Health Economic Analysis incorporating effects on Labour outcomes, Households, Environment and Inequalities for food taxes in the United Kingdom

Health Economic Analysis of food taxes (HEALTHEI)

Version 1.0 September 2022

RESEARCH REFERENCE NUMBERS
researchregistry8207

PROTOCOL VERSION NUMBER AND DATE

Version Number	Date	Ethical Approval
Version 1.0	23/08/2022	No
Version 1.1	13/02/2023	Yes
Version 2.0	05/03/2024	Yes

FUNDER
This project is funded by the NIHR Public Health Research NIHR133927.

SPONSOR
The University of Sheffield will be the research sponsor.

KEY TRIAL CONTACTS

Short title/Acronym	Health Economic Analysis of food taxes (HEALTHEI)
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Funder(s)	NIHR Public Health Research
Sponsor	The University of Sheffield

i. LIST of CONTENTS

ii. LIST OF ABBREVIATIONS

Define all unusual or 'technical' terms related to the trial. Add or delete as appropriate to your trial. Maintain alphabetical order for ease of reference.

AIDS	Almost Ideal Demand System
BMI	Body Mass Index
HFSS	High in Fat, Sugar, and Salt
HSE	Health Survey for England
LCFS	Living Costs and Food Survey
NDNS	National Diet and Nutrition Survey
NHS	National Health Service
QALY	Quality Adjusted Life Year
SSB	Sugar sweetened beverages
SPHR	School for Public Health Research
VAT	Value Added Tax
WP	Work Package

iii. STUDY SUMMARY

Study Title	Health Economic Analysis incorporating effects on Labour outcomes, Households, Environment and Inequalities (HEALTHEI) for food taxes in the United Kingdom
Internal ref. no. (or short title)	Health Economic Analysis of food taxes (HEALTHEI)
Research Design	Mixed methods research
Summary	The excess consumption of calories in the UK leads to obesity, which is a cause of diabetes and cardiovascular disease. Unhealthy diets, in which consumers eat excess quantities of food High in Fat, Sugar and Salt (HFSS), are causing ill health and are an influential factor in creating health inequalities. Increasing the price of HFSS products could reduce the consumption of unhealthy foods, with potential health benefits. There is increased political interest in weight loss due to the Covid-19 crisis. There are many options available to target different food products, or nutrients profiles, at point of sale, or targeting manufacturers. The specification of these policies could impact the overall benefits to health and/or consequences to other sectors (employment, economy, environment) and health inequalities. There is a need for evidence on the potential health, economic and environmental benefits of food taxes in the UK. However, food taxes may be unpopular, and the negative consequences of food taxes must also be considered. The potential for unintended consequences and adverse effects in the wider system, such as impacts on low income households, is also needed to identify policies with potential for implementation. HEALTHEI (Health Economic Analysis incorporating effects on Labour outcomes, Households, Environment and Inequalities) will identify the most promising strategies for food taxes and generate evidence on their potential impact on health and wider societal outcomes. We will establish: 1. Which food taxes are most likely to be feasible and acceptable to implement in the UK? 2. What are the likely consumer responses to price changes on products consumed in and out of home? How do these responses vary between social groups? 3. What are the likely industry responses to pass-through price increases to consumers? Will the policies lead to reformulation? 4. What are the likely impacts of food taxes on wider societal outcomes including, household spending by social groups, local/global supply chains, environmental outcomes and macroeconomic indicators? 5. What are the likely impacts of food taxes on health outcome, health related quality of life, National Health Service (NHS) costs, health related labour outcomes? 6. How are health outcomes distributed and do they reduce health inequalities? HEALTHEI will inform policy makers on the viability of food taxes, and provide a detailed systems evaluation of the potential impacts of three policy options. We will work with the public, food advocacy groups and policy makers to tailor food taxes, assess the relative benefits of these, and improve dissemination to public and policy makers. We will use UK datasets to understand how consumers and industry will most likely respond to policies. Consumer and industry responses may vary between social groups and foods and this will

	impact the effectiveness and distribution of benefits. Opportunities for reformulation will be explored as this will likely vary between food groups. We will use multiple modelling frameworks to extrapolate simulated changes in purchases to wider societal outcomes. For the health and health related impacts the SPHR diabetes prevention microsimulation model will allow dynamic simulation of individuals' nutritional intake and outcomes to be stratified by social groups. We will explore uncertainty in our estimates with probabilistic and scenario sensitivity analysis.

iv. FUNDING AND SUPPORT IN KIND

FUNDER(S) (Names and contact details of ALL organisations providing funding and/or support in kind for this trial)
NIHR Public Health Research

v. ROLE OF RESEARCH SPONSOR AND FUNDER

This project is funded by the NIHR Public Health Research NIHR133927. The views expressed are those of the author(s) and not necessarily those of the NIHR or the Department of Health and Social Care.

The University of Sheffield is the research sponsor and host organisation.

vi. ROLES AND RESPONSIBILITIES OF STUDY STEERING COMMITTEE

The Trial Steering Committee will have a majority independent representation, including the Chair. They will meet regularly and to provide overall supervision for the project on behalf of the Project Funder and to ensure that the project is conducted to the rigorous standards set out in the Department of Health's Research Governance Framework for Health and Social Care and the Guidelines for Good Clinical Practice.

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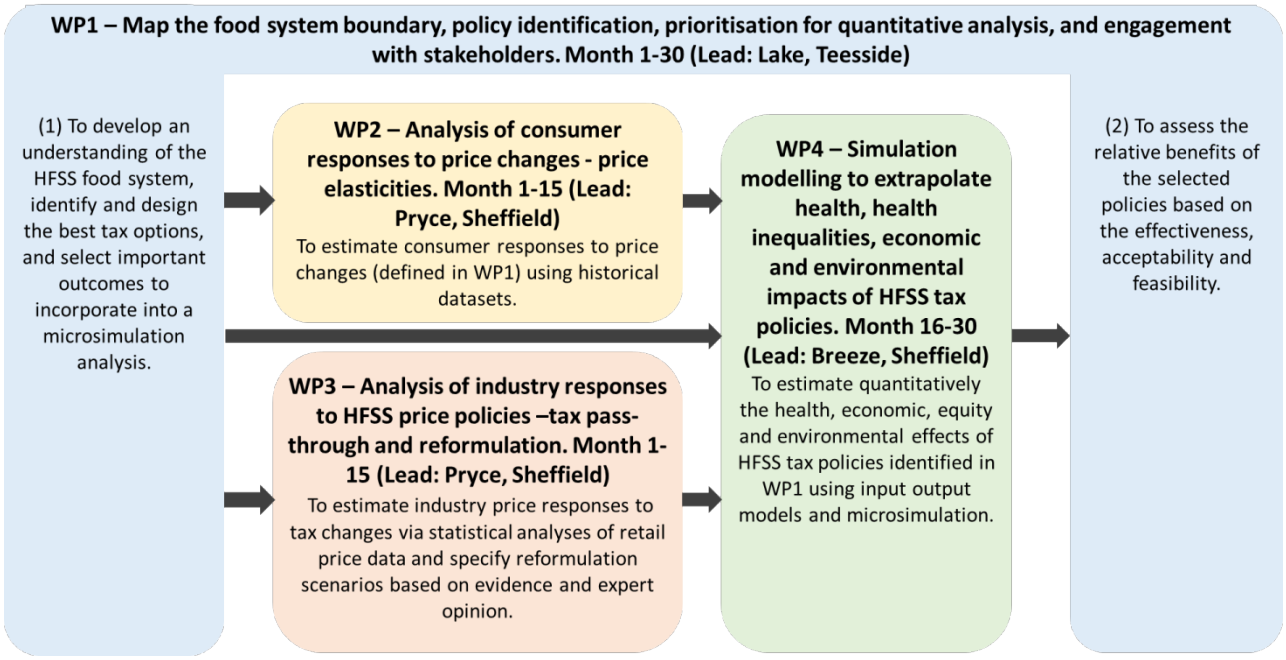
viii. KEY WORDS: Public Health, Obesity, Economics

ix. RESEARCH FLOW CHART



1 BACKGROUND

In England 28% of adults live with obesity, and 36.2% are overweight (1). Unhealthy diets and obesity play a critical role in non-communicable disease related mortality and morbidity (2). In 2014/5 the National Health Service (NHS) spent £6.1 billion on overweight and obesity-related ill-health, and the economic costs were estimated to be £27 billion (2). The Covid-19 pandemic has highlighted the adverse effects of obesity; obesity was found to be a major risk factor for adverse health outcomes from the disease (3). Health inequalities in obesity are observed from childhood. Children in the most deprived socioeconomic groups are more than twice as likely to be measured as obese as those in the least deprived group (4), and the disparity is maintained into adulthood.

