Evaluation of planning policy to regulate takeaway food outlets for improved health in England

Research Registry UIN: 6637

Protocol Version Table:

Version number	Author	Purpose/change	Date
1.0	Thomas Burgoine		9/3/21
1.1	Thomas Burgoine	Staff, Collaborator, SSC & PAG updates; WP4 milestones delayed by 2 months	20/10/21
1.2	Thomas Burgoine	Staff, Co-I & SSC updates; WP5 & 6.2 timelines revised	27/4/23

Funded by the NIHR Public Health Research Programme
Project number: NIHR130597

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1 Protocol contacts and authorisation

1.1 Chief Investigator

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1.2 Co-Investigators

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Professor Antonieta Medina-Lara
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Professor Richard Smith
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Dr Claire Thompson
Senior Research Fellow, School of Health and Social Work, University of Hertfordshire, UK.

Professor Martin White
Professor of Population Health Research & Programme Leader, UKCRC Centre for Diet and Activity Research (CEDAR), MRC Epidemiology Unit, University of Cambridge, UK.

1.3 Collaborators

Professor David Hammond
CIHR PHAC Chair in Applied Public Health, School of Public Health and Health Sciences, University of Waterloo, Canada

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Mr Stephen Sharp
Senior Statistician, UKCRC Centre for Diet and Activity Research (CEDAR), MRC Epidemiology Unit, University of Cambridge, UK.

Dr Lana Vanderlee
Assistant Professor, School of Nutrition, Université Laval, Canada.

Dr Peter Scarborough
Associate Professor & University Research Lecturer, Nuffield Department of Population Health, University of Oxford, UK.

Dr Ben Amies-Cull
DPhil Candidate, Nuffield Department of Population Health, University of Oxford, UK.
General Practitioner, Mount Road Surgery, Manchester.

1.4 Study Steering Committee

We have appointed an independent Study Steering Committee (SSC), as follows:

Professor Jamie Pearce (Chair)
Professor of Health Geography, School of Geosciences, University of Edinburgh, UK.

Professor Tim Townshend
Professor of Urban Design for Health, School of Architecture, Planning & Landscape, Newcastle University, UK.

Professor Janis Baird
Professor of Public Health and Epidemiology, MRC Lifecourse Epidemiology Unit, University of Southampton, UK.

Professor Marc Suhrcke
Professor of Global Health Economics, Centre for Health Economics, University of York, UK.

Dr Stephanie Chambers
Lecturer in Sociology of Health and Wellbeing, Health and Wellbeing, MRC/CSO Social and Public Health Sciences Unit, University of Glasgow, UK.

Ms Steph Downey
Lay member

1.5 Project Advisory Group

We have appointed a non-academic Project Advisory Group (PAG), constituted of policy & practice partners, as follows:.

Mr Scott Lloyd
Advanced Public Health Practitioner, Public Health South Tees, Middlesbrough Council / Redcar & Cleveland Borough Council, UK.

Ms Claire Turbutt
Worklessness & Workplace Health Lead, Public Health England South West, UK.

Mr Craig Lister
Health and Wellbeing Programme Lead, Public Health England East of England, UK.

Dr David Johns
Consultant in Public Health, Nottingham City Council, UK.

Dr Katie Hunter
Consultant in Public Health, Communities & Skills Directorate, Greater London Authority, UK.

Ms Emma Strachan
Advanced Health Improvement Specialist (Food and Nutrition), Leeds City Council, UK.

1.6 Protocol sign-off

Chief Investigator signature:

Responsibilities

2.1 Chief Investigator

Dr Thomas Burgoine, Senior Research Associate whose research focusses on social and environmental determinants of diets and health. He will provide overall leadership of the study and co-lead Work Packages (WPs) 1 and 7.

2.2 Co-Investigators

Dr Jean Adams, Senior University Lecturer & Programme Lead whose expertise is in the evaluation of dietary public health interventions. She will co-lead WPs 1 and 6.2.

Dr Ben Amies-Cull, Health Modeller whose expertise is in impact modelling of public health interventions. She will co-lead WP2.

Mr Michael Chang, Programme Manager – Planning and Health, whose expertise is in town planning and the role of evidence in policy. He will co-lead WPs 5-7.

Professor Steven Cummins, Professor of Population Health whose expertise is environmental and systems determinants of health. He will co-lead WPs 4 and 6.1.

Professor Antonieta Medina-Lara, Associate Professor in Health Economics, whose expertise is in economic analysis of public health interventions. He will co-lead WP3.

Dr Oliver Mytton, Honorary Senior Visiting Fellow, whose expertise is in public health modelling and policy evaluation. He will co-lead WP2.

Professor Richard Smith, Deputy Pro-Vice Chancellor & Professor of Health Economics, whose expertise is in economic analysis of public health interventions. He will co-lead WP3.

Dr Claire Thompson, Senior Research Fellow whose expertise is in qualitative public health research. She will co-lead WPs 4 and 6.1.

Professor Martin White, Professor of Population Health Research & Programme Lead, whose expertise is in public health policy evaluation. He will co-lead WP5.

2.3 Collaborators

Dr Tarra Penney, Assistant Professor who expertise includes longitudinal qualitative data analysis. She will collaborate on WP5.

Professor David Hammond, CIHR PHAC Chair in Applied Public Health and Principal Investigator for the International Food Policy Study (IFPS), used in WP6.2.

Mr Stephen Sharp, Senior Statistician who will oversee all statistical work including design, analysis and interpretation of results.

Dr Lana Vanderlee, Assistant Professor and Researcher on the IFPS, used in WP6.2.

Dr Peter Scarborough, Associate Professor & University Research Lecturer, co-developer of the PRIMEtime model and local PRIMEtime model. He will collaborate on WP2.

2.4 Project staff

Ms Aubrey Ko, London School of Hygiene and Tropical Medicine. Study Support Administrator.

Ms Alexandra Williams, University of Cambridge. Research Assistant (2021-2022).

Dr John Rahilly, University of Cambridge. Research Associate.

Dr Suzan Hassan, London School of Hygiene and Tropical Medicine. Research Fellow.

Ms Annie Schiff, University of Cambridge. Project Coordinator.

Dr Bochu Liu, University of Cambridge. Research Associate.

Dr Matthew Keeble, University of Cambridge. Research Associate.

Bea Savory, London School of Hygiene and Tropical Medicine. Research Assistant.

3 Protocol summary

3.1 Scientific abstract

Poor diet and obesity are leading causes of mortality. Takeaway food outlets ('takeaways') tend to sell energy-dense food, with frequent consumption linked to weight gain. There are 60,000 takeaways in England with more in deprived areas and annual growth four times that of population growth. Physical access ('exposure') to takeaways is positively associated with takeaway consumption and obesity. Urban planners are unable to remove planning permission from existing takeaways, but they can refuse permission to new takeaways. The most common form of planning policy is the school-based 'exclusion zone' adopted by 44 of 325 LAs in England to date. The intent of these interventions is to prevent further takeaway proliferation around schools. While appearing to target children, our previous findings suggest this is a politically acceptable means to reduce whole population takeaway exposure.

The health and other impacts of exclusion zones are unknown. If effective, this absence of evidence is a barrier to adoption and implementation and delays public health benefit.

Across seven work packages (WPs) we will exploit the natural experiment of variation in LA intervention to conduct a comprehensive evaluation. WP1: if exclusion zones impact health they must first affect retailing. We will use pre-post data from intervention and control areas to assess impacts on numbers of: takeaways; other food and non-food outlets; planning applications received, rejected, and appealed. WP2: health impacts could only be observed in the long-term. We will model impacts to 2040 on population: takeaway exposure; obesity prevalence and related morbidity. WP3: policymakers are concerned about economic impacts. We will model costs and benefits by 2040 to: businesses, local economy, local and national government, NHS; society. In WPs 1-3, impacts will also be explored by urban/rural and socioeconomic contexts. WP4: LAs benefit from the experiences of others. We will conduct post-intervention stakeholder interviews to understand: implementation experiences and perceived effectiveness; implementation barriers and facilitators; how the intervention might be optimised; and with stakeholders we will produce LA guidance on how to best implement future interventions. WP5: how takeaways react to the intervention and how LAs respond is likely to affect policy content and uptake. We will exploit public consultation data to document how: takeaways react to the intervention; LAs respond to takeaway reactions; and whether these stakeholder narratives have changed over time. WP6: policies with public support are more likely to be adopted, and perceived effectiveness increases acceptability. We will explore overall and by SES, the proportion of children and adults who: are concerned about takeaways and why; support the intervention; think the intervention will be effective. WP7: we will work with policymakers to synthesise and disseminate findings.

