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Conference on ‘Diet and health inequalities’ Plenary Lecture One

Tackling diet inequalities in the UK food system: is food insecurity driving the obesity epidemic? (The FIO Food project)

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By 2050 the number of adults living with obesity in the UK will rise with approximately one in four in the adult population. This rising trend is not equitable, with higher prevalence in socially disadvantaged groups. There is an apparent paradox of not being able to provide food for the family to eat, a feature of food insecurity and living with obesity. With the current cost-of-living crisis, there is a challenge to afford both food and fuel bills. Environmentally sustainable and healthy diets are proposed to improve public health and reduce the impact of the food system on the environment, while also improving diet quality. However, healthier foods tend to be nearly three times more expensive than unhealthy foods, and this provides a challenge for citizens on low incomes. In this review, we explore some of the evidence for solutions in the retail food environment to support the UK food system to be safe, nutritious, environmentally friendly and fair for all. We highlight the value of co-production in research, to give value and power to the lived experience to address these inequalities. Our multidisciplinary research approach within the FIO Food research grant will generate new insights into modifiable and potentially impactful changes to the UK food system, specifically for the retail food sector. We believe that the co-creation, design and delivery of research with those living with obesity and food insecurity will help to transform the UK food system for health and the environment in this vulnerable group.

Key words: Diet inequality: Health inequality: Food insecurity: Food system: Sustainability: Obesity: Co-production

There is a wide range of factors that influence our ability to be healthy. Our health and well-being are influenced by a complex interplay between the wider determinants of health (e.g. income, debt, employment or housing), psycho-social factors (e.g. isolation, social support or self-esteem), health behaviours (e.g. diet or smoking) and physiological impacts (e.g. blood pressure, cholesterol level or depression)⁽¹⁾. These determinants or influences are not spread equally throughout the

population, resulting in some groups experiencing multiple disadvantages throughout their lives. Health inequalities are defined as ‘avoidable differences in health outcomes between groups or populations, such as differences in how long we live, or the age at which we get preventable diseases or health conditions⁽¹⁾’. Differences in health across the population, and between different groups within society are not fair and require immediate remedial actions from policymakers.

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Abbreviation: SES, socioeconomic status.

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Through the lens of social justice, which considers the nature of fair distribution, and to what extent this may conflict with individual rights of ownership and acquisition, the disadvantageous circumstances limit the chances to live a longer, healthier life⁽²⁾. In England there is a 19-year gap in healthy life expectancy (whether or not we experience health conditions or diseases that impact how long we live in good health) between the most and least affluent areas of the country, with people in the most deprived neighbourhood, from certain ethnic minority and inclusion groups developing multiple health conditions 10–15 years earlier than in the least deprived communities, thereby spending more years in-ill health and dying sooner^(1,3). The most recent data on how long we live overall (life expectancy for local areas of the UK: between 2001–2003 and 2018–2020) include most recent UK data from the coronavirus disease-2019 period⁽⁴⁾. These data indicate that life expectancy for men has fallen in England as a whole, but there is a significant variation across the regions of England for both men and women. In Scotland, health inequalities contribute to four times higher rates of unnecessary premature deaths every year (<75 years), in the most deprived areas compared to the least deprived⁽⁵⁾. For men and women in the most deprived areas, nearly 26 fewer years are spent in ‘good health’⁽⁵⁾. Scotland is thought to be particularly disadvantaged. Due to the vast health gap, it has been considered as the ‘sick man’ of Europe, with observational studies over the past few decades reporting higher mortality in this region in comparison to the rest of the UK and European countries⁽⁶⁾. The so-called ‘Scottish effect’ is partly explained by the deprivation profile, contributing to the higher levels of excess mortality rates^(7,8).

Poor diet is one of the largest preventable risk factors for ill health, contributing to early mortality and morbidity⁽⁹⁾. Inequalities in diets contribute to overall inequalities in health with those in the UK most at risk⁽¹⁰⁾, including people living with disabilities, those on lower income, those living in deprived areas, those from some minority ethnic backgrounds and vulnerable people such as the homeless⁽¹⁾.

The recent cost-of-living crisis is considered to be driven by a dual increased shift in the cost of energy (gas, electricity) and food prices. While energy prices have risen faster, food makes up a far greater share of the typical household’s consumption (13 v. 5% in 2019–2020)⁽¹¹⁾. The National Food Strategy independent review⁽¹²⁾ from Hendry Dimbleby, stated that: ‘The food system we have now has evolved over many years. It won’t be easy to reshape it. But time is not on our side. For our own health, and that of our planet, we must act now’. The report made several recommendations, to improve the UK food system, including reducing diet-related inequalities⁽¹²⁾. In this review, we will reflect on the link between food insecurity and obesity and approaches applied in our research to tackle these inequalities.