In the UK 37% of dietary energy for adults and 47% of energy for primary school children comes from foods High in Fat, Sugar, and Salt (HFSS), representing a sizable source of excessive calorie consumption (5). Confectionery, snacks, sweet drinks and puddings contribute to a large proportion of the consumption of sugar and saturated fat; 52.9% of purchases of total sugar, and 19.15% of purchases of saturated fat (6). HFSS foods tend to be ultra-processed, and these foods have been linked with obesity and non-communicable diseases (7). The consumption of sweet snacks and take-aways have been increasing in recent years and are high among children, which highlights the need for policies to reverse these trends (8). The Food Foundation estimates that one third of overall food spending is spent on food and beverages consumed outside of the home. Fast food restaurants tend to be cheaper and more likely to serve HFSS foods than table service restaurants (5). Fast food consumption has been linked to obesity (9).

Increasing the prices of unhealthy foods and/or decreasing the prices of healthy foods have been proposed and found to be effective in improving diets (10). HFSS foods are consistently cheaper than healthy foods in the UK and globally (11). Therefore, food pricing policies could be used to address health inequalities (12). Fiscal interventions, particularly those that place low demands on peoples' cognitive, social, material and financial resources, are more likely to have equitable effects or reduce inequalities (13). Policies targeting HFSS foods may be favourable, compared with taxes targeting red meat which are high calorie, high carbon footprint, but also have high nutritional value (14). There is also evidence to suggest greater public support for taxes on sugar than meat (15). Food subsidies may increase consumption of healthier foods, but they are costly to implement and may lead to unintended consequences, such as an overall increase in calories. There have been calls for taxes on unhealthy foods from national and global non-governmental organisations. The World Health Organisation (WHO) proposes the use of taxes and subsidies to promote healthy food choices (16). The Global Alliance for Improved Nutrition included HFSS food taxes among 42 actions to improve food systems (17). The Food Foundation called for Value Added Tax (VAT) on foods to be reassessed to impose the 20% tax on healthy foods and remove the 20% tax on healthy non-essential foods (18). The recent publication of the National Food Strategy called for a tax on wholesale sugar and salt (15).

The Covid-19 crisis has renewed interest and motivation to implement policies to reduce the burden of obesity. In 2020 the UK Government announced an obesity strategy (2) and has committed to further action to reverse obesity trends and reduce health inequalities. There is a strong media, and public interest in debates surrounding the public health and equity impacts of food taxes as evidenced by the recent report 'The Plan' from the National Food Strategy (15). In 2018 the sugar levy on sugar sweetened beverages (SSB) was imposed on non-alcoholic beverages at a lower rate on sugar drinks with a total sugar content of 5 grams or more per 100 millilitres and a higher rate for drinks with 8 grams or more per 100 millilitres. The policy reduced sugar consumption, primarily through reformulation (19) and may set a precedent for future food taxes to encourage reformulation. However, voluntary reformulation of sugar in the UK has decreased sugar per 100g by only 3% between 2015 and 2019, suggesting that manufacturers are unwilling to, or have fewer options to reformulate high sugar products (20). There are, arguably, greater challenges in extending taxes to foods, compared with SSBs, because foods have a more complex mixture of ingredients, whereas SSBs have no nutritional value. There are difficulties in identifying methods to identify criteria for HFSS foods that are easy to implement and do not affect foods that do not increase health risks (21).

Public support for food taxes is mixed and food taxes may be unpopular as indicated by the unsuccessful attempt to revise VAT on hot food take-aways in the UK (22). A systems approach to evaluating food taxes is needed to capture the benefits and adverse consequences of these policies.

Literature review (performed to inform proposal development)
Aims: To provide an overview of the impacts of food and non-alcoholic beverage price increases in national or local settings to facilitate the specification of food taxes and research design.

Method: The evaluation of tax and subsidy policies targeting food and non-alcoholic beverages is a growing area of research across public health, nutrition, and economics disciplines. We conducted a search in Pubmed/Medline to identify evidence for the impact of price policies which targeted and non-alcoholic beverages on a broad range of health, economic and environmental outcomes. Search terms combined ***setting*** queries (fiscal, national, state, city, workplace, schools, supermarket, restaurant, fast food, and cafeteria), ***intervention*** queries (tax, subsidy, incentive, and price) and ***food*** queries (food, beverage, fruit, vegetable, soda, meat, dairy, fat, junk food, confectionery). Systematic reviews were included in the review of evidence if they identified and assessed evidence of food price policies on outcomes including food prices, consumption, health, economic or environmental impact.

Results: The search identified 2,100 articles published since 2010 and a filter selected systematic reviews (N=67). Of the 67 studies identified 38 met the inclusion criteria. The reviews summarised evidence from randomised controlled trials, real-world evaluations, price elasticity analyses, and simulation/modelling studies. Most studies reported positive benefits for price-based policies (35/38). A small number of reviews compared price-based policies with other dietary policy approaches and generally taxes/subsidies were found to be equally or more effective than other policies (23:26).

The Effectiveness of price increases across food groups/nutrients
Table 1 reports responses by consumers to changes in prices for HFSS related food groups, expressed in price elasticity of demand, across a range of studies. The estimates highlight that consumers are most likely to respond to price changes on meat, sugar-sweetened beverages, and take-aways. Price responses to sugar and confectionery were moderate, and lowest for high fat foods. There is a gap in the literature to describe price elasticity of demand for out-of-home food purchases.

Table 1: Summary of price elasticity of demand for food groups

	Price elasticity of demand*	Source of evidence
Take-aways	-0.81 (-0.56, -1.07)	Andreyeva 2010 (27)
Sugar-sweetened beverages	-1.08 (-0.71, -3.87)	Powell 2013 (28)
Beef	-0.75 (-0.83, -0.67)	Andreyeva 2010 (27)
Pork	-0.72 (-0.78, -0.66)	Andreyeva 2010 (27)
Sweets confectionery	-0.56 (-0.65, -0.48)	Cornelsen 2015 (29)
Fats/oils	-0.48 (-0.66, -0.29)	Andreyeva 2010 (27)
Cheese	-0.44 (-0.63, -0.29)	Andreyeva 2010 (27)

* Negative price elasticity of demand indicates that price increases reduce purchases of this food group. A price elasticity of demand of less than (-)1 means that purchases are reduced by proportionally less than the price increase.

A real-world evaluation of a Hungarian tax on sugar-added foods identified a 4% reduction in consumption of taxed foods (30). Reviews of real-world and intervention-based evaluations of taxes on SSBs concluded that these policies are effective in reducing SSB consumption (10, 31:37). Real world evaluations of the Danish fat tax reported reductions in consumption across some high fat food groups (38), however challenges to the Danish fat tax resulted in it being repealed (39).

Evidence on the impact of price changes on health
Observed changes in health in response to a change in food and beverage prices are less common in real-world evaluations (40). There is limited evidence for the effects of SSB taxes on obesity (37). Experimental studies identify few studies reporting health outcomes (41-43). Reviews that have made the link between food price policies and health mostly rely on modelling studies (23, 34-36, 39, 44-

46). These studies generally find that price policies lead to improvements in health (23, 34:35, 39, 45, 47). However substitution to unhealthy foods reduce or reverse simulated health gains (44, 47).