3.2 Plain English summary

About 60,000 shops in England sell hot food to take away. Takeaway food tends to be high in salt, fat and calories. People who live and work in areas with the most takeaways eat more takeaway food and are more likely to live with obesity than those who live and work

elsewhere. Online food ordering ‘apps’ make it easier to access takeaway food, but this still mostly comes from local takeaways.

Local Authorities (LAs) are increasingly worried about the impact of takeaways on health. Existing takeaways cannot be shut down, but a quarter of LAs have applied planning rules to new takeaways in this typically fast growing sector. The most common approach is 400-800m (0.25-0.5 mile) ‘exclusion zones’ around schools where planning permission is denied to new takeaways. Forty-four LAs have zones and 70 more are considering them. In previous research, our interviews with planners suggest that the focus on schools is a strategy to make zones more politically acceptable. These policies are intended to target whole communities. There is very little research on the impacts of preventing new takeaways from opening.

Our main research question is: “What is the impact of exclusion zones on the number of takeaways?” Using a dataset of all food outlets in England, we will compare takeaway numbers in areas with and without exclusion zones, two years before and after zones are introduced. We will also study areas just outside zones in case takeaways are displaced there. Any health impacts of zones are likely to be small and take a long time to occur. We will use statistical modelling to estimate the impact of zones on obesity and health. Policymakers are concerned that exclusion zones may harm local economies. We will conduct an economic analysis to explore the costs and benefits of these zones across the whole of society. Exclusion zone policies vary between LAs and may not be implemented as intended. We will interview 30 LA officials to understand what, if any, problems they had with implementation, and how these were addressed. We will work with participants to design exclusion zone policies that address these problems and share these with LAs who have not yet implemented zones. Exclusion zones are more likely to be adopted and effective if they are acceptable to local residents and business people. We will use written responses to statutory local consultations on exclusion zones to see how food businesses react. In ‘go along’ interviews with 32 local residents, we will explore views on takeaways and exclusion zones in depth. We will use a survey of 4000 people to understand any concerns more widely.

The need for planning permission for new takeaways was recently relaxed for 24 months in response to coronavirus. Our study will use data from before the rules were relaxed and the results will be relevant after the rules are tightened up. The main audience for our findings is local and national policymakers and practitioners. Dissemination activities will include workshops, evidence briefs, blogs and presentations at relevant conferences.

4 Background

4.1 The public health problem: takeaway food outlet proliferation and obesity

Poor diet and excess weight are leading causes of morbidity and mortality (1), resulting in substantial costs to the NHS and society (2). There are persistent inequalities in diet and weight (3). Takeaway food outlets ('takeaways') sell hot food to eat off the premises (4). A quarter of UK adults eat takeaway food weekly (5). In 2016, £10 billion was spent on takeaway food in the UK, an increase of 34% from 2009 (6).Takeaway food is energy-dense, nutrient poor and served in large portion sizes (4, 7, 8). In a recent study in Liverpool, three quarters of takeaway meals analysed (excluding side orders and drinks) exceeded 1125 calories, with a quarter exceeding 1800 calories i.e. 90% of a woman's recommended daily calorie allowance. Frequent takeaway consumption is linked to obesity and weight gain (9-11).

Despite the rise of online platforms, most takeaway food is still made in kitchens on the high street. There are approximately 60,000 takeaways in England, with annual growth four times that of population growth (12). Takeaways are more prevalent in deprived areas (13, 14), and are more concentrated around schools in deprived areas (15, 16).

Physical access to takeaways ('exposure') is considered a risk factor for high levels of and inequalities in poor diet and excess weight (see *4.3 Review of existing evidence*). Using their existing powers, urban planners have the ability to modify this exposure (17). This is being increasingly explored as an intervention to improve the public's health (18).

4.2 The intervention: takeaway exclusion zones around schools

Takeaways occupy their own 'use-class' (category for the use of a non-residential building) within the English planning system (19). Planning permission must be obtained from the local authority (LA) for a new takeaway premises or to change the use-class of an existing premises to a takeaway (20). Planners are unable to remove planning permission from (i.e. close down) existing takeaways (21). However, they can refuse planning permission to new outlets. Using the planning system in this way to create healthier neighbourhoods is encouraged by national planning guidance (20), the NHS and Public Health England (PHE) (22, 23).

Our census of all 325 English LAs found the most common planning approach to restricting proliferation of new takeaways is the school-based 'exclusion zone' ('the intervention') (18). The intended effect of this intervention is to prevent further increases in the number of takeaways in these areas through denying planning permission to applications from prospective new takeaway owners.

The precise specification of exclusion zones varies. They can be different shapes (e.g. based on the street network or as the crow flies) or sizes (e.g. 400m, 800m), and aligned to the school gate or the central point of a school. They can surround primary schools, secondary schools or both (24).

Low-agency, population interventions that change how easy it is to access less healthy food (such as exclusion zones) are likely to have greater and more equitable effects than high-agency interventions (such as providing information on healthier choices to the public) (25, 26).

Exclusion zones are scalable to all 325 English LAs. They have been implemented in 44 LAs to date (Figure 1); 70 more have draft policies (18). PHE has launched a framework to help LAs adopt exclusion zones (23), encouraging further uptake, and they are a flagship intervention in the London Plan, which directly affects the actions of all 33 Greater London LAs (with a total population of 8.9 million) (27). Internationally, similar policies have been piloted in the US and Australia (28).

Although exclusions zones are centred on schools and therefore appear to focus on children, we found that this was considered a politically acceptable framing to reduce takeaway exposure across the whole population (21). If 400m exclusion zones were implemented around all schools, over 90% of inner-London by area would be included in a zone (unpublished data). The same is likely to be true in other dense urban areas.

Despite a decade of implementation, **the retail and health impacts of takeaway exclusion zones are entirely unknown**. There has been no evaluation of whether exclusion zones have achieved retail change or had negative unintended effects, how such effects might have varied by local context, or the extent to which any such retail changes might have impacted obesity and related illness. Lessons have not been learned from the process of policy implementation, which could be shared to inform future optimisation and effectiveness. There have been no studies on cost-effectiveness, including how costs and benefits are distributed to different groups in the short- to long-term. There may have been negative social and economic effects of these interventions, making them publicly and politically unacceptable, and reducing the likelihood of further widespread adoption and implementation. The nature of the response from takeaway food businesses, and how this has changed, is also unknown.

This absence of a diverse range of evidence is a barrier to policy adoption and implementation (21). LAs cannot afford to waste resources on ineffective interventions, and LA implementers are vulnerable to successful legal challenge. As well as providing evidence on takeaway exclusion zones in particular, a comprehensive evaluation of this intervention will provide evidence on the potential of urban planning to support public health in general.

4.3 Review of existing evidence

Physical exposure to takeaways is associated with takeaway consumption and obesity (29-31). However, systematic reviews have not been able to quantify the influence of neighbourhood food environments (32, 33), due to differences in concepts and methods (34). In our study assessing home, work and commuting journey ‘exposure’ to takeaways, adults most exposed consumed an additional 40g of takeaway food per week, had a higher mean BMI (+1.2kg/m^2) and were twice as likely to be obese, as those least exposed (29). In >50,000 Greater London adults, we found those with the highest takeaway exposure were

50% more likely to be obese than those with the lowest exposure (30). This effect was strongest in those of lower socioeconomic status (SES) (30, 31).

A US study found that a different type of 'zoning' (planning) intervention centred on a limited geographical area and addressing only standalone 'fast-food' outlets (not those in 'strip malls', where they are most commonly located), was too weak to affect retail change (35). We are not aware of any UK research, or studies from elsewhere in the world, documenting the effectiveness of takeaway exclusion zones.