The double burden of food insecurity

There are many approaches to describing food security. One of the definitions coined by the World Summit on

Food Security⁽¹³⁾ characterises food security as a situation in which, ‘... all people at all times have physical, social and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life’. The proposed definition highlights the four dimensions of food security: availability (related to the supply chain), access (physical, social or economic), utilisation (nutrient use by the body) and stability^(13,14). Therefore, food insecurity is a complex social issue that requires a multidisciplinary approach with insights and experiences shared by policymakers, retailers, healthcare providers and people directly affected.

Historically, food insecurity was measured using hunger or anthropometric measures such as underweight status or wasting and stunting in children (on an individual level) and the prevalence of undernourishment at the population level⁽¹⁵⁾. These are still valid approaches in low-income countries, where food insecurity tends to be unequivocal with hunger and undernutrition. In contrast, in middle- to high-income countries, in parallel to hunger, obesity is increasingly becoming a strong predictor of food insecurity^(15–17). It is commonly overlooked, that by definition, overconsumption is also a form of malnutrition, and despite excessive energy consumption, it may result in nutrient deficiencies (‘hidden hunger’), both contributing to poor physical and mental health as well as the development of chronic diseases⁽¹⁵⁾. Although the link between food insecurity and obesity may seem counterintuitive at first, there are several factors that may explain this relationship, which will be discussed later in this review.

The food system in the UK is burdened with all forms of malnutrition, including people experiencing hunger, but also those who are living with obesity. Hence, system-wide interventions focusing solely on individuals’ responsibility and consumer education are insufficient in improving population health. To tackle the obesogenic environment, a whole system approach is needed, which ‘...promotes moving from individualistic health problems, and simple linear models towards understanding the complexity through systems, organisations and environments’^(18–20).

The ‘food system’ approach

The recent cost-of-living crisis has amplified the problem of food insecurity in the UK⁽²¹⁾. According to the Scottish Health Survey⁽²²⁾, 9% of adults were worried about running out of food, 6% ate less and 3% ran out of food. In 2019/2021 combined, the highest levels of food insecurity were among single parents (34% worried they would run out of food) and single adults under age 65 (10% worried they would run out of food)⁽²²⁾. The latest tracking figures published by the Food Foundation are even more stark⁽²³⁾. From an online survey of over 10 000 adults in the UK, 18% or 9.3 million households experienced food insecurity in January 2023⁽²³⁾. These food-insecure households are more likely to be cutting back on purchasing healthy foods such as fruit,



vegetables and fish. The report highlighted that in households with an adult limited a lot by disability, food insecurity was three times higher; half of the households with low income, receiving universal credit, report food insecurity; and non-white ethnic groups are at higher risk of food insecurity than white ethnic groups.

Increasing food prices create a huge challenge for those with lower income. The cost of a basic basket of food has increased by approximately 20–25% between April 2022 and February 2023, and food inflation has risen by 18.2% in the 12 months up to February 2023⁽²⁴⁾. The poorest fifth of UK households would need to spend 50% of their disposable income on food to meet the cost of the UK government-recommended healthy diet, in contrast to just 11% for the richest fifth⁽²⁵⁾. Healthier foods are twice as expensive per kJ, compared to less healthy foods⁽²⁵⁾.

Increasing food prices are not just regulated by industry and the top British retailers; hence a more holistic approach needs to be considered. The UK food system is intricate and includes a wide spectrum of interconnected stakeholder networks, involved in production, through processing, sales, consumption and waste management⁽²⁶⁾. Each network has its own agendas and priorities, hence aligning common goals can be extremely challenging. For this reason, a 'food systems' approach is a preferential outlook, as it allows to the exploration of different perspectives and trade-offs of the transformations, to help achieve a compromise between often competing priorities of the food systems actors (e.g. profit-orientated retailers v. health-seeking consumers)⁽²⁶⁾. It also helps to understand the multifaceted factors that drive food system components, e.g. geographical, social, political, legal, fiscal, environmental, etc. Food systems mapping has become increasingly popular in recent years because it can support finding complementary, and potentially synergistic solutions to a healthier and more sustainable food environment^(26,27).

The paradox of food insecurity and obesity

Despite many UK government reports on tackling obesity, the trends for obesity (defined as BMI >30 kg/m²) in men and women are increasing in Scotland⁽²⁸⁾ and England⁽²⁹⁾. In Scotland, 67% of adults are living with overweight and obesity and nearly a quarter of children starting primary school were at risk of overweight and obesity⁽²⁸⁾. People living with obesity are more likely to experience a range of serious and chronic health issues including CVD such as stroke and heart disease and type 2 diabetes^(30,31).