Evidence on the impact of price changes on macroeconomic measures
Only three reviews report the impact of food price policies on government revenue and wider macroeconomic consequences. Some studies estimate negative macroeconomic impacts on employment from implementing diet related fiscal policies (48). However, this evidence comes from industry sponsored reports and may be subject to bias. Diet-related fiscal policies are likely to raise revenue (47:48), but may be volatile over time as consumers adapt to price changes (39).

Evidence on the impact of price changes on socioeconomic groups
There is evidence that low income populations are more price responsive than high income populations and that price-based policies are likely to reduce health inequalities (49-51). The differences in price responsiveness between socioeconomic groups is likely to vary across food groups (27, 50) with more variation in responses to milk and take-aways (27).

Evidence on the impact of price changes on environmental consequences
None of the reviews reported the environmental consequences of food and beverage price changes, despite the environmental impact being an important outcome for our stakeholders and Patient and Public Involvement (PPI) groups.

Modelling methods review
Simulation studies enable policy makers to explore the impacts of multiple untried policies and have been used in economic evaluations of tax policies (52). Economic evaluations commonly adopt cohort based modelling structures, particularly for food tax evaluations, rather than individual microsimulation approaches (52). Economic evaluations commonly report the impact of policy on health and health-related cost outcomes, but much less frequently report the wider societal impacts on labour market and macroeconomic measures.

Modelling studies have limitations (52:53). These often occur when the impact of food taxes are overstated for a number of reasons. The wider societal consequences are not estimated (52). Substitution effects between food groups are not always taken into account (29). Analyses have assumed that price changes will be passed on to consumers (53). As a result, the effects of market competition are under-estimated (54), and the model boundary excludes mitigating effects (55).

Cohort-based models are more frequently used in evaluations of population-level dietary policies in the United Kingdom (UK) (52). However, cohort models are much less flexible to look at the distributional impacts of policies across social groups, temporal changes of intervention effects, and estimating the timing of policy impacts.

Summary
There is a large body of research in the field of food taxes which we have used to develop our research plan. Evidence from the literature suggests that the specification of policies, i.e. choice of food/s targeted, are important. Nevertheless, existing research does not provide sufficient evidence to identify the best options for food taxes in the UK that will be feasible to implement, acceptable to the public, generate the greatest benefits to society and minimise potential adverse effects. Knowledge gaps exist because it is difficult to compare tax options based on existing evidence. Health impacts and consumer behaviour differ between social groups and national settings. The wider outcomes of interest across government departments, such as environmental outcomes and economic benefits are inconsistently reported across studies.

2 RATIONALE

The overall focus of this study will look to identify food taxes on HFSS foods with strong potential for implementation based on assessments of feasibility and acceptability. Following our discussions with stakeholders, the public, and our review of the evidence (above) we propose a focus on sweet snacks and take-aways due to strong associations with health and childhood obesity, high price elasticities of demand (27,56) and associations with low socioeconomic groups (57:58).

Proposals for food taxes need to provide robust estimates of the effects on those outcomes that matter the most to policy makers and the public, such as low income households, health, economic growth and the environment. Discussions between our team and policy makers, experts and the public highlighted the importance of the distribution of health benefits and household spending across socioeconomic groups. The potentially regressive nature of taxes are presented as arguments against food and drinks taxes, (59) see, for example The Sun newspaper "Hands Off Our Grub Campaign",2018). These must be balanced against greater health benefits in low socioeconomic groups (60). In order to balance different and competing objectives a dashboard of health and wider societal outcomes across tax policies will be reported using a common modelling framework. We will continue to work with stakeholders and the PPI panel to develop the analysis plan to ensure that the proposed outcomes, and social group stratifications, are relevant and informative to a broad audience.

Our systems approach includes consultation with stakeholders, including public representatives, to select food policy options that are feasible and acceptable. We will utilise conceptual modelling tools to explore how food tax policies operate within the food system and use simulation modelling methods to consider the behavioural responses by consumers and industry. We recognise that these responses are unlikely to be uniform across social groups/products. We will consider the impact of taxes on health, economic, employment, inequalities and environment outcomes, and, where relevant, stratify these by social groups. The limitations of modelling studies can be avoided through well designed simulation studies embedded in a systems evaluation approach.

3 OBJECTIVES

Which HFSS food taxes (sweet snacks, take-aways plus prioritised options) would have the greatest benefits to health, labour and work outcomes, household expenditure, environmental sustainability and inequalities (health and food expenditure) within the food system in the UK?

Work Package 1 (WP 1) – Map the food system boundary, policy identification, prioritisation for quantitative analysis, and engagement with stakeholders.
Aim: (1) To develop an understanding of the HFSS food system, identify and design tax options, and select important outcomes to incorporate into a microsimulation analysis. (2) To assess the relative benefits of the selected policies based on effectiveness, acceptability and feasibility.
Objectives

1. To conduct a rapid review to provide stakeholders with harmonised evidence on the range of food tax interventions for Workshop #1.
2. To discuss with stakeholders the preferred design and specification of taxes, and specify outcomes and social groups for the health economic analyses.
3. To conduct semi-structured interviews with stakeholders to elicit potential barriers to implementation of tax intervention options to include legal, technical, public, media and political challenges.
4. To conduct content analysis of online and print and online media coverage of food and non-alcoholic drink taxes.
5. To finalise and present clear summaries of food taxation options.5

Work Package 2 (WP2) – Analysis of consumer responses to price changes - price elasticities.

Aim: To estimate consumer responses to price changes (policies defined in WP 1) using historical datasets.
Objectives

6. To estimate responses to price (own-price and cross-price elasticity of demand) for health and unhealthy foods consumed at home.
7. To estimate responses to price (own-price and cross-price elasticity of demand) for foods at home and out-of home.

Work Package 3 (WP3) – Analysis of industry responses to HFSS price policies - tax pass-through and reformulation.
Aim: To estimate industry price responses to tax changes via statistical analyses of retail price data and specify reformulation scenarios based on a review and expert opinion.
Objectives

8. To estimate pass-through costs to consumers following historical change policies on food and non-alcoholic drinks
9. To estimate reformulation responses to tax policies.

Work Package 4 (WP4) – Simulation modelling to extrapolate health, health inequalities, economic and environmental impacts of HFSS tax policies.
Aim: To estimate quantitatively the health, economic, equity and environmental effects of HFSS tax policies identified in WP1 using input output models and microsimulation.
Objectives

10. To estimate the impact of tax policies on household spending across social groups, as well as the impacts on UK and global value chains, macroeconomic outputs, and wider environmental sustainability.
11. To estimate the impact of tax policies on consumption, health, health-related costs and employment across social groups.

4 RESEARCH DESIGN

WP 1: Map the food system boundary, policy identification, prioritisation for quantitative analysis, and engagement with stakeholders. Month 1-30. Lead: Lake, Teesside.

WP 1 utilises a number of methods to consult stakeholders to identify HFSS food tax policy options and assess their potential effectiveness, acceptability and feasibility. Using the evidence gathered within WP 1 we will work with stakeholders to identify three food tax policy options to evaluate and finalise the analysis plan for WP 2-4.

Objective 1: To conduct a rapid review to provide workshop #1 participants with harmonised evidence on a range of food tax interventions.
We will conduct a 'rapid review' of the effectiveness of food tax intervention options, and associated evidence and debates.

Objectives: to undertake a pragmatic review of the existing literature (primary research and grey literature), and to draw together evidence from food tax policies and barriers to implementation, which will inform stakeholder discussions in workshop #1.

Methodology: We will use a more flexible approach than a typical academic review to gather and synthesise all appropriate literature, while using and referring to a pre-planned framework to ensure we use the most systematic approach possible. We will follow best-practice in our review (61).

Search Strategy
Databases: PubMed, HMIC, Scopus, Google, Mintel/Mintel Food and Drink, Business Source Premier; **Dates:** 2010-present; **Language**: English language documents only; **Search terms:** (food and beverages OR take-away OR junk food OR fast food OR sweet OR confectionery OR snack OR

sodium OR salt) AND (tax OR price OR levy OR fiscal). **Sources:** Peer-reviewed research papers and grey literature, governmental and non-governmental reports via resources such as Food Research Collaboration.