If takeaway exclusion zones bring public health benefit, the continued absence of evidence delays this benefit being realised. Delays result in further expansion of the problem of takeaway proliferation and reduced impact of eventual implementation, as there is no current or foreseeable mechanism by which these new takeaways could be eliminated once established (36). In Blackburn, 39% of food outlets are takeaways – the highest proportion in England (12). If the same composition was achieved across England, and assuming continued annual growth of 3.2%, 29,877 new takeaways will open in the next 13 years – a 50% increase.

4.4 Our preliminary work

Multiple members of this project team (Burgoine, Adams, Cummins, White), alongside others, led the first national survey of planning regulations to address takeaway proliferation, and explored acceptability of these interventions to LA planning and public health stakeholders. Details of funding for this previous project were as follows:

Start date: 1/11/17

End date: 30/3/19

Project identifier: SPHR-CAM-PH112-HFT

Funder: NIHR School for Public Health Research (SPHR)

Title: Exploring the nature and acceptability of local authority actions to restrict proliferation of hot-food takeaways in England: preparation for a large-scale evaluation.

Our survey results are pilot data that enable this work (i.e. we already know the year and location of all exclusion zone policies adopted in England to date), and our qualitative research findings underscored the importance of policy evaluation to support adoption and implementation. We published three papers from this preliminary project:

A national survey of takeaway planning regulations in England (Keeble et al. Health Place 2019): https://tinyurl.com/y3opgl4j

A cross-sectional analysis of local government correlates of the use of planning regulations (Keeble et al. IJBNPA 2019): https://tinyurl.com/yyhp33vx

Qualitative research on policy acceptability with LA stakeholders (Keeble et al. Health Place 2020): https://tinyurl.com/y75mkgnx

5 Objectives

Informed by pilot research with LAs (18, 21, 36), and our draft causal model (Figure 2), we will exploit the natural experiment of variation in local authority implementation of takeaway exclusion zones around schools **to conduct a comprehensive evaluation of impacts on retail, health and economic outcomes; implementation and opportunities to optimise the intervention; and explore acceptability to businesses and the public.**

There are seven interconnected work packages (WPs), see Figure 1. For exclusion zones to impact on health, they must first impact on local retailing. In WP1, we will use pre- and post-intervention data from intervention and matched control areas to assess the impact of the intervention on numbers of:

a. takeaways
b. other types of food and non-food outlets
c. planning applications received, rejected and appealed.

Health impacts resulting from the intervention could only be observed in large, long-term studies. These are unlikely to offer value for money. In WP2, we will use simulation modelling to estimate intervention impacts by 2040 on population:

d. takeaway exposure
e. obesity prevalence and related morbidity.

Policymakers are concerned about the economic impacts of intervention (21). In WP3, we will model to 2040:

f. economic impact on businesses, the local economy, local and national government, the NHS
g. the costs and benefits of intervention from a societal perspective.

In WPs1-3, impacts are also explored by urban/rural and socioeconomic context.

LAs benefit from the experiences of others (21, 36). In WP4, we will conduct post-intervention interviews with implementers to understand:

h. experiences of policy implementation, and perceived policy effectiveness
i. perceived barriers and facilitators to effective implementation
j. what steps might be taken to optimise the intervention.

We will work with stakeholders to:

k. co-produce guidance for LAs on how to best optimise and implement future policies.

How food businesses react to the intervention, and how LAs respond, is likely to shape the content of interventions and further uptake. In WP5, we will exploit data from public consultations to document how:

l. takeaways react to the intervention and whether and how this varied by business type
m. LAs responded to takeaway reactions
n. these stakeholder narratives have changed and shaped one another over time.

Policies with greater public support are more likely to be adopted, and greater perceived effectiveness increases acceptability (37, 38). In WP6.1, we will use go-along interviews with young people, their parents and other guardians, and in WP6.2, we will use existing survey data, to explore overall and by SES, who:

o. are concerned about takeaways and why
p. support the intervention
q. think the intervention will be effective.

In WP7, we will triangulate and synthesise findings from WPs1-6, map evidence onto our causal model and draw overall and context-specific conclusions about effectiveness.

FIGURE 1: Left, pilot data from a completed NIHR-funded survey of all local authority takeaway food outlet exclusion zones policies to improve health, shown in the form of an intervention timeline. Right, study design flow diagram for this project, showing seven interconnected work packages (WPs), informed by previous pilot work.

PILOT DATA

Survey of all local authority takeaway food outlet exclusion zone planning policy interventions[1]

Local authority	Year and month of policy adoption										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Waltham Forest	Mar										
Barking and Dagenham		Jul									
Brent			Mar								
Rossendale			Jun								
St Helens			Jun								
Stockport			Mar								
Kingston upon Thames				Apr							
Newham				Jan							
Barnsley				Jan							
Halton				Mar							
Sandwell				Jul							
Islington					Mar						
Tower Hamlets					Apr						
Broxbourne					Jun						
Copeland					Dec						
Dudley					Sep						
Hertsmere					Nov						
Stoke-on-Trent					May						
Enfield						Nov					
Lambeth						Sep					
Lewisham						Nov					
Bradford						Nov					
Bristol						Jul					
Medway						Jul					
Warrington						Apr					
Hackney							Jul				
Wandsworth							Mar				
Blackburn with Darwen							Dec				
Gateshead							Jun				
Rochdale							Apr				
Newcastle upon Tyne								Oct			
Kingston upon Hull								Jun			
N Lincolnshire								Nov			
Manchester									Mar		
Sefton									Sep		
Torbay									Feb		
S Tyneside									Nov		
Wakefield									Jan		
N Tyneside									Jul		
Bromsgrove									Jan		
Haringey									Jul		
Wolverhampton										May	
Redbridge										Mar	
Leeds											Apr

[1]Keeble M, Burgoine T, White M, Summerbell C, Cummins S, Adams J. Health Place 2019;57:171-8.

THIS PROJECT

Evaluation of planning policy to regulate takeaway food outlets for improved health in England

WP1
Retail impacts
Evaluable interventions:
Retail outcomes = 19
Planning outcomes = 44

WP2
Health impacts
Effects of intervention modelled in 6 LAs

WP3
Economic impacts
Effects of intervention evaluated in 19 LAs

WP4
Implementation and optimisation
30 participants from 5 of 44 LA implementers

WP5
Business reactions
Evaluable interventions = 44

Public acceptability

WP6.1
Go-along participants
N = 64

WP6.2
IFPS UK adults
N = 4,000
IFPS UK young people
N=2,000

WP7
Engagement and dissemination
Independent scientific/policy & practice partner, and public PPI panels