Obesity is disproportionately represented in socially disadvantaged groups, for those living in areas of deprivation, a trend that has become more marked over the past 60 years⁽³²⁾ and more recently during the coronavirus disease-2019 pandemic^(22,28,29). In general, the statistics in 2021 indicate worrying patterns, with the prevalence of obesity and overweight increasing across the age groups, to age 55–64, with more adult males than females living with overweight^(28,29). Children living in the poorest areas are four times more likely than

children from the richest areas to be severely obese when they arrive at primary school⁽¹²⁾. They are five times more likely to be severely obese when they leave it. Sixteen per cent of people in the lowest income group live with diabetes: more than twice the percentage of those in the highest income group⁽³³⁾.

So why is it that those who struggle to afford food are also the most affected by the obesity epidemic? A number of researchers have explored this seemingly contradicting link between food insecurity and increased risk of obesity^(16,17,34–37). The paradox highlights the social bias towards an assumption that food insecurity is experienced by people with low body weight. The peculiarity of the dysfunctional food system is that obesity can co-exist with hunger and/or low-quality diet. Most of the literature has consistently shown that there is a significant association between food insecurity and obesity, specifically in women from high-income countries^(17,38,39). In the United States, people living with food insecurity have a 32% higher odds of obesity compared to food-secure individuals⁽⁴⁰⁾. Several hypotheses were proposed to explain this link: (1) low food security is associated with obesity because of the high-energy, palatable food consumed by low food secure populations, or (2) low food security is associated with obesity because of the limited knowledge, time and resources that low food-secure populations experience to engage in healthful eating and exercise^(41–43).

These punitive explanations however exacerbate the weight stigma, placing the responsibility on the individual while the obesity issue is much more complex. Factors linking food insecurity and obesity are listed in Table 1 (list not extensive or in priority).

There is growing scientific consensus that certain dietary behaviours are associated with obesity, including higher consumption of sugar-sweetened beverages, fast food and other foods with higher energy density and lower consumption of fruits, vegetables and whole grains^(44–46). At the same time, there is evidence that low-income households tend to consume more of these 'obesogenic' foods and beverages and fewer 'health-enhancing' foods and beverages^(43,47). The confluence of these factors hardly seems a paradox. Studies have shown that energy-dense, nutrient-poor foods cost less and that cost is an effective driver of behaviour⁽⁴⁷⁾. In addition to monetary cost, time cost may influence eating behaviours. For example, the U.S. Department of Agriculture's Thrifty Food Plan, a menu plan demonstrating ways to limit financial costs while optimising nutrition, has been estimated to require more than twice the number of hours of food preparation time that the average American food preparer spends⁽⁴⁸⁾.

Furthermore, it is not uncommon that access to healthy and nutritious foods is restricted by geographical factors. The most deprived areas are often characterised as 'food deserts' (locations with little access to nutritious foods)⁽⁴⁹⁾. It has been estimated, that about one in ten deprived areas in England and Wales can be classified as a 'food desert'⁽⁵⁰⁾ suggesting that restricted access to a food store is an important barrier to eating healthily among people living in those areas. More recently, a new term has been popularised – 'food swamps'⁽⁵¹⁾,

Table 1. Factors contributing to obesity among those living with food insecurity^(17,18,20,38,40,42)

Factor	Description
Low income and food prices	Low income limits the freedom of shopping choices. Healthy foods are usually more expensive. Alternatives of refined grains, and products with added sugars and fats are inexpensive or subject to in-store offers.
Education and awareness	Lack of awareness of combining low-cost nutritious foods to also meet family or individual dietary goals/preferences. Lack of opportunity or awareness to choose to allow environmentally sustainable eating (e.g. plant-based or meat-free) which may be more expensive per unit (e.g. plant-based milk as cow's milk replacement).
Food choices	Increased energy intake from processed and ready-to-eat food, with low nutritious value and often higher in cost.
Access to supermarkets	Low-income neighbourhoods usually lack full-service retail stores; food shopping can be reliant on walking to smaller corner (convenience) stores that have limited choices and products can be more expensive.
Overeating	Poverty can lead to lack of filling and nutritious foods and eating less or skipping meals. This also means that when food is available there is overeating. This leads to cycles of food restriction or deprivation followed by overeating
Access to healthcare	In the UK there is a variety of weight management options based on the 'post-code lottery'. This results in a lack of diagnosis and treatment of emerging overweight and obesity.
Physical activity	There are fewer parks, gymnasiums or bike paths in more deprived areas. Unsafe neighbourhoods also mean children get less time to spend outdoors playing.
Mental health	Low-income families also face high levels of stress due to food insecurity, financial pressures, lack of access to health care, inadequate transportation, poor housing and surrounding neighbourhood violence. Stress may lead to weight gain and obesity; eating as an emotional response.

which is supposed to be an even better predictor of obesity than 'food deserts'⁽⁵²⁾. 'Food swamps' describe neighbourhoods with an abundance of less healthy food options (e.g. takeaways, fast-food chains, convenience stores, etc.)⁽⁵²⁾. Evidence from the UK Biobank study shows that income and increased exposure to fast-food outlets were independently associated with BMI, body fat, obesity and frequent processed meat consumption⁽⁵³⁾.