Inclusion Criteria
Geography: High-income countries. **Outcomes:** Study details (type, size, and population), Outcome measures (indication of objective/subjective measurement), intervention and target, key finding(s). **Methodologies:** No restrictions, quantitative and qualitative analyses to be included of experimental, quasi experimental and observational studies.

Screening
All titles and abstracts will be screened by one reviewer, and the shortlist will be reviewed by the entire WP1 research team to finalise those meeting the inclusion criteria. Full text versions of these will be retrieved, extracted and assessed by one reviewer, consulting with another member of the WP1 team where any ambiguity exists. Conference proceedings/Study protocols will be categorised as an "ongoing study", and where possible authors will be contacted for further information relating to these.

Extraction
A standardised data extraction template will be developed and agreed by the project management group which will record study characteristics/key findings. Evidence from the review will be extracted by one reviewer under themes for effectiveness, costs/unintended consequences, and barriers to implementation. We will not formally assess the quality of the papers.

Synthesis
A narrative synthesis of the collected data is planned. Key findings will be contextualised within the study design, quality assessment, objectivity of the outcome measure and funding source. The WP1 team will work collaboratively to produce the synthesis. Peer discussion will be used throughout the review to ensure rigour within the review process. The data will be synthesised into a short briefing document for sharing with stakeholders prior to qualitative interviews and Workshop #1. The WP1 team will critically appraise the document before use.

Objective 2: To discuss with stakeholders the preferred design and specification of taxes, and specify outcomes and social groups for the health economic analyses.
A stakeholder group of 10-15 participants, will be formed to participate in 3 half-day workshops face-to-face or using a hybrid model. A separate public workshop was planned between workshop #1 and #2 to elicit consult public views of food taxes and contribute to the evidence presented to stakeholder in workshop #2. A separate workshop was initially suggested to ensure that the views of marginalised groups were explicitly captured in the process of policy selection. The decision was discussed with the project management team, PPI panel and study steering committee. In workshop #1 (Month 5) we will agree on a conceptual model for food taxes and model boundary, identify a range of food tax policies, identify barriers to implementation to explore further. Workshop #2 (Month 12) will agree three food tax policy designs to quantitatively evaluate based on findings from WP1, and agree the analysis plan for WP 2-4. Towards the end of the project (when WP4 is complete) we will organise Workshop #3 (Month 28) with the original stakeholder team, plus at least 3 public representatives, to review our research findings, and discuss findings and recommendations for the relative benefits of taxes and develop the dissemination strategy. We will organise an online workshop (Workshop #4, Month 28) with a group of approximately 15 stakeholders and PPI representatives to review the research findings. This will be a new group of participants, specifically recruited from people who have not previously participated in the research.

Stakeholder Recruitment
Based on the recently developed 'Food Policy Map' (62), we will develop a stakeholder recruitment grid to ensure that we have representation of stakeholders across public sectors and disciplines of public health, nutrition, environment and economics. From our extensive networks across policy

makers, third sector organisations, public representatives and academic experts we will invite stakeholders to attend the workshops. The PPI panel will advise on recruitment of public representatives to the public workshop. In order to maintain independence from industry, and in accordance with UKPRP guidance, we will *not* include industry representatives in the stakeholder group, but will consult with industry in the qualitative interviews (Objective 3) if specific expertise is needed.

Workshop Design
The initial workshop planning will focus on stakeholder recruitment, identify and fill gaps in the recruitment grid, design the workshop discussion document, specify visual aids/interactive tools for the workshop (in collaboration with a graphic designer), and discuss proposed workshop structure. Workshops #1-3 will be conducted face-to-face/ or hybrid and hosted across Sheffield, Teesside and City, with the option for stakeholders to join remotely, if necessary. A week before the workshops the team will schedule a brief workshop rehearsal to test technology, confirm roles and tasks for the workshop. Prior to the workshop the stakeholders will be sent a discussion document to provide background information, objectives and information/key questions to aid discussion points. The PPI panel will support the development of accessible resources and discussion documents for the workshop. Workshops will be facilitated by Lake and Moore and supported by an experienced post-doc researcher using tools such as; Padlet, graphics, group exercises and discussions. Larger groups will be broken down and specific topics and tasks assigned. Stakeholders who are unable to attend will be invited to comment on the briefing document, and meeting notes to provide additional feedback before or after the workshop. Public participants and Voluntary Sector Organisations will be compensated for their time and travel to attend these workshops. Workshops will be conducted in English. However, costs for discussion documents to be translated into up to two other languages have been budgeted to obtain written feedback from non-English speaking participants.

Project team management
Amelia Lake will lead the workshop planning team with representatives from all institutions attending planning meetings. The team will be supported by a post-doctoral researcher and graphic designer at Teesside University to develop the discussion documents, infographics and planning materials.

Evaluation
At the end of each workshop stakeholders will complete stakeholder engagement questionnaires to explore their experiences of the workshop. The feedback will be used to improve the design of subsequent workshops.

Objective 3: To conduct semi-structured interviews with stakeholders to elicit potential barriers to implementation of tax intervention options to include legal, technical, public, media and political challenges.
Structured qualitative interviews (approx. 15-20), will assess the perceived effectiveness, equity impacts, implementation challenges (legal, technical), and acceptability (public, media and industry). Informed by our review and Workshop #1, we will develop a topic guide for our interviews.

Sample
We will select participants purposively based on their expertise and in response to the barriers to implementation identified in workshop #1. First, participants will be identified from government consultations on the Sugar Sweetened Beverage Levy, Tackling Obesity Strategy and National Food Strategy. This initial sample is likely to include policy makers, academics and third sector advocacy organisations. Second, we will assess the technical details on technical issues with reformulation, legal, and administrative challenges. This sample will more likely involve participants from food technicians and industry. We will aim to conduct 15-20 interviews in total, comprising civil service (including representation from other UK Nations) (n=5) and academic experts (n=5), food system advocates with tax or reformulation expertise (n=5), industry/technical representatives (n=5). Senior government officials and Ministers are unlikely to agree to participate in formal qualitative research, therefore we will liaise with them informally.

Procedure
Participants will be contacted by phone or email and invited to participate - a short summary of the project will be shared with participants and written consent obtained where agreement to participate is given. Prior to the interview, the review briefing will be shared with participants. Interviews will be conducted via an online platform or telephone and will follow the topic guide. Interviews will explore the options for food tax policies. Participants will be asked to reflect on:

- The likely impact of each taxation option on consumption behaviour and whether the impact will differ between social groups.
- The potential for enhanced effects of the policies through reformulation,
- The potential for adverse/unintended consequences, particularly on environmental, economic and vulnerable groups.
- The feasibility of implementing each taxation policy and technical barriers to implementation.
- The likely response from public and media for each food tax policy.

Time will be allowed to invite participants to suggest other taxation specifications options not already introduced in the interview.

Coding and analysis
The interview data will be transcribed and uploaded into the qualitative analysis software programme NVivo 12. The WP1 team will use transcripts and audio recordings to become familiar with the data. Data will be analysed using a reflexive thematic analysis approach, whereby data is open-coded line by line according to its context and meaning (63). Descriptive themes will then be developed based upon the similarities identified within the interview data. This will allow for data to be considered holistically and used to characterise relationships between themes. Development of themes will follow an iterative process based upon initial findings. Final themes will be presented as an output for this objective capturing the barriers and facilitators, process and implementation issues and explore possible associated unintended consequences to potential food tax policy options.

Objective 4: To conduct content analysis of online and print and online media coverage of food and non-alcoholic drink taxes.
A qualitative content analysis will be undertaken of UK printed and online newspapers published between 2017 and 2023) to capture UK news discourse and debate on food and non-alcoholic drink taxes since Boris Johnson announced a review of 'sin taxes' in 2019. Previous reviews of media coverage of sugar taxes in the UK have been undertaken (59, 64) as well as research analysing media coverage of sugar taxes introduced in other countries (65) and, more recently media coverage of meat taxes (66). However, to our knowledge no research looking at the totality of UK media coverage of any and all food and non-alcoholic drink taxes has yet been undertaken.