Data availability dictates N of evaluable interventions

A, B, C, D, E, F

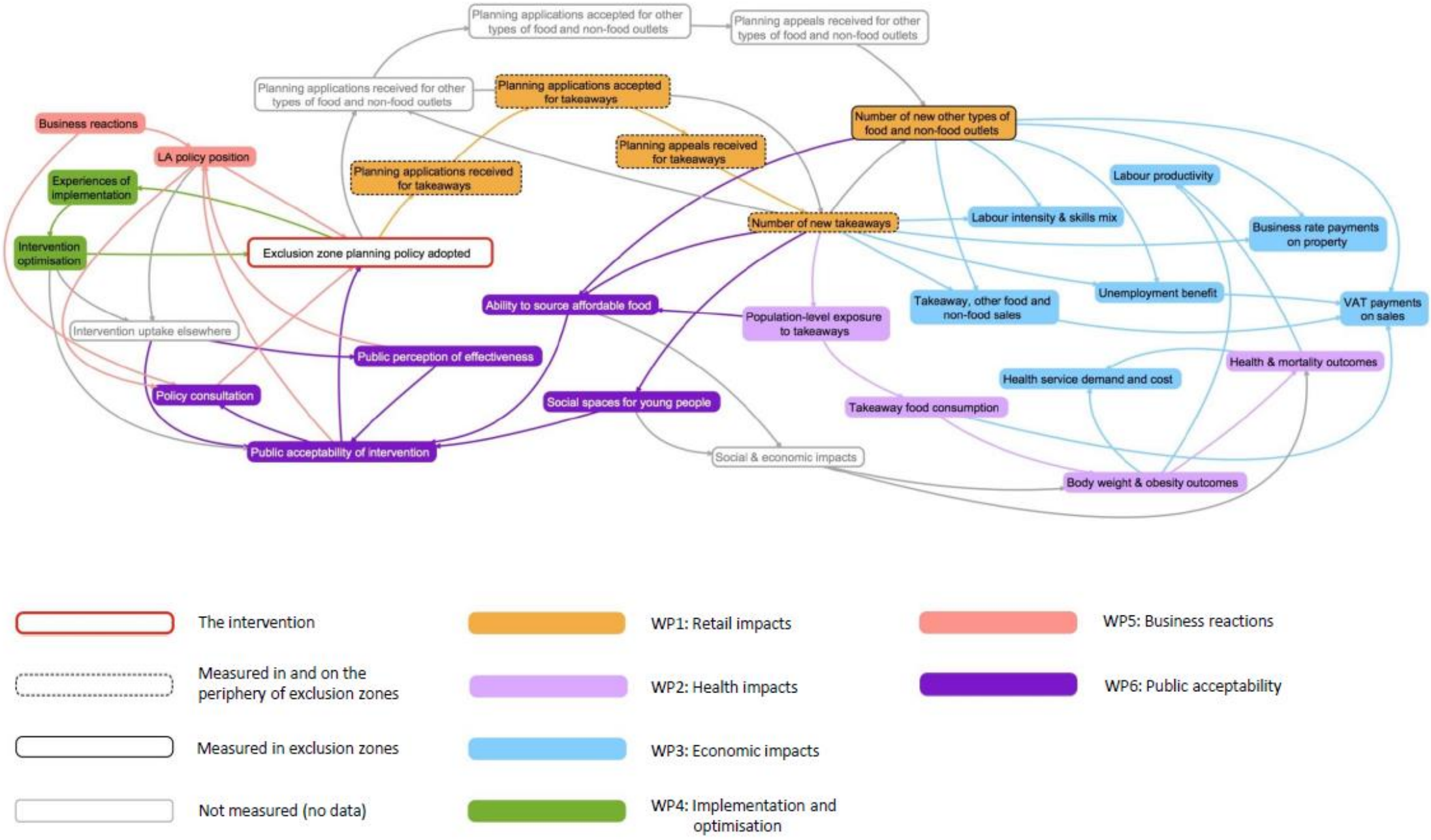
Flow of data from completed pilot study to WPs in this project

Flow of data between WPs in this project

Description of WP links (where link not to WP7)

- A: Observed intervention impacts on retail outlets
- B: Modelled impacts on obesity and related morbidity
- C: A posteriori contacts for sub-group analyses
- D: Perfect policy implementation scenario
- E: Identification of zone for go-along 's (WP6.1)
- F: Informs response options for survey (WP6.2)

FIGURE 2: Causal model.



6 Work packages

6.1 Retail impacts (WP1)

If exclusion zones have health impacts, they must first affect local retailing. Exploiting routine data, we will evaluate to what extent this intervention has brought about its intended effects (i.e. change in number of takeaways) and how (e.g. fewer takeaway planning applications, more rejected takeaway planning applications, more denied takeaway planning application appeals), and any unintended consequences.

Design
Difference-in-differences (DID) analysis comparing numbers of takeaways, other retail outlets and takeaway planning outcomes in and on the periphery of exclusion zones in intervention and control LAs, before and after intervention. All instances and specifications of the intervention, from 2009 to 2019 have been recorded in pilot work (18).

Controls
The Chartered Institute of Public Finance and Accounting (CIPFA) use a range of metrics including total population, unemployment and mortality rates to identify the 15 most statistically comparable LAs in England to every individual LA (39, 40). For each intervention LA, we will use CIPFA data to identify the most statistically comparable LA with no intervention as a candidate control. We will test the suitability of each control by graphing pre-intervention trend data for numbers of takeaways and takeaway planning applications received, to test the assumption that these trends were similar. If necessary, we will explore the possibility of using synthetic controls. To minimise confounding from even the most suitable yet still imperfectly matched LA control, we will adjust for relevant LA contextual and compositional characteristics (e.g. population characteristics, geographic size, outlet density).

Intended outcome measures
Within exclusions zones, numbers of:

- takeaways, at 1 year pre- and post-intervention
- takeaway planning applications received, rejected (with or without exclusion zone policy cited in justification for decision; the former can be linked directly to the planning intervention), appealed, subsequently rejected (with or without policy cited, see previous) in 2 years pre- and post-intervention

NB duration of pre- and post-intervention periods for each outcome differ due to data availability (see *6.1 Methods and data*), and in order to maximise the number of evaluable interventions.

Unintended outcome measures
On the periphery (within 100m) of exclusion zones, numbers of:

- takeaways, at 1 year pre- and post-intervention
- takeaway planning applications received, rejected, appealed, and subsequently rejected (as described above), in 2 years pre- and post-intervention

Within exclusion zones, numbers of:

- other food (cafes, restaurants, chain fast-food outlets) and non-food outlets (off-licenses, betting shops, tanning salons), at 1 year pre- and post-intervention

Methods and data
Data already held in-house or internet-based data collection as follows:

- takeaways, other food and non-food retail outlet locations, which have been archived in-house every quarter from March 2014 (source: Food environment assessment tool (Feat), www.feat-tool.org.uk (12))
- takeaway planning application data, collected monthly from 2009 (freely available from LA websites)
- school locations (freely available from the Department for Education website (41))

School locations and exclusion zones (according to specifications described in adopted policy documents e.g. 400m street network buffers or 800m as the crow flies buffers) mapped using geographical information systems. Outlets and applications mapped to determine if they are within or on the periphery of exclusion zones.

Sample size
Analytic sample size varies according to data availability. 19 LAs have adopted exclusion zones since 2015 and are included in analyses of takeaways and other retail outlets; smallest detectable mean post-intervention effect size = 2.0 new outlets per LA (80% power, α=5%, assumed SD=3). All 44 LAs that have adopted exclusion zones since 2009 are included in analyses of planning outcomes; smallest detectable mean post-intervention effect size = 1.3 new applications (80% power, α=5%, assumed SD=3). For context, 33 new applications were received by, and 38 new takeaways opened in, Manchester LA in 2016, meaning we would be able to estimate effect sizes of <10% of annual expected numbers of applications and openings here.

Analysis, socioeconomic status and inequalities
DID makes use of longitudinal outcome data (e.g. number of takeaway planning applications) from LAs that adopted the intervention and matched LA controls. In the absence of an intervention it is assumed that trends in a given outcome would be parallel between these LAs over time. Any deviation in trend for a given outcome in the intervention LA, from that observed in the control LA, can therefore be considered the intervention effect. In keeping with guidelines (42), we will calculate absolute change, e.g. where 'n' is total number of takeaway outlets, 'Int' is LA with intervention, 'Cont' is matched LA control without intervention, 'pre' is one year before and 'post' is one year after intervention: $(n\ Int_{post} - n\ Int_{pre}) - (n\ Cont_{post} - n\ Cont_{pre})$. We will estimate: the overall intervention effect across LAs combined (our primary outcome); the intervention effect across key LA urban/rural and socioeconomic contexts *a priori* determined (via exploratory sub-group analyses, interpreted cautiously as potentially underpowered) and across other contexts impacting implementation *a posteriori* determined in WP4 (as secondary outcomes).

Sensitivity Analyses
To explore the sensitivity of our findings to the selection of control LAs, we will repeat analyses for each intervention LA using the mean values for each outcome across the other LA controls, subset by equivalent urban/rural status and area-level deprivation.

6.2 Health impacts (WP2)

Although exclusion zones are centred on schools, they are intended to reduce takeaway exposure across the whole population (18). To directly observe the intervention's full and long-term impacts

on health would require a large and long-term study, which might not be feasible and would be unlikely to offer value for money. In lieu of observing these impacts, we will *model* them to 2040.

Design
We will develop a new simulation model to quantify the effects of planning policies on people's exposure to takeaways and its subsequent effect on body mass index (BMI), overall, by SES, and by ethnicity (model and data permitting, see *6.2 Outcomes, socioeconomic status and inequalities*). We will use an existing health impact model (PRIMEtime) to estimate changes in BMI on health (43, 44).