The uncertainty about food access can generate stress and anxiety which may trigger physiological and psychological mechanisms underpinning overeating and low-quality diet⁽⁵⁴⁾. For example, food insecurity may be associated with compensatory feeding practices (i.e. high-energy supplements) by parents concerned that their children are not getting enough to eat⁽⁵⁵⁾.

Lastly, some unhealthy behaviours can be related to poor mental health and other associated health conditions⁽⁵⁶⁾. Low socioeconomic status (SES) is a risk factor for a variety of disorders, including mental and behavioural problems, which may trigger a lifelong chain of physical illnesses^(57,58). Kivimäki *et al.*⁽⁵⁸⁾ reported that low SES was associated with nearly one-third of the studied diseases or health conditions (eighteen out of fifty-six). Multimorbidity (the presence of two or more long-term health conditions) was shown for sixteen of those diseases in this vulnerable population group. Interestingly, the study revealed that the *disease cascade* in those with low SES is strongly interconnected with mental health problems. For instance, the risk of the co-occurrence of obesity with mood disorders (e.g. depression or anxiety) was nearly five times higher among participants with low SES, in comparison to higher SES⁽⁵⁸⁾. Similar findings were reported by the latest Great Britain Census 2021 data⁽⁵⁹⁾. Adults with moderate-to-severe depressive symptoms had higher odds of food insecurity (3.1 higher odds) than those with no-to-mild depressive symptoms⁽⁵⁹⁾. Both studies^(57,58) were of cross-sectional nature, so the link is not causative and can be interpreted in a bidirectional manner; does obesity promote ill mental health or poor mental health contributes to weight gain? Conversely,

longitudinal data reported a worrying trend, that multimorbidity is currently observed at younger ages, when compared with previous generations, with income and BMI being key determinants of the morbidity trajectories, understood as the co-occurrence of multiple diseases within the same individual developed over a period of time^(60,61). Perhaps the co-occurrence of diseases and poor mental health explains why interventions focused on education and behaviour change in those from disadvantaged groups are not as effective when compared to groups with higher income⁽⁶²⁾ and more holistic health approaches are needed in those with the lowest incomes.

It is interesting that interventions that focus on food and resources for individuals and education to improve knowledge for low SES populations can have limited impact. At worst, they can even widen inequalities. For example, a Mexican intervention based on cash and in-kind transfers for low-income families did not improve the diet quality and body weight status of the recipients as anticipated⁽⁶³⁾. On the contrary, the additional monetary resources contributed to weight gain, as a result of increased energy consumption rather than purchases of more expensive foods such as fruit, vegetables or fish⁽⁶³⁾.

What about diet sustainability?

Sustainable diets are defined as 'dietary patterns that promote all dimensions of individuals' health and wellbeing; have low environmental pressure and impact; are accessible, affordable, safe and equitable; and are culturally acceptable'⁽⁶⁴⁾. Care needs to be taken as not all healthy eating patterns are guaranteed to be environmentally sustainable, and conversely, a diet that has a low environmental impact is not necessarily nutritionally adequate. Both aspects need to be considered for planetary health⁽⁶⁵⁾. The One Blue Dot report⁽⁶⁶⁾ from the British Dietetic Association details the need to support a change in eating habits that are both healthy and sustainable for the environment. Healthy, sustainable eating patterns



have been associated with improved health outcomes, such as reduced risk of obesity and reduced rates of diabetes and heart disease and could thus result in reductions in total mortality by 6–16%⁽⁶⁶⁾. The UK Committee for Climate Change Net Zero report⁽⁶⁷⁾ included specific dietary recommendations that UK intakes of ruminant meat (beef and lamb) and dairy should be reduced by 20% and evidence to help consumers translate this into behaviour change are necessary.

Sustainability is a priority for each of the devolved governments in the UK. In Scotland, the Good Food Nation policy, first published in 2014, set out an aspiration to produce food that is ‘tasty to eat and nutritious, fresh and environmentally sustainable’⁽⁶⁸⁾. The Carbon Trust⁽⁶⁹⁾ analysis of the Eatwell Guide shows a lower environmental impact than the current UK diet, supporting this approach. The Carbon Trust estimates that if individuals moved from current eating patterns to the Eatwell Guide recommendations, a 31% reduction in greenhouse gas emissions, 17% saving on water use and a 34% reduction in land use could be achieved⁽⁶⁹⁾. The National Food Strategy⁽¹²⁾