Data Collection
The news database *Factiva* will be used to search for articles from English language online and printed newspaper articles published in the UK. Search strings will be developed using combinations of relevant search terms. This will be informed by the rapid review outlined in WP1 Objective 1, for example, (food OR beverage OR drink OR take-away OR junk food OR fast food OR meat OR fat OR sweet OR sugar OR confectionery OR snacks OR sodium OR salt) AND (tax OR price OR levy OR fiscal). The search terms will be tested in a pilot phase. Articles returned from the searches will be reviewed for relevance and those not explicitly mentioning a food or non-alcoholic drinks tax will be excluded, along with duplicates and letters. The remaining articles will form the final sample.

Coding and Analysis
Manifest data including the date of the article, the author of the article, the publication it appeared in, interviewees quoted and the headline will be transferred to a spreadsheet and analysed for trends, for example the number of articles per publication over time. The text of the articles will be uploaded into the qualitative data analysis software NVivo. A pilot qualitative content analysis will be undertaken, using a coding framework informed by the rapid review in Objective 1. This will be used to refine the final coding framework, which will be reviewed following the discussions with stakeholders in

workshop 1 and cross-referenced against the qualitative work in Objective 3. This could include searching for article slant (positive or negative towards food and non-alcoholic drink taxes); arguments for and against food and non-alcoholic drinks taxes; problem definitions; solutions and solution definitions and positionality of sources. The coding will be performed by at least two researchers with an assessment of inter-coder reliability to reduce bias. Final analysis including presentation of the trends and themes will be presented as an output exploring overall UK media representation of food and non-alcoholic drink taxes between 2017 and 2023.

Objective 5: To finalise and present clear summaries of food taxation options
Evidence relating to the food tax options identified in the rapid review, workshop #1 and from the semi-structured interviews will be gathered, synthesised and presented in summary documents for each option. Summary documents will be created by triangulating findings from objectives 1, 2, 3 and 4 and will include graphically designed infographic material to aid understanding which will be considered by participants in Workshop #2.

WP 1 Outputs

1. A manuscript to summarise feasibility and acceptability of food tax options to be submitted to Milbank Quarterly,
2. A visual summary document including infographics to illustrate food tax options,
3. A Fuse policy briefing document including infographics to be professionally developed with input from PPI panel,
4. A conference presentation at the UK Congress on Obesity.

WP2 – Analysis of consumer responses to price changes - price elasticities. Month 1-15. WP Lead: Pryce, Sheffield.

WP2 will build on existing evidence on price elasticity of demand for various food types. A review in 2010 highlighted several important points: meat (particularly beef and pork) demand has received a lot of attention; more attention needs to be paid to the substitution between healthy and unhealthy foods; and more attention should be paid to the interaction of income and price (27). A subsequent review in 2016 (29), examined in detail the methodological differences, highlighted the importance of testing the sensitivity of estimates, and showed that the majority of the literature use the Almost Ideal Demand System (AIDS) (67). The existing literature also tends to generate price elasticity estimates for broad food commodities - for example, vegetables - rather than specific products. A recent study extended the literature by splitting food types into healthy and unhealthy subgroups (56). However, the existing literature focuses on in-home food consumption using self-reported scanner data.

The aims of this work package are to generate new evidence on the price elasticity for various, disaggregated food types, to align with the policies proposed in WP 1. This will extend the literature by also examining take-away food and eating out, and investigate social group differences identified by stakeholders in WP1.

Objective 6: To estimate own-price and cross-price elasticity of demand for health and unhealthy foods consumed at home.
From Month 1 of the project we will use the Living Costs and Food Survey (LCFS) 2006-20, which is a nationally-representative survey asking respondents to record all expenditure in a two-week diary that the research team can access (68). We will use the Living Costs and Food Survey to construct price indices based on the mean price paid for items within the time period and region. Where possible we will structure the food groups in a similar framework to previous work on within the home purchases in the UK (56). We aim to replicate previous work to enable comparison of price elasticity and cross-elasticity of demand estimates between two UK datasets. In line with previous research, we hypothesise that increases in price will reduce demand for foods, and that price response will vary across food groups. We also anticipate that the analysis will identify cross-price elasticities to describe the impact of price increases on the demand for other food and drinks. The comparison will enable validation of the estimates against an independent study and assessment of potential biases

from the cross-sectional data. If biases are observed, we will test the analyses using alternative methods, such as pseudo-panel regression. This preparatory work will allow us to start working on data preparation before the food tax policies and social groups are specified in Month 12.

We will use the Almost Ideal Demand System, both because it is the most commonly used demand specification in the literature (56) and also because it uses expenditure shares as the dependent variable - the Living Costs and Food Survey only captures expenditure on out-of-home purchases rather than quantity purchased.

Objective 7: To estimate own-price and cross-price elasticity of demand for foods at home and out-of home by social groups.

In the second phase of the analysis we will extend the analyses in Objective 6 to look at the elasticity of demand for out-of-home purchases, revise the structure of analyses to be compatible with food tax policies and explore price responsiveness by social groups. We hypothesise that increases in the price of out-of-home purchases will reduce the demand for these foods. It is possible that consumers will respond to price changes by choosing other types of food outside the home or increasing consumption of foods purchased at home. This analysis will describe the patterns in demand for food in response to price changes on foods purchased outside of the home. The analysis will extend the work in objective 6 to explore differences in price elasticity between social groups. We hypothesise that overall price responsiveness will differ between social groups, for example low income households will be more price responsive than high income groups. In addition, the patterns of price response (cross-price elasticities) may differ between social groups, such as age, gender, socioeconomic status and ethnicity.

The Living Costs and Food Survey requires respondents to complete a two-week purchase diary which includes both at-home and out-of-home food, though the out-of-home is categorised differently to reflect the fact that customers purchase meals rather than the constituent foods (for example, a sandwich rather than bread, butter, filling). However, the recording is quite detailed in terms of price paid and the type of food purchased.

To extend the literature further, we will use a hierarchical model which allows estimation of own-price elasticities for very disaggregated commodities and cross-price elasticities with closely related food types, whilst allowing broader cross-price elasticities across high-level food groups. For example, we can estimate an own-price elasticity for chicken, cross-price elasticity between chicken and beef, and a cross-price elasticity between chicken (via an increase in the price of meat) and soft drinks. The hierarchical model groups will be informed by the literature for the larger food groups, as this will also allow us to compare directly with estimates from the literature. The specification of the hierarchical groups will also be aligned to the policy designs from WP1. If necessary, expert opinion will supplement analyses to determine lower level substitutions i.e. between brand/products.

It is known that household income has a strong influence on the response to price. We will explore the impact of age, gender, socioeconomic status and ethnicity on the price-elasticity of demand, with the option to look at multiple attributes, such as families with children on low incomes. Due to the sample size it is unlikely that all demographic characteristics will be able to be included in the model. We will run exploratory analyses and consult with the stakeholder group and PPI panel to identify appropriate social groups to include in the analysis.

WP 2 Outputs

1. Conference working paper and presentation to be given at the Health Economist's Study Group,
2. Journal paper on food price elasticities using AIDS and hierarchical model groups,
3. A full technical report on the outputs that will feed into the modelling for WP4,
4. Research summary will be developed with stakeholders and our public advisory group to communicate findings to policy makers and the public.

WP3 – Analysis of industry responses to price changes - tax pass-through and reformulation. Month 1-15. WP Lead: Pryce, Sheffield.

Objective 8: Investigate the extent to which Value Added Tax (VAT) are likely to be passed on to consumers as retail price changes across the product and price spectrum for confectionary

Pass-through costs responses are difficult to predict. Pass through may vary between foods targeted by the same policy, and across product types within a category (71). Price changes may also be implemented at different times, in response to policy announcements as well as on implementation of the policy (72). Best estimates of responses are preferred to simple assumptions such as no response or complete pass-through. We will gather evidence to inform scenarios to include in our simulation modelling (WP4).

