time between policy implementation and the review, any outcomes identified were short-term and are not guaranteed to last over many years. For example, in regard to changes in consumption, it is possible that consumers would not sustain these behaviour patterns once the attention given to the SDIL settles down.

Furthermore, from the background research done prior to the review, it was evident that there were several concerns regarding the regressive nature of the tax and how it would impact the low socioeconomic status populations. However, the review was unable to elaborate if the SDIL contributed to widening or narrowing the pre-existing inequalities in health, as the studies included did not cover how the effects of the SDIL varied across population subgroups with different socioeconomic statuses. In an ideal scenario, the search strategy would have been adjusted to incorporate studies on this topic. However, this was not plausible due to the time constraints of the dissertation process.

Although the review highlighted that the reformulation activities resulted in significant reductions in calorie consumption, there were no conclusions made on the health benefits of the SDIL. It is beyond the scope of this dissertation to explore the health outcomes that resulted from the levy, as it was only implemented a few years ago. Further primary research needs to be conducted to determine the changes in the prevalence of diabetes, obesity and dental caries that resulted from the reduced calorie consumption.

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CHAPTER FIVE CONCLUSION

Based on the results of the review, it can be concluded that the SDIL attained its objective to reduce sugar consumption from SSBs. Most of this decrease is due to reformulation by industry rather than changes in consumer behaviour. The tiered design of the levy, a clear threshold to avoid the tax, and the two-year gap between announcement and implementation accelerated the reformulation responses from the soft drinks industry. The research also highlighted that the overall decrease in sugar consumption with no overall change in volume sales and the absence of any long-term negative impacts on the domestic turnover of soft drinks companies means that the SDIL would be of benefit to public health without harming the UK soft drinks industry. Additionally, the research provided recommendations for policymakers to improve the effectiveness of the levy, which include extending the levy to other beverage categories, the gradual lowering of the lower levy threshold, updating tax rates regularly, and taxing sugar as an ingredient rather than taxing individual products. Despite the positive impacts of the levy, the research has highlighted that there is a lack of evidence supporting that the SDIL is sufficient to address the health concerns linked to SSBs. Although the SDIL will not solve the obesity crisis or eradicate any health impacts resulting from the SSBs, it is a step forward in the right direction. A single policy intervention, such as the SDIL, is never sufficient to tackle a public health problem. Hence multiple interventions need to be pursued simultaneously to reduce the health impacts of SSBs and other unhealthy products.

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APPENDIX 1:

Table 1 Main Characteristics of Eligible Studies

Author, Date, Study title	Aim	Methods	Study period	Outcomes	Major findings	Limitations
Bandy et al., 2020 (43) Reductions in sugar sales from soft drinks in the UK from 2015 to 2018.	To assess the response of consumers and soft drink companies to sugar consumption reduction measures such as the SDIL.	Annual cross-sectional study on UK soft drinks on the market in 2018 through nutrient composition data obtained from 'Brand View' paired with volume sales data from 'Euromonitor'.	2015-2018	Changes in volume sales of products subject to and exempt from the SDIL. Changes in sugar content and volume of sugars sold. Changes in product portfolios of soft drink companies.	The total volume sales of soft drinks with >5g/100ml sugar content decreased from 31% in 2015 to 15% in 2018 but the total volume sales of soft drinks with <5g/100ml sugar increased from 43% in 2015 to 48% in 2018. The mean sugar content of soft drinks decreased by 30% between 2015 and 2018. The total volume of sugars sold reduced from 368,000 t in 2015 to 261,000 in 2018. The major changes in product portfolios in the soft drinks industry involved existing products reformulation and introduction of new products.	The data was only collected at four annual time points, not capturing changes that occurred immediately after the announcement and implementation of the levy. Therefore, this study did not assess the specific impact of the SDIL among the general trend in reduction of sugar content at the time.
Cornelsen et al., 2017 (45) Change in non-alcoholic beverage sales following a 10-pence levy on sugar-sweetened beverages within a national chain of restaurants in the UK: interrupted time	To evaluate the changes in sales of non-alcoholic beverages 12 weeks and 6 months after the implementation of the SDIL.	Controlled interrupted time series analysis on itemised time series data on soft drinks sales at 37 Jamie's Italian restaurants, extracted from EPOS system.	June 2014-feb 2016	% Change in the number of SSBs and other non-alcoholic beverages sold per customer at 12 weeks and 6 months.	In comparison to the pre-intervention period, the number of SSBs sold per customer decreased by 11% at 12 weeks post implementation and by 9.3% at 6 months post implementation.	The changes observed could be due to other complementary activities such as menu redesign and introduction of new beverages. The study was conducted on only one chain of restaurants. The 4 weekly data model did not fit all