Scenarios
We will simulate two or three* intervention scenarios and compare these to a scenario of business as usual (i.e. no intervention adopted) to 2040. We will evaluate: 1) actual intervention as implemented (i.e. the reduction in new takeaways opening observed in WP1, overall and by urban/rural status); 2) perfect implementation (i.e. no new takeaways opened since intervention); and 3) optimised policy implementation (i.e. the maximum reduction in new takeaways opening likely to be achievable in practice, using results from WP4). Recognising the different contextual influences of the intervention's observed impact in WP1, we will run these simulations in six LAs (specified below) that have adopted the intervention, across key urban-rural LA classifications, which are often used as comparative benchmarks by policymakers at both local and national levels (40): a) major urban – London (e.g. Hackney); b) major urban – not London (e.g. Leeds); c) large urban (e.g. Bristol); d) other urban (e.g. Blackburn with Darwen); e) significant (26-50%) rural (e.g. Wakefield); f) predominantly (50-80%) rural (e.g. North Lincolnshire).

* The exact number of scenarios modelled will be contingent on findings from WP1 and finalised in discussion with the SSC. Where *statistically significant* ($p<0.05$) effects on local retailing are observed in WP1, we will model their impact on health, in addition to perfect and optimised implementation scenarios i.e. three scenarios total. Where observed impacts on retail are *not statistically significant* in WP1, we will model only the health impacts of perfect implementation (i.e. the extent of health impact that could be achieved if the intervention worked perfectly) and optimised implementation (i.e. the extent of health impact that could be achieved if the intervention was optimised from that implemented) scenarios i.e. two scenarios total.

Modelling takeaway exposure and effect on BMI
We will develop a small area population-based geo-spatial model of individual-level exposure to takeaway food outlets in home and work environments, and along journeys from home to work (modelled as the shortest street network route), using travel to work data from the UK Census (45). For business as usual in 5, 10 and 20 years, numbers of new takeaway food outlets will increase over time based on rates of past growth (observed from quarterly outlet trend data held in-house (12)), with locations determined stochastically constrained by historical patterns of growth. Based on findings from WP1 and WP4, restricted future growth will be predicted for the intervention scenarios at the same time intervals, again using a stochastic model to estimate outlet location.

We will estimate the impact of adults' changing exposure to takeaways in their combined home, work and journey environments on body weight, using a meta-analysis of two previous studies quantifying the relationship between takeaway exposure in these environments and BMI (29, 30).

Modelling effect on health outcomes
We will use synthetic local estimates of population BMI from the Active People Active Lives Survey (46). To determine the impact of changes in BMI on population health, we will use the established PRIMEtime model (a proportional multi-state lifetable model), to estimate lifetime burden of cardiovascular diseases, type 2 diabetes, BMI-related cancers and musculoskeletal disorders (47). Collaborator Scarborough and Co-investigator Amies-Cull are co-developers of the PRIMEtime model. The relationship between BMI and health is estimated based on published meta-analyses for each of the different diseases (48).

Outcomes, socioeconomic status and inequalities
We will report the overall impact of the intervention compared to business as usual, on the number of takeaway outlets, people's exposure to takeaways, mean population BMI, prevalence of obesity and overweight, and quality of life (associated with changes in disease status) for each local authority through to 2040. We will also estimate effects on life expectancy and quality-adjusted life expectancy.

We will do this by calculating SES- and ethnicity-specific estimates of takeaway exposure, based on home index of multiple deprivation score and 2011 UK census data. In combination with SES-specific local estimates of population BMI from the Active People Active Lives Survey (46), we will produce overweight and obesity prevalence estimates and associated health impacts by SES for each LA and for the six LAs combined. In addition, at our planned project meeting in month 22, we will review the possibility of producing these estimates by ethnic group, contingent on development of the PRIMEtime model to enable this and availability of ethnicity-specific local estimates of population BMI. Overall and SES-stratified (and potentially ethnicity-stratified) health impacts for each scenario will serve as inputs to WP3, to help quantify the economic effects of this intervention.

Uncertainty and Sensitivity Analyses
Monte Carlo analyses will be used to estimate 95% uncertainty intervals, reflecting reported uncertainty in model parameters. Sensitivity analyses will be used to test key assumptions within the model, informed by qualitative research in WP4.

6.3 Economic impacts (WP3)

Policymakers are concerned about the economic impacts of intervention, including to whom they accrue, and how they interact in the short- to long-term (49, 50). Moreover, established associations between each of area density of takeaways and takeaway food consumption, with area level socioeconomic status, necessitates consideration of differential impacts across socioeconomic groups.

Design
Cost-benefit analysis (CBA) to evaluate the full range of impacts (costs and benefits) at a societal-level and across all affected stakeholder groups in the short-, medium- and long-term (see *6.3 Outcomes*), and by SES.

Outcomes
Monetary valuation of costs and benefits for society overall and by stakeholder group (local businesses directly and indirectly affected, local economy, local government, national government,

National Health Service (NHS)), at three time horizons (5,10 and 20 years), to produce benefit/cost ratios, Net Present Value (NPV) and Internal Rate of Return (IRR) metrics.

Data sources

Using observed intervention impacts on numbers of takeaway food, other food and non-food retail outlets (i.e. retail composition), in and on the periphery of exclusion zones from WP1*, impacts will be modelled on:

- Local businesses: exclusion zones will affect sales and business income. The net effect will depend on the balance between reduced sales from restricted takeaway outlets versus increased sales of takeaway outlets on the periphery of exclusion zones, and of unrestricted retailers (other food and non-food outlets) taking up vacancies that would otherwise be occupied by takeaway outlets within exclusion zones (observed in WP1*). Data from the Annual Business Survey will be used to estimate these impacts (51).
- Local economy: labour intensity and skill mix varies by business type. Thus, changes in retail composition within and on the periphery of exclusion zones (from WP1*) might differentially affect patterns of employment and the local economy. National statistics on ground rent, unemployment and retail labour (51-54), will be analysed to identify these impacts. Reductions in obesity and related morbidity might have positive economic impacts on the local economy via increased productivity (55). This impact will be the sum of decreases in lost working hours (absenteeism) and reduced work performance (presenteeism).
- Local government: LAs face potential losses in business rate payments, which vary by property value, as the retail composition of high streets change in response to intervention. We will use routine data on non-domestic business rate payments collected by LAs (56), in combination with findings from WP1* regarding retail composition within and on the periphery of exclusion zones, to estimate the net effect of regulation.
- National government: as the retail composition of high streets change in response to intervention, national government face potential losses of VAT payments and a rise in unemployment benefits to be paid. These impacts will be estimated using published sales data on business activity and location (57), and findings from WP1* on post-intervention retail change.
- NHS: health care resource impacts will be modelled based on post-intervention changes in obesity and obesity-related morbidity (from WP2*). These impacts will be converted to monetary values to calculate costs saved due to treatment averted, using published figures representing the value of statistical life and associated morbidity (58, 59).

* As planned, this cost-benefit analysis is contingent on findings from WP1 (retail impacts) and WP2 (health impacts). If observed effects of the intervention on retail are *not statistically significant* in WP1, then health impacts of the intervention as implemented would not be modelled in WP2. Should this be the case, we will likely refocus this cost-benefit analysis on 'perfect' and 'optimised' policy implementation scenarios (see *6.2 Scenarios*), to understand *potential* economic costs and benefits under these hypothetically achievable conditions. We will make this decision, alongside considering any further scenarios of interest, in close conversation with our SSC, and details will be added here when confirmed.

Sample size

19 LAs previously subject to evaluation of intervention effects on retail outlet outcomes (see *6.1 Sample size*).

Analysis, socioeconomic status and inequalities
Costs and benefits will be calculated annually to obtain yearly net effects. These will be discounted over time using the standard government rate (60). In order to determine the robustness of these results, sensitivity analyses will be conducted with key cost drivers and the discount rate. We will then calculate benefit/cost ratio, NPV and IRR for each stakeholder group and society overall, for each time horizon (5, 10, 20 years), and by SES.