In our primary analysis we will analyse tax pass-through on confectionery goods and take-aways in response to VAT changes in 2008, 2010, and 2011 using data from LCFS to describe changes in the distribution of prices within these food groups (68). Using similar methods to what has been previously done in the market for alcohol (69), We will estimate the pass through of taxes to consumers for different types of confectionery. For this research, we will break down confectionery into product groups which are standard rated VAT. For example, for confectionery we will specify six groups: plain/solid chocolate, chocolate bars and biscuits which are partially or fully coated in chocolate, sweets, cereal bars, dried fruit and fruit bars, and other confectionery items that are not covered by the listed groups. We will use regression methods to estimate the counterfactual price, the price that would exist if the food industry passed the VAT changes through to the retailers exactly rather than over- or under-shifting tax changes onto different products differently. Panel data quantile regression will be used to assess the impact of tax changes on the distribution of prices.

In a secondary analysis, using data from Kantar World Panel, we will cross-validate our results from the LCFS for confectionery products by repeating the analysis using this data. The Kantar data contains information on the size and detailed sales value on a large number of confectionery products purchased in Scotland 2006-2012. Using panel data quantile regression, we will be able to examine the extent to which the price of the individual products has changed as VAT has changed across the price spectrum and across a range of confectionary types.

We will use these estimates of pass-through responses to tax changes to inform discussions with experts, and cross-validate against trends and findings from published literature, to develop scenarios for the analyses in WP4.

Objective 9: To estimate reformulation responses to tax policies.
Reformulation of HFSS foods can have a substantial impact on the intake of sugar, salt and fat and does not require changes to consumer behaviour or spending on food. Voluntary reformulation has not had a substantial impact on many HFSS products (20), but the sugar drinks levy did prompt reformulation of sugar sweetened beverages in the UK (19). Estimating reformulation responses from industry are difficult to predict, and previous modelling studies have developed discrete scenario analyses to evaluate the consequences of industry responses on modelled outcomes (73).

We will conduct a rapid review of reformulation from real-world evaluations. The search strategy will include (Food and Beverages OR take-away OR Junk food OR fast food OR Sweet OR Junk food OR confectionery OR Snacks OR sodium OR salt) AND (tax OR price OR levy OR fiscal) AND (reformulation OR response OR manufacturer). Data extraction will include the products affected, nutrients affected, magnitude and variability in response, and factors affecting the response. Data will be synthesized to used to estimate expected reformulation scenarios and gaps in the evidence will be informed through elicitation of experts.

We will elicit reformulation responses to food tax policy options with experts to describe industry responses to tax policies. The choice of foods to modify in reformulation will depend on the

specification of tax policies chosen in WP1. For each food tax option we will identify nutrients (sugar, salt, fat fibre) for the foods impacted by the tax that may be modified. We will consult with 3-5 experts in food science and nutrition to estimate the most likely reformulation response for these foods for each policy option. We will use elicitation techniques to assign a probability distribution to the reformulation effects in order to capture experts' uncertainty in reformulation responses and formally incorporate this uncertainty in our health economic analysis in WP4 (70). We will prepare short briefing documents to discuss with experts to summarise the aims of the elicitation, a description of the elicitation methods, and summarise evidence from the sugar drinks levy, voluntary reformulation evaluations and our findings from the analysis of pass-through responses.

WP 3 Outputs

1. Journal paper on tax pass-through for confectionary,
2. A full technical report on the outputs that will feed into the modelling for WP4,
3. Research summary will be developed with stakeholders and our public advisory group to communicate findings to policy makers and the public.

WP4 – Simulation modelling to extrapolate health, health inequalities, economic and environmental impacts of HFSS tax policies. Month 16-30. WP Lead: Breeze, Sheffield.

We will estimate the impact of three food tax policies, selected in WP1, on the general population of the United Kingdom over the short (1, 3 and 5 year), medium (20 years) and lifetime horizons. Evidence from WP2 and 3 will inform base case scenarios to describe consumer and industry responses to food taxes from which will extrapolate responses into health, economic and environmental impacts.

Objective 10: To estimate the impact of tax policies from LCFS spending to wider societal impacts (household purchasing, environmental and macroeconomic outcomes)

We will review the evidence from WP2 and WP3 to select the price-elasticity, cross-price elasticity, and pass-through costs that describe the most likely responses of consumers and industry to tax policies. Changes in prices will be modelled by combining information on the specification of tax policies with estimated pass-through costs, allowing for differences between product types. We will simulate changes to current purchasing patterns, described by the LCFS survey, by combining price increases with price elasticities to generate simulated counterfactual food purchasing scenarios for each tax option. Using the differences between the original LCFS data and simulated counterfactual scenarios we will describe impacts on wider societal outcomes.

1) Household expenditure. Discussions with PPI groups highlighted the importance of tax impacts on household spending, and spending on essential food in particular. We will stratify the LCFS data to observe the impact of the policy on average weekly spend of food distributed across social groups. This will determine whether the policies will lead to increased spending on food for disadvantaged groups, or if substitution to cheaper products will mitigate this effect. The social groups of interest will be agreed with stakeholders in WP1, but could include household income, National Statistics Socio-economic classification, or BAME groups.
2) Global and local supply chains. We will use UK supply and use input-output tables published by the Office for National Statistics (74), in addition to global and food commodity focused multiregional input output tables (specifically the EORA (75), and FABIO databases (76)) to examine the economic structure of food supply chains. We will use structural decomposition analysis (77) and value chain analysis to understand the UK and global supply chain impacts of the different tax options. This will allow us to model how changes in demand due to taxes will affect income of supply chain actors (farmers, manufacturers etc.).
3) Environmental outcomes. We will link existing food life cycle analysis (78) and food waste (79:80) databases matched to LCFS and NDNS data to calculate the wider food system environmental impacts of the scenarios. We will use a multi-criteria approach to environmental impacts including Water footprint, Land use (e.g. m2 per amount of food produced), Greenhouse gas emissions (GHGE, or CO2e), Eutrophication potential (referring

to water pollution), and household food waste). This will allow us to create an environmental scorecard for the WP1 food tax policies and best-case scenarios, following the methods under development by Clark (Oxford Martin School) to calculate the Foundation Earth ecolabel (https://www.foundation-earth.org/). If additional verification of the impacts are required, we can use environmental factors from EORA's multiregional input output tables to cross check our results.

4) Macroeconomic indicators. As above, we will use the UK supply and use input-output tables (74) and global multiregional input output tables to calculate the direct and indirect macroeconomic impacts (change in GDP and employment) of the WP1 food tax policies.

Objective 11: To estimate the impact of tax policies on consumption, health, health-related costs and employment across social groups.

We will run simulations with each tax policy identified in WP1 using version 5.0 of the School for Public Health Research (SPHR) diabetes prevention microsimulation model, and compared against a do-nothing scenario (81). The advantages of this modelling approach are:

1. Combined dietary response. Changes in sugar, fibre, salt and fat are modelled simultaneously to generate a single integrated effect on health rather than assuming nutrients have independent, or unrelated, health impacts.
2. Dynamic changes to diet. Changes to diet can occur gradually, or wane over time, to allow for the effects of price changes or reformulation to occur at different times.
3. Individual diet and health trajectories. The simulation of food tax policies will interact with societal patterning of consumption and health trajectories to enable a more flexible assessment of the impact on health inequalities. The microsimulation will capture intersectionality and allows for flexibility to accommodate different sub-groups of interest to stakeholders.

A SPHR diabetes prevention model is currently being adapted to include a novel dietary change module as part of a project funded by the NIHR School for Public Health Research. The project is due to finish on 31st March 2022 and will enable changes in food consumption to be translated into changes in health, life expectancy and health inequalities in a single modelling framework. A representative sample of individuals enter the model from years 1-11 of the National Diet and Nutrition Survey (NDNS) (82). The data provides food consumption patterns, socio-demographic characteristics and baseline metabolic risk. Missing data, including baseline EQ-5D and health conditions, will be imputed using multiple imputation methods and data from other national surveys, such as the Health Survey for England.