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series analysis of a natural experiment.						included restaurants and impacts were not modelled using a price variable.
Chu et al., 2020 (48) The sugar content of children's and lunchbox beverages sold in the UK before and after the soft drink industry levy.	To report sugar and energy content of drinks specifically targeted at children in the UK. To compare the sugar content of beverages eligible for the SDIL among those drinks before and after the introduction of the levy.	Descriptive data and nutritional information extracted from official manufacturer websites, supermarket webpages, and in-store samples on commercial fruit juices, juice drinks, and smoothies targeted at children in the UK.	December 2017 – September 2018	Mean sugar and energy content of identified drinks. Amount of sugar before and after the levy in drinks eligible for the SDIL and % sugar reduction in reformulated drinks.	All 131 identified drinks contained a mean sugar content of 6.3 g/100mL and a mean energy content of 29.2 kcal/100mL. Among 7 drinks eligible for the levy, 4 samples reformulated their sugar content to <5g/100mL following the SDIL. 3 Juice drinks not subject to the levy also reduced their sugar content. Most drinks targeted at children were not eligible for the SDIL although they contained high amounts of free sugar.	Among the beverages studied, only 7 juice drinks were affected by the levy.
Dickson et al.,2021 (46) Does a spoonful of sugar levy help the calories go down? An analysis of the UK Soft Drinks Industry Levy.	To evaluate the effects of the UK SDIL on soft drinks sales, prices, calories consumed and reformulation activities.	Market level and brand level analysis on population data of soft drinks sales obtained from EPOS and nutritional information obtained from in-store packing of the top 100 brands by sales value.	July 2014 – January 2020	Mean price, volume, and calorie intake of levied, reformulated, diet, and non-levied brands before announcement of the levy, period between announcement and implementation, and after implementation of the levy.	Total calories consumed per week from soft drinks reduced by 5.9bn calories following the UK SDIL and reformulation of drinks accounted for 83% of this decrease, whilst the rest was due to changes in consumer behaviour.	Focussed only on supply-side responses??? Only top 100 brands included
Forde et al., 2022 (51) Understanding marketing responses to a	To explore changes made by SSB companies to their marketing and decision-	One-to-one semi-structured qualitative telephone interviews on 18 stakeholders	January 2019- May 2019	How soft drink companies react to taxation.	In response to the levy, soft drinks companies altered their marketing	Some interviewees were already known to the interviewer, introducing

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tax on sugary drinks: A qualitative interview study in the United Kingdom, 2019	making processes in response to a sugar tax.	from civil society, industry, and academia. Thematic analysis of the interviews was used to develop a theoretical framework of marketing decision-making.			processes through several ways including reformulation, packaging changes, price increase, and brand acquisition. The SDIL acted as a stimulus which accelerated, rather than precipitated these changes. The marketing changes were highly dependent on contextual internal and external factors such as reputation, brand strength, competitor's reaction, consumer interests, previous experiences, and the size of the company's portfolio.	confirmation bias. The sample interviewed do not represent all companies that manufacture soft drinks in the UK. The interviews took place a year after implementation, allowing recall bias
Hashem et al.,2019 (49) Labelling changes in response to a tax on sugar sweetened beverages, United Kingdom of Great Britain and Northern Ireland.	To evaluate changes in the energy and sugar content on labels of carbonated sugar sweetened soft drinks between 2014 and 2018, before and after the implementation of the SDIL.	Data collected from product packaging and nutrition information panels on soft drinks at 9 main supermarkets in 2014 and 2018 were analysed.	May 2014 – April 2018	Mean sugar content and energy content g/100 mL of drinks included in 2014 and 2018	Of the drinks included in both years, the mean sugar content of drinks was 9.1g/100mL in 2014 and 5.3g/100mL in 2018, showing a 42% reduction between the two years. The mean energy content reduced by 40% from 38kcal/100mL in 2014 to 23kcal/100mL in 2018. In 2014, 23% of drinks had a red sugar label and 6% had a green sugar label which changed to 1% and 27%	