6.4 Implementation and optimisation (WP4)

Understanding experiences of intervention implementation helps to optimise future policymaking (61, 62). This WP will build understanding of the experience of implementing the intervention, uncovering the strengths, weaknesses and their evolution. This will allow us to describe the local conditions that produce maximum benefit in terms of health improvement and delivery, as well as generate guidance to optimise similar interventions for use by other LAs.

Design
Process evaluation of intervention implementation, informing co-production of guidelines for future intervention optimisation. Increasingly, co-production approaches are being used to respond to current challenges in public health and service delivery as they can support design and optimisation (63). The project will take an experience-based co-design approach (64).

Population sampled from
LAs who have adopted the intervention (n=44).

Inclusion criteria and sample size
We will first purposively select five intervention LAs that are diverse in terms of urban/rural status, population size and location. From these, we will recruit and interview public health and planning professionals with direct intervention experience (n=~30). We will use an existing database of contacts in all intervention LAs (18), and snowball to purposively recruit.

After conducting interviews, we will select a total of around 10 participants from as diverse a range of LAs as is possible (from the pool of previous interviewees who express an interest in this component) and from business and school communities to take part in a series of three stakeholder workshops.

Data collection
Interviews: we will undertake ~60-minute semi-structured interviews with participants (n=~30), using an interview schedule designed to elicit answers to our proposed research questions. From previous experience, we anticipate that some participants who work together may prefer to be interviewed together. The aim is to generate narratives of implementation (collaborative narratives in some cases) that can be used to understand how practitioners position themselves and act in relation to the intervention and identify discrete ‘types’ of intervention experience and practice (65). This will enable us to explore variations in implementation and justifications for them, such as the size and shape of exclusion zones and how contextual considerations such as urban/rural and socioeconomic status, local population, politics and economy, may shape these specifications. We will also explore potential barriers to implementation such as limitations of the planning system to address or ‘move’ existing takeaway food outlets, managing relations with community groups and local businesses, and strategies used by chain and independent takeaways to avoid regulation, such as prospective takeaway owners ‘masquerading’ as full-service restaurants.

Stakeholder workshops: co-production of policy optimisation and implementation guidance will be generated via a series of three half-day stakeholder workshops held over a nine-month period. Each workshop will be organised around one or more challenges identified in the interviews and possible solutions. The participants (n=~10) will be invited to prepare in advance and present material on practical responses to these challenges that will subsequently be developed and refined in break-out sessions, structured discussions and talking circles adapted from participatory methods (66). Workshop summaries will be written by the facilitator and circulated for feedback, to inform development of policy optimisation guidance. Given that the workshops are part of a co-production process, and will not provide 'data' as such, consensus building, creation and refinement will be undertaken instead of conventional analysis.

Analysis of interviews

The data collection will equate to ~30 hours of interview data. Interviews will be digitally-recorded, anonymised and transcribed, and analysed using a General Inductive Approach (GIA) facilitated by NVivo software. A GIA is guided by the objectives of the evaluation rather than a specific theory or hypothesis. The categories generated through initial coding have five key features: label, description, data associated with the category, links to other categories, and the type of model in which the category is embedded (67). These categories will be used to identify and explore links between contexts (C), mechanisms (M) and outcomes (O). CMO triads will be developed into a framework to generate middle-range theories around processes, barriers and facilitators (68). Particular attention will be paid to discordant or dissonant voices i.e. elements of the transcript that do not readily accommodate a theme but that are notable for future analysis.

Socioeconomic status and inequalities

Given that exclusion zones are implemented at the local community level, interpretations of the policy will be shaped by local contextual influences such as socioeconomic status, deprivation and the specific needs of local populations. Sampling to capture these local variations and analysing local narratives of implementation alongside shared experiences around barriers and facilitators, will allow us to identify transferable good practice and optimised policy solutions to address inequalities.

6.5 Business reactions (WP5)

Public acceptability of new policies is often gauged by LAs using qualitative consultation. How independent and chain takeaway food businesses react to the intervention and how LAs respond is likely to shape the content and uptake of interventions elsewhere (27). Prevailing stakeholder narratives may depend on the type of policy document in which the intervention is described and local socioeconomic context. We will exploit previously unused secondary data collected and made public by LAs to analyse these perspectives.

Design

Longitudinal, qualitative study, using data from mandatory public consultations preceding policy adoption across two types of policy document (supplementary planning documents (SPDs) and local plans), to describe independent and chain takeaway food business reactions to the intervention and LA counter-responses, including whether and how these have evolved over time.

Population

LAs that have adopted the intervention in SPDs (n=22) and local plans (n=22) from 2009 to 2019.

Methods and data

Written submissions to public consultations are a matter of public record, published freely online or by freedom of information (FOI) request from LAs. Our pilot work has identified the 44 LAs who have been through this process of policy adoption (18), facilitating desk-based data collection of consultation documents. Names and addresses provided with submissions will allow us to identify those from chain (six large businesses with more than 50 outlets nationwide (8): McDonald's, Burger King, KFC, Leon, Wimpy, Subway) and independent (all other) takeaway food businesses, alongside associated local authority counter-responses, for data extraction. We will also extract submissions from the public for WP6.

Sample size
Public consultations often receive hundreds of submissions. Pilot data from Waltham Forest LA's SPD consultation indicate that of 353 submissions, 8% were from takeaway businesses (69). If generalizable, our analytic sample will have at least 1200 submissions from this stakeholder group, and the same number of LA counter-responses.

Analysis, socioeconomic status and inequalities
We will conduct a longitudinal, case-based, thematic analysis. Consultation responses from independent and chain businesses and reactions of LAs will be organised into a time series to identify shifting themes over time. This technique will involve six stages: 1) familiarisation with data; 2) generation of initial codes; 3) searching for themes; 4) reviewing themes; 5) defining and naming themes; 6) reporting results, supported by illustrative quotes. Themes will be generated inductively using a data-driven approach and no *a priori* defined coding framework. Using this approach we will be able to explore how prevailing narratives for each group have developed over time and in response to one another, and subsequently whether these differ by type of policy document and across key socioeconomic contexts. Individual businesses and/or companies will be anonymised in presenting findings and referred to as 'independent' or 'chain' only. Themes emerging from reactions and counter-responses will also be cross-referenced against changes in key national planning policy and guidance documents (e.g. the Government's Childhood Obesity Plan 2 (70)) published during this time period, as identified by Chang. Analysis will be supported by NVivo software.

6.6 Public acceptability (WP6)

Policies with greater public acceptability are more likely to be implemented, and greater perceived effectiveness increases acceptability (37, 38). In-depth qualitative interviews offer the advantage of data richness, but representative samples increase generalisability. We will use both approaches in WP6.

6.6.1 Go-along interviews (WP6.1)

We will explore narratives of acceptability and perceived effectiveness of the intervention across contrasting socioeconomic contexts, using go-along interviews with young people, parents, community groups and school staff.

Design
Go-along interviews involve researchers conducting in-depth interviews while accompanying participants on trips in familiar environments (71). Such approaches are adaptable to group size

and context and are increasingly used in health research (72). Go-along interviews will allow direct access to takeaway food practices of participants as they unfold in real time and space.

Sampling, recruitment, data collection and sample size
Go-along interviews will take the form of accompanied trips, focusing on the takeaway food environment within an exclusion zone (i.e. likely to be within an 800m radius of a school's location). We will focus on two exclusion zones in contrasting LAs with respect to area deprivation (using IMD profiles), identified by LA stakeholders participating in workshops in WP4. To ascertain multiple perspectives on these spaces, one go-along interview will be undertaken for each of the four following naturally occurring groups (6-8 participants per group) within each exclusion zone (~i.e. 64 participants in total): a) young people; b) parents; c) community group members; and d) teachers and community support officers, who will all be recruited through schools.

Teachers will be consulted to help identify groups of young people who are friends and who are likely to use this space in a similar way. Groups of young people, parents, community group members, and teachers and community support officers, will be interviewed separately. This is particularly important for groups of young people, who might otherwise censor their opinions in the presence of adults. To permit this, all safeguarding requirements for working with school-aged children will be met, including DBS checking for the researcher and informed consent (or assent) being obtained from the parent or guardian as well as the young person. Additionally, trips will take place during school hours and will be accompanied by a school chaperone. Semi-structured interview schedules will focus on intervention acceptability and perceived effectiveness by probing on experiences of the local area, and barriers and facilitators to effectiveness. Interviews will be digitally recorded and transcribed. Transcriptions will be augmented with field notes and photographs of the environment taken by the researcher, for the purpose of aiding the analysis only.