If no tax policy is specified, natural history trajectories for BMI, systolic blood pressure, HbA1c, total and HDL cholesterol are derived from statistical models of the Whitehall II cohort and English Longitudinal Study of Ageing (83, 84). The SPHR diabetes prevention model links metabolic risk trajectories and other individual characteristics to long-term health conditions, including diabetes, microvascular complications, cardiovascular disease, cancers (breast and colorectal), congestive heart failure, osteoarthritis, depression and dementia. Diabetes diagnosis is simulated based on a range of conditions, including HbA1c tests, to describe opportunistic detection patterns. Major health events are determined using nationally representative epidemiological models, and include adjustment for socioeconomic status where possible. The SPHR diabetes prevention model already allows us to compute outcomes for (1) the rate of people living with overweight and obesity in the population (2) the incidence of diabetes, cardiovascular disease, cancer, congestive heart failure, osteoarthritis, depression, and dementia (3) disease-specific mortality and the consequent life years gained and Quality Adjusted Life Years (QALYs). (4) disease specific NHS treatment costs and social care costs. QALYs and Costs are discounted at 1.5%.

For each food tax policy we will produce scenarios to describe changes to individual food consumption, and nutritional intake due to reformulation, in annual cycles conditional on changes in purchases by food group from the described in Objective 10. Individuals' changes to food consumption will be conditional on different baseline consumptions, price elasticities across social

groups, different pass-through costs between products, and differences in reformulation across products. These simulated individual level changes to calorie and nutrient intake in the NDNS will be translated into changes to individual-level metabolic trajectories. In the do-nothing scenario we will assume food purchasing patterns remain constant over this period.

The model is flexible to adaptations to meet the requirements of a broad range of stakeholders, as evidenced by recent work to evaluate dementia prevention (84), and adaptation to return on investment analyses (85). In the proposed work we will make the following changes to the model.

1) Include children in the simulated population. We will derive metabolic trajectories based on cross-sectional data from the Health Survey for England (HSE). We will maintain heterogeneity in the distribution of metabolic risks in the population by assuming that an individual's position (percentile) in the distribution of metabolic risk factors remains constant over time.
2) Extend health outcomes. The full list of health conditions will be informed after consultation with stakeholders in Workshop #2. A review of other population models of dietary interventions highlighted that additional health outcomes related to dental caries and cirrhosis may be considered (52). In addition to this we will consider expanding the list of cancers in the SPHR model.
3) Labour Outcomes. In a previous version of the SPHR model changes to EQ-5D were translated into productivity losses via statistical regression estimates. We will incorporate statistical models into the microsimulation to estimate the impact of changes in EQ-5D on labour market outcomes. This will produce estimates for changes in household income, social benefit payments, unemployment, and retirement. This will provide detailed assessment of the impact of the policies on labour market outcomes, rather than an estimate of productivity losses. We will also observe difference in these outcomes between social groups. We will cross-validate outcomes with methods used in Objective 11.4.
4) Social and Informal care cost estimates. The SPHR model includes the social care costs for cardiovascular events, osteoarthritis and dementia, where there is evidence to inform an increase in social care costs associated with a health event/outcome. Social care costs and costs of informal care are strongly associated with BMI, and a method for predicting hours of social care in individuals over the age of 65 has been proposed (86). The estimated costs are adjusted for comorbidities. We can include these cost estimates into our model to estimate the impact of reduction in BMI on social care costs, adjusting for other determinants of social care costs.

The SPHR diabetes prevention model has undergone a number of validation tests to assess how simulated disease trajectories fit to observed evidence. All new code will undergo a process of error checking and verification process. Standard validation checks, in the form of unit tests, will be used to check the specification of tax policy scenarios.

Socioeconomic position and inequalities

In our analysis the price-elasticity of demand, consumption patterns and epidemiological models will impact on the response to food taxes across social groups. We will investigate social group differences by stratifying the impact of taxes on household expenditure, health outcomes, NHS and Personal Social Services (PSS) costs and health-related labour market outcomes by social groups to observe how the benefits and burden of food taxes are distributed. The specification of social groups will include a measure of socioeconomic status to observe equity impacts of the policies (81), but may be extended to other social groups of interest as requested by the stakeholders and PPI panel members. In previous analyses we have stratified the analysis by IMD quintile and estimate the impact of policies across socioeconomic groups. These estimates can determine which social groups benefits most from increases in QALYs, diabetes diagnoses, and cardiovascular disease. By looking across socioeconomic groups we can also established whether the social gradient for a health measure i.e. obesity rate, is reduced by the policy.

Uncertainty and Sensitivity analysis

First, we will assess the impact of statistical uncertainty around our estimated parameters through probabilistic Monte Carlo simulation. We will sample values from statistical distributions for the own-price elasticities, cross-price elasticities, pass through costs, and reformulation effects to generate a range of simulated effects on food purchasing. This will allow us to present uncertainty intervals around each point-estimate of effects for each tax policy, where the intervals represent the uncertainty contributed by price elasticities, pass-through costs, and reformulation. From this we can produce uncertainty intervals around the outputs generated in Objective 10. The uncertainty in changes to food purchasing will be combined with probabilistic sensitivity analysis procedures in the SPHR diabetes prevention model to generate uncertainty intervals outcomes from Objective 11.

Second, we will generate scenarios for structural sensitivity analysis to explore the impact of data sources and modelling assumptions on outcomes. For example, we plan to run the model using elasticity estimates from previously published (56), and forthcoming analyses. We will consult with stakeholders to identify alternative evidence to the base case assumptions and/or key areas of uncertainty to inform sensitivity analyses.

Third, we will generate a sensitivity analysis in which an alternative discount rate is used to test model sensitivity to discounting. We acknowledge that there is likely to be underreporting of dietary assessment in the NDNS. Methods have been developed to correct for calorie intake bias, but not for the quantities of individual food groups. We will assess whether the energy intake correction models can be used to approximate adjustments to dietary assessments. We will use these adjusted analyses to observe the sensitivity of the BMI and metabolic risk factors to assess whether the bias is likely to impact on the microsimulation outcomes. If the metabolic risk factors are sensitive to dietary assessment bias we will run sensitivity analyses to observe the sensitivity of model outcomes to the underreporting of food consumption in dietary assessment methods in the NDNS.

WP 4 Outputs

1. A full technical report will describe the microsimulation modelling approaches, assumptions and methods to Value in Health,
2. The main paper will present a complete policy impact analysis across all outcomes to submit to The Lancet Public Health
3. A professional policy briefing document will be developed with input from the stakeholders and PPI panel to communicate findings to policy makers and the public,
4. Infographics to illustrate the outcomes/scorecard for each food tax policy option,
5. A full technical description of the microsimulation model and accompanying microsimulation model with the code for model functions available through GitLab.

5 DATA MANAGEMENT

5.1 Data collection tools and source document identification

The interviews will produce audio recordings. The digital recordings of each workshop and interview will be stored as video/audio files (.mp4/.mp3); the anonymised transcripts of each session will be stored as .docx files. Transcription conventions will be agreed at the start and adhered to by all. Where participants indicate they are uncomfortable being recorded, contemporaneous notes will be taken and stored as .docx files. NVivo will be used to aid analysis, and the final files will be stored as .nvp files.

The data derived from the elicitation exercises will be generated in an online tool designed for elicitation exercises. The data reported in the tool during the interview will be extracted from the online tool and stored in a prepared excel spreadsheet with anonymised labelling for future reference.