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					in 2018, respectively.	
Law et al., 2020 (44) The impact of UK soft drinks industry levy on manufacturers' domestic turnover.	To examine if there was a statistically significant change in the domestic turnover of UK soft drinks manufacturers following the announcement and implementation of the SDIL.	Interrupted time series analysis on monthly time series data on UK manufacturers' domestic turnover obtained from ONS pre-announcement, post-announcement and post-implementation of the SDIL.	April 2010-March 2019	Difference in average domestic turnover (1) pre-announcement and post-announcement (2) post-announcement and post-implementation of the SDIL.	In the two-year period between announcement and implementation, there was a statistically significant short-term negative impact on the level (-5.6%) and trend (-0.5%) of domestic turnover. However, there was no statistically significant change in trend and level of turnover post-implementation. After implementation, the turnover returned to its pre-announcement growth rate (0.3-0.5%, $p<0.001$).	The ONS data collected also included unsweetened water, hence not accurately reflecting domestic turnover of SSB manufacturers, and contributing to measurement bias. The study did not investigate the impact of the SDIL on the industry's profitability or analyse the impact of the levy on substitute products that could have caused an increase in GDP.
Pell et al., 2021 (50) Changes in soft drinks purchased by British households associated with the UK soft drinks industry levy: controlled interrupted time series analysis.	To determine changes in household purchasing of drinks and confectionery a year following the implementation of the UK SDIL.	Controlled interrupted time series analysis on data collected from a panel of households who reported their purchasing weekly to a market research company.	March 2014-March 2019	Absolute and relative changes in volume of soft drinks and sugar content of soft drinks purchased per household per week post-implementation compared to pre-announcement of SDIL.	In comparison to pre-announcement levels, after implementation the volume of high tier drinks purchased reduced by 155mL per household per week (44.3%) and sugar content purchased in these drinks reduced by 18.0g (45.9%). The volume of low-tier drinks purchased decreased by 177.3mL per household per week (85.9%) and sugar content purchased in	Only purchases of products brought into homes were studied. Sugar reduction interventions other than the SDIL could have contributed to the changes revealed. Households participating in the study could be from low socioeconomic backgrounds, hence not representing the entire UK population. The results only reflect a short-term impact on purchasing and consumption. The study relies

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					these drinks decreased by 12.5g (86.2%). Overall, there was no change in total volume of drinks purchased but total sugar purchased decreased by 29.5g (9.8%).	on consumers recording their purchases accurately.
Public Health England (PHE), 2020 (47) Sugar reduction: Report on progress between 2015 and 2019. (Only sections relevant to the SDIL were reviewed)	To assess the changes in the sugar content and sales of drinks covered by the SDIL between 2015 and 2019.	Analyses of data on volume of sales and nutrition information collected every 6 months in 2015 (baseline year) and every 4 months in 2019 (year 3) from Kantar FMCG's consumer panel and between 2017 and 2019 from Lumina Intelligence.	2015-2019	Changes in total sugar content, calories consumed, and sales of drinks subject to the levy between 2015 and 2019. Changes in sugar content and calories consumed from soft drinks in the eating out of home sector between 2017 and 2019.	The total sales of soft drinks in all 3 tiers of the levy increased by 14.9% from 2015 to 2019 whereas the total sugar sales from the drinks reduced by 35.4%. The average total sugar content for SSBs in the eating out of home sector decreased by 38.5% from 5.8g/100mL in 2017 to 3.6g/100mL in 2019.	There were no confidence intervals associated, hence the statistical significance of the changes was not assessed in the report. The change in level of sales were not calculated for the eating out of home sector as there were different number of products studied each year. The panel participants could have under-reported their purchases.
Scarborough et al.,2020 (38) Impact of the announcement and implementation of the UK Soft Drinks Industry Levy on sugar content, price, product size and number of available soft drinks in the UK, 2015-19: A controlled interrupted time series analysis.	To evaluate the impact of the SDIL on the proportion of soft drinks subject to levy, their price, product size and product diversity in the marketplace.	Controlled interrupted time series analysis on data on 209,637 observations of soft drinks obtained at 85 time points in the study period from websites of leading supermarkets in the UK.	September 2015-February 2019	Changes in proportion of drinks subject to levy, mean product size and mean price of available soft drinks, and number of different soft drinks available to purchase in comparison to extrapolated data from pre-announcement trends.	Proportion of drinks subject to the levy decreased by 33.8% post implementation but there were no reduction in levy-exempt drinks. The price of high levy drinks increased by £0.075 per litre but there were no significant changes in prices of low levy or no levy category drinks. There were no significant changes to the sizes of branded drinks but own-	No account of changes to sugar consumption from drinks due to the SDIL. No information on sales were used. It was assumed that trends in the control group of drinks will not be affected by the SDL.

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					brand drinks increased the product size of high levy drinks by 172mL and decreased size of low levy drinks by 141mL.	

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APPENDIX 2:

Table 2 Key Outcomes of the Chosen Studies

Outcome measures	Studies assessing the outcome
Sales of soft drinks	Bandy et al., 2020 Cornelsen et al., 2017 Public Health England (PHE), 2020 Dickson et al.,2021 Pell et al., 2021
Sugar purchased through SSBs	Bandy et al., 2020 Pell et al., 2021 Public Health England (PHE), 2020
Domestic turnover of soft drinks companies	Law et al., 2020
Reformulation	Bandy et al., 2020 Dickson et al.,2021 Scarborough et al.,2020 Forde et al., 2022 Chu et al., 2020 Hashem et al.,2019
Pricing changes	Dickson et al.,2021 Scarborough et al.,2020 Forde et al., 2022