Analysis
Augmented transcripts will be imported into NVivo for thematic analysis (73, 74). Data will be managed in the first instance by mapping key derived concepts. Augmented transcripts will be analysed iteratively, and emergent themes and concepts revisited and refined in subsequent interviews. Particular attention will be paid to young people's narratives and discourse concerning the environment and the intervention, as well as discordant voices or dissonant cases. Emergent themes together will form the basis of analytical interpretation (73).

6.6.2 Nationwide survey data (WP6.2)

We will use nationwide survey data to assess the proportion of adults and young people who: a) are concerned about takeaways; b) support the intervention; and c) think it will be effective.

Design and data collection
We will conduct cross-sectional analysis of 2021 data from the International Food Policy Study (IFPS; www.foodpolicystudy.com). This annual, online survey of adults and their children explores attitudes to food-related policies. Approximately 6000 adults and 2000 of their children are included annually in UK IFPS data collection. Adams and White are the UK IFPS investigators, and collaborators Hammond and Vanderlee lead IFPS. Data collection is outsourced to Neilson, an international market research company with the first wave in November 2017. IFPS is funded to 2023 by the Canadian Institutes of Health Research.

Study population and inclusion criteria
IFPS participants are adult (≥18y) members of Nielson's Consumer Insights Global Panel and their children (10-17y), who provide informed consent, and correctly answer data quality questions. We will include IFPS participants in the 2021 wave, living in England, aged ≥16y, who provide complete data on variables of interest.

Sampling and recruitment
Neilson panels are recruited using probability and non-probability sampling. For IFPS, Nielsen draws a stratified random sample of adults from their UK panel, based on known region-specific age-sex distributions, boosting sub-groups with known low response. Monetary incentives are provided. Adults are asked if they have a child aged 10-17y and to provide consent for them to be approached. Children also provide consent.

Outcomes and data collection
The outcomes of interest will be proportion of respondents who: a) consider the number of takeaways they encounter is too few/many and reasons for this; b) support the intervention; and c) consider the intervention will be effective.

We will ask the following questions to quantify these: a) thinking about the number of takeaways you encounter on a day-to-day basis, do you think there are too few, too many or about the right number? If you said too few/many, why?; b) some councils are regulating where new takeaways can open to cap the number of takeaways around schools. Do you support or oppose this?; and c) how effective do you think this will be as a method to reduce how much takeaway food is eaten by young people?

Participants will be characterised using core questions on age, gender, ethnicity and parental status. Postcode of residence will be used to determine quintile of neighbourhood index of multiple deprivation score (as a proxy for SES); and to characterise LA of residence in terms of prevalence of overweight and obesity, current takeaway numbers and rates, and rurality.

Sample size
We expect ~6000 people will meet the inclusion criteria. If 20% respond "yes" to a "yes/no" question, the precision around this (95% CI) is ±1.9%. At 50% this will be ±4.9%

Analysis
Survey weights will be constructed and calibrated to region-specific age/sex/ethnic benchmarks using census data and used throughout to adjust for non-response bias. After conducting descriptive analyses, we will use binary and multivariate logistic regression to explore variation in outcomes by the personal and LA characteristics described above.

Socioeconomic status and inequalities
Efforts are made to recruit a representative sample to IFPS and survey weights applied to adjust for any residual non-response bias. We will explore variation in outcomes according to age, gender, ethnicity, socioeconomic and parental status.

6.7 Engagement and dissemination (WP7)

Translational impact through engagement and collaboration with key stakeholders and the public, supported by an effective and responsive dissemination strategy, is critical and therefore addressed via a dedicated work package.

Engagement with key stakeholders
Our primary audience are decision makers in LA Public Health and Planning departments. Representatives from these departments and other umbrella organisations with links to local government (PHE, GLA) will be invited to join our PAG. The PAG will meet biannually, to ensure ongoing dialogue between researchers and those who stand to benefit in local government. As part of the PAG, these key stakeholders will help steer our scientific and dissemination strategies (see *6.7 Dissemination*) by reviewing WP protocols, contributing to ongoing development of our causal model, providing detailed feedback and reflections on specific analyses, interpreting results and guiding dissemination plans. This collaboration will also maintain buy-in and enable greater use of our results to achieve impact.

Public involvement and engagement
Throughout the project, we will also maintain continual engagement with the public. Cambridge University Hospital's community PPI panel is made up of adults who have general population experience of using takeaway food outlets. The panel reviewed and contributed to this application and have committed to remaining engaged throughout at biannual PPI meetings. We will also establish a virtual PPI advisory group (recruited through the Children's Food Campaign), whom we can consult with on a rolling basis as needed throughout the project. Between them, these panels will provide input on our methods, causal model development, interpretation of results, and testing messages for accessibility before public dissemination.

At specific points, other groups will be engaged in PPI activities. We will engage with members of the Kenton community group in Newcastle, which includes parents and teaching staff at Kenton High school. This group have direct experience of successfully appealing against the opening of a McDonald's restaurant very close to this school. They have faced the challenge of marshalling a diversity of academic evidence to support their cause and will advise on language and framing of non-academic research outputs. Also, as they have direct knowledge of the planning appeals process, we will ask them to help us interpret takeaway food industry reactions to public consultation in WP5. We will invite a representative from this group to attend SSC meetings annually as a PPI member.

To guide our work with young people, including questionnaire design and go along interview topic guides, and to ensure that the views of young people are represented in the development of our causal model, we will convene a panel of adolescents with experience of using takeaway food outlets on the school fringe. We will recruit via the Young People's Advisory Group at the University of Hertfordshire, at the outset of WP6.

Synthesis of findings
We will integrate and synthesise our findings from WPs 1-6 to draw overall conclusions on intervention effectiveness. Bringing together and triangulating diverse strands of quantitative and qualitative evidence into a single narrative will strengthen causal inference (75). We will map findings to our causal model (Figure 2) to consider if they align with the overarching intervention theory. We will consider if pattern matching (76) or causal process observation (77) methods can

usefully contribute to this exercise. We will consider whether additional analyses are necessary to address any gaps in our understanding that we identify. Synthesis will be undertaken in collaboration with policymakers, with the ambition to describe a clear and coherent narrative regarding intervention effectiveness, to maximise impact potential. In addition to biannual PAG meetings, which will be formally documented, we will also host a half-day event in Cambridge in the last six months to further discuss and test the face validity of our conclusions.

Dissemination

Our dissemination strategy will focus on knowledge translation to decision-makers in local government (planning and public health colleagues, Directors of Public Health) and national government as our primary audience. Complementing our final report and nine planned publications in open-access peer reviewed journals, we will also publish the final project synthesis and WP4's policy optimisation guidelines. The project synthesis will be published as a CEDAR Evidence Brief. Evidence Briefs are accessible policy-orientated research summaries, with targeted dissemination to identified decision-makers via CEDAR's extensive policy network, and networks of PHE, GLA and individual LAs via our policy & practice partners. We will work with our SSC, PAG, Co-I Chang and the dedicated CEDAR knowledge exchange team to determine the most appropriate vehicle for dissemination of WP4's policy optimisation guidelines, including for example, in the form of a collaborative PHE / CEDAR co-branded policy guidance briefing note for LAs.

Throughout the project, under the guidance of the SSC, PAG and PPI panels, and in some cases facilitated by members of these groups, we will also use the following pathways to impact: presentations at national and international, academic (e.g. SSM, ISBNPA) and non-academic conferences (e.g. LGA, PHE); towards the end of the project, a half-day event in Cambridge with a policy audience (see above); a pre-conference workshop at the PHE Applied Epidemiology meeting (majority non-academic audience), and other workshops and training events for professionals such as those held by the Royal Town Planning Institute (RTPI); new forms of information sharing used widely by LAs including PHE webinars and access to the PHE KHub for sharing outputs, facilitated by Chang; responding to evidence calls from UK Government (members of the team have provided written and oral evidence to multiple parliamentary Select Committees); blog posts (e.g. PHE Public Health Matters, Town and Country Planning Association, Fuse blog) and social media (e.g. Twitter). We will exploit existing relationships with decision-makers at all levels of government, organisations working across LAs (e.g. LGA, GLA, TCPA), executive agencies of government (e.g. PHE) and advocacy groups (e.g. UK Health Forum, Royal Society for Public Health, Food Foundation), as further means to share and engage these groups with our project outputs.