5.2 Data handling and record keeping

A study protocol (including contact details for the principal investigator) and a copy of the methods for each research activity (including information about the collection of data, analytical and procedural information, definitions of variables, units of measurement, any assumptions made, the format and file type of the data, and software used to collect and/or process the data) will be stored with all collected data.
During the project research data will be stored on the project team's secure network drive. Access to the folders will be restricted to team members who need to access the data. The network drives are regularly backed-up and managed by the University IT services.
Data from the elicitation study, and secondary datasets will be stored at the University of Sheffield. All sensitive data stored at the University of Sheffield will abide by the ScHARR Information Governance Policy. https://www.sheffield.ac.uk/scharr/research/information-governance

5.3 Access to Data

The project PI will have access to all data stored at the University of Sheffield. Access to the project folder will be restricted to team members working on the project. Access to project sub-folders holding sensitive data will be restricted to team members needed access to this information.

5.4 Archiving

Data from the expert elicitation will be presented in the technical report for the project, and will be accessible via open access publications reporting the project findings.
Secondary datasets will not be made available or shared. Secondary datasets used to generate evidence and model parameters for use in the mathematical models will be preserved for the duration of the project, and for 12 months after the outputs have been published. After this point the datasets will be removed from the project folders.
Data collected from published literature and expert elicitation for the model parameters for the SPHR Diabetes Prevention Model will be made available via a license agreement to use the model.
All research data will be preserved in a data repository unless the data cannot be anonymised or consent for preservation is not obtained from participants.

6 MONITORING, AUDIT & INSPECTION

As this is not a clinical trial no trial monitoring plan will be developed. The University of Sheffield will be the research sponsor and host organisation. Dr. P. Breeze (Research Fellow, Sheffield) and Prof. A. Brennan (Professor, Sheffield) are the Co-Principal Investigators. Dr. Breeze will undertake project management, with supervisory and leadership support. Prof. A. Lake (Professor, Teesside & Fuse) will be the principal co-applicant from Teesside and Dr. C. Reynolds (Senior Lecturer, City) the principal co-applicant from City University. Subcontracts will be set up between Sheffield and

collaborating institutions detailing the budget resources allocated, the responsibilities and expected contributions of each party. Stakeholder engagement events will be hosted by all institutions, and the costs for these and travel expenses will be held at each institution. Costs for PPI will be held at Sheffield. The collaboration will be coordinated through the Project Management Group comprising Dr. Breeze, Prof. Brennan, Prof. Lake, Dr. Reynolds, Dr. R. Pryce, and two PPI panel representatives. The Project Management Group will meet via online platforms every 2 months to ensure that progress is made according to project timelines. Progress reports will be circulated to all collaborators and the public advisory group every 6 months to ensure continued engagement and contribution.

7 ETHICAL AND REGULATORY CONSIDERATIONS

7.1 Research Ethics Committee (REC) review & reports

Ethical approval is required for this research. NRES ethics approval will not be required for WP1-4; we will follow and comply with the Economic and Social Research Council's research ethics framework. Ethical approval for the programme was obtained from School of Health and Related research ethical review committee (049874) on 20/01/2023). In addition, ethical approval for WP1 was obtained through the internal ethics review process in the School of Health and Life Sciences Research Ethics Committee at Teesside University (11124 Moore).

All participants will be provided with an information sheet outlining the study, their participation in it, and the steps which will be taken to ensure confidentiality. Prior to the workshops and interviews we will ask participants to read the information sheet and sign a consent form. Interview participants will participate anonymously. Hard copies will be destroyed and data stored securely at Teesside.

7.2 Peer review

The research plan has been reviewed by the funding committee and has undergone peer review. The protocol will undergo further review post-award from the funder.

The study steering committee has been appointed to provide overall supervision for the project on behalf of the Project Funder and to ensure that the project is conducted to the rigorous standards set out in the Department of Health's Research Governance Framework for Health and Social Care and the Guidelines for Good Clinical Practice.

7.3 Public and Patient Involvement

We have consulted with two public panel groups (PUGP, DeepEnd) and third sector organisations (Sustain, Obesity Health Alliance, WRAP). The outcomes of these discussions resulted in a commitment to evaluate taxes on confectionery and take-aways, household food budgets, and an assessment of the impact of taxes on the price of essential foods. We will form a public advisory group for the study to inform the methods, interpretation of data, and dissemination of findings. We aim to recruit 8-10 people with representation from diverse population groups via third sector organisations, the Sheffield 'DeepEnd' PPI network and using the People in Research website. Baxter (Senior Research Fellow, Sheffield) is the PPI lead on this proposal and will be the main point of contact for the panel. PPI input will be incorporated into the design, analysis, interpretation and dissemination of this research. We have sufficient support, training and remuneration for the panel. Two representatives of the PPI panel will join management group meetings.

7.4 Protocol compliance

Protocol compliance will be monitored by the principle investigators and deviations from the protocol will be documented and communicated to the study steering committee for approval.

- prospective, planned deviations or waivers to the protocol are not allowed under the UK regulations on Clinical Trials and must not be used e.g. it is not acceptable to enrol a

participant if they do not meet the eligibility criteria or restrictions specified in the study protocol

- accidental protocol deviations can happen at any time. They must be adequately documented on the relevant forms and reported to the Chief Investigator and Sponsor immediately.
- deviations from the protocol which are found to frequently recur are not acceptable, will require immediate action and could potentially be classified as a serious breach.

7.5 Financial and other competing interests for the chief investigator, PIs at each site and committee members for the overall study management

The project PI has no financial and other competing interests.

The competing interests of the study steering committee will be reported once the committee have been recruited.

7.6 Amendments

Amendments to the protocol will be submitted to the study steering committee who will have the responsibility to approve or reject the amendment with a 2/3 majority.

8 DISSEMINIATION POLICY

We plan to submit five research papers to peer-reviewed scientific journals describing the methodological contribution and a comprehensive description of the findings of our research to the academic disciplines. All papers will be published open access. In WP1 and WP4 we will target health/nutrition journals to maximise impact in these disciplines. We will also produce papers with a methodological focus from the activities across WP2-4.

Manuscript 1: An assessment on the effectiveness, feasibility and acceptability of food taxes in the UK. Target Journal: Milbank Quarterly.

Manuscript 2: Estimation of own- and cross-price elasticities of at-home and out of homel demand in the UK- analysis of the Living Costs and Food Survey. Target Journal: Social Science and Medicine.

Manuscript 3: Food tax pass-through across the product and price range: do retailers treat food products differently? Target Journal: Social Science and Medicine

Manuscript 4: Evaluating the health economic impact of food and drinks taxes in the United Kingdom: a microsimulation analysis. Target Journal: Value in Health

Manuscript 5: A whole systems approach to evaluate the costs and benefits of food and drinks taxes in the United Kingdom. Target Journal: The Lancet Public Health.

Conference Presentations

Two presentations at UK Congress on Obesity to present findings from WP1 and WP4.

One presentation at the Health Economics Study Group to present results from WP2.

One international presentation at the Society of Medical Decision Making to present results from WP4.

Modelling infrastructure

The research will develop modelling infrastructure to evaluate the benefits and costs of food policy in the UK. The work provides an analytical framework to extend the analyses of the LCFS dataset to consider other policies impacting household consumables, such as alcohol, smoking or policies impacting energy consumption and motor fuels.

Policy Impact

We will co-develop professionally produced policy briefing documents with our public involvement group and with input from our stakeholder group to identify key messages and findings and communicate findings in an accessible format, such as social media output.

Briefing Document 1: “Food Taxes in the UK: What are the options?”

Briefing Document 2: “Food Taxes in the UK: Household, health, economic and environment impacts”

We will schedule a webinar for stakeholders at month 16 to communicate the findings of WP1-3 and present the analysis plan for WP4.

Public Impact

Michael O’Malley, a graphics designer, will support the production of high quality infographics. We will work with PPI representatives to identify clear, meaningful messages for the public, develop communication materials and identify appropriate outlets for dissemination.

Infographics 1: We will develop infographics for our stakeholder workshops to communicate food taxes options and how the mechanisms for impact differ, ie point of sale taxes vs. excise taxes.

Infographics 2: We will synthesize the information generated from WP1 into infographics and visual summaries to enable communication of findings and comparisons between options to stakeholders.
Infographics 3: “Food Taxes in the UK: Household, health, economic and environment scorecards

9 REFERENCES

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