Moreover, where opportunities exist to embed results in emerging national and local regulatory frameworks such as policy and practice guidance, these will be explored and facilitated by Chang (PHE). These opportunities are important because local planning practice is premised by conformity to national guidance documents (20). Led by Chang, national PHE recently published *Using the planning system to promote healthy weight environments (23)*, which included an evidence review (co-written by project co-applicants) and example policy wording to assist all LAs in adopting planning strategies to address unhealthy neighbourhoods. The results from this project will feed directly into an update of this document. Where possible, we will also share findings through the Food environment assessment tool (Feat) (12), led by Burgoine.

We will engage the public in multiple ways. We will work with University and NIHR press offices to disseminate relevant findings to the mass media via press releases. Media reporting will serve as an important pathway to impact. We will engage the public in discussions concerning our findings via social media, posts on widely accessed public-facing websites and blogs such as The Conversation, and events and activities at University of Cambridge Festivals of Sciences and Ideas, and other public engagement forums including the MRC Epidemiology Unit's schools' engagement programme.

7 Data monitoring, quality control and quality assurance

The University of Cambridge is the lead institution and Sponsor. A formal multi-centre collaboration agreement will govern ways of working and financial arrangements with project Investigators at LSHTM, Universities of Exeter, Oxford, Hertfordshire, and PHE, costed-collaborators at York University (Toronto, Canada) and uncosted-collaborators at the University of Waterloo.

The Chief Investigator (Burgoine) will have primary responsibility for scientific and strategic project oversight, supported by WP leads and co-leads. Administrative study support will be based at the University of Cambridge and LSHTM.

WP leads and co-leads will be responsible for day-to-day management of WPs. All WP leads and co-leads will meet every four to six weeks to update on progress and ensure strategic coordination. Meetings will be by teleconference, but in-person biannually. Additional WP-specific meetings will take place regularly as the work requires. Collaborators and PPI representatives will be invited where appropriate for their input. A Study Steering Committee (SSC) will be appointed, including independent academics and lay representation, to provide external oversight. The SSC will meet annually in-person. A Project Advisory Group (PAG) will be appointed, including non-academic policy & practice partners. The PAG will meet biannually, alternating teleconference and in-person formats.

8 Ethics and regulatory issues

The majority of WPs use publicly available data and ethics approval is therefore not required for these. Approval has already been granted by the University of Waterloo Research Ethics Committee (ORE # 21460) and the University of Cambridge Humanities & Social Sciences Research Ethics Committee (ref 19/225), for collection of IFPS data (WP6.2).

Interviews and workshops with LA stakeholders (WP4), and go-along interviews with young people, their parents and other guardians (WP6.1), will be subject to LSHTM Research Ethics Committee approval. This approval will be sought at the outset of these WPs. Participants recruited into these WPs will provide written, informed consent to take part, and for WP6.1 consent will be obtained from both school children and their parents. The researcher conducting these interviews will be DBS checked, and all interviews with children will be accompanied by a chaperone from the school. Any additional school-specific, local safeguarding measures required will also be met.

All data will be held in accordance with data management and protection protocols at the Universities of Exeter, Oxford, Cambridge, Hertfordshire and LSHTM. All primary data collected in interviews will be anonymised, with any potentially identifiable information stored separately. IT systems across these institutions are maintained by professional staff, with back-up and security processes. All IT systems are controlled and limited to approved individuals.

The research will be undertaken to the highest research governance standards. We will work closely with data management teams to ensure compliance with the Data Protection Act 1998 and, GDPR.

9 Study reporting and publication

We have developed a comprehensive strategy (see *6.7 Dissemination*) to effectively disseminate our findings by a variety of means. We will report on project progress to NIHR every six months or in line with major project milestones as required, and will submit a first draft of our final report within two weeks of contract end.

10 Study timetable and milestones

The project will run for 36 months from 1st April 2021 (Figure 3), with staff recruitment for WPs 1 & 4 starting before this in November 2020. The protocol will be updated to further include research staff names when these appointments have been made. Some WPs overlap to reduce overall project length and associated costs. Some WP start dates staggered due to dependencies. WP7 will span the project to embed knowledge exchange throughout (Figure 1). Each WP has unique milestones to measure progress against, including for project outputs.

FIGURE 3: Gantt chart for 36 month project starting April 2021.

Project Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Calendar Month	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
WP1: Retail impacts																																				
Milestone 1 Protocol refinement	x	x																																		
Milestone 2 Data collection			x	x	x	x	x	x																												
Milestone 3 Data entry & cleaning									x	x	x	x																								
Milestone 4 Data analysis													x	x	x	x	x	x																		
Milestone 5 Write up																			x	x	x	x	x	x												
Milestone 6 Manuscript submitted																					x															
Milestone 7 Manuscript submitted																								x												
WP2: Health impacts																																				
Milestone 8 Protocol refinement													x	x																						
Milestone 9 Data collection															x	x																				
Milestone 10 Building exposure model																	x	x	x	x	x	x														
Milestone 11 Model preparation																							x	x	x	x										
Milestone 12 Data analysis																											x	x	x	x	x	x	x			
Milestone 13 Write up																																		x	x	x
Milestone 14 Manuscript submitted																																				x
WP3: Economic impacts																																				
Milestone 15 Protocol refinement													x	x																						
Milestone 16 Data collection															x	x	x	x	x	x	x	x	x	x	x	x										
Milestone 17 Data analysis																											x	x	x	x	x	x	x			
Milestone 18 Write up																																		x	x	x
Milestone 19 Manuscript submitted																																				x
WP4: Implementation and optimisation																																				
Milestone 20 Protocol refinement			x	x																																
Milestone 21 Ethics approval					x	x	x																													
Milestone 22 Data collection & transcription								x	x	x	x	x	x	x																						
Milestone 23 Stakeholder workshops															x	x	x																			
Milestone 24 Data analysis															x	x	x	x																		
Milestone 25 Write up																			x	x	x	x	x	x												
Milestone 26 Draft opimisation guidelines																									x	x										
Milestone 27 Manuscript submitted																										x										
Milestone 28 Practice guidelines published																										x										
WP5: Business reactions																																				
Milestone 29 Protocol refinement																						x	x													
Milestone 30 Data collection																								x												
Milestone 31 Data entry & cleaning																									x	x										
Milestone 32 Data analysis																											x	x	x	x						
Milestone 33 Write up																															x	x	x	x	x	x
Milestone 34 Manuscript submitted																																			x	
WP6.1: Public acceptability (go-along interviews)																																				
Milestone 35 Ethics approval								x	x																											
Milestone 36 Data collection & transcription																x	x	x																		
Milestone 37 Data analysis																							x	x	x											
Milestone 38 Write up																										x	x	x								
Milestone 39 Manuscript submitted																												x								
WP6.2: Public acceptability (survey)																																				
Milestone 40 Data collection									x																											
Milestone 41 Data entry & cleaning																									x											
Milestone 42 Data analysis																									x	x	x									
Milestone 43 Write up																												x	x	x	x	x	x			
Milestone 44 Manuscript submitted																																		x		
WP7: Engagement & dissemination																																				
Milestone 45 Study Steering Committee (SSC) meeting							x												x												x					
Milestone 46 Project Advisory Group (PAG) meeting							x						x						x						x						x					
Milestone 47 PPI meeting (with CUH PPI group)							x												x												x					
Milestone 48 PPI meeting (with young people)													x																							
Milestone 49 PPI meeting (with community group)																			x																	
Milestone 50 Synthesis of findings																									x	x	x	x	x	x						
Milestone 51 Write up																															x	x	x	x	x	x
Milestone 52 Manuscript submitted																																			x	
Milestone 53 Evidence brief published																																				x
Reporting																																				
Milestone 54 Interim report						x						x						x						x						x						
Milestone 55 Final report																																		x	x	x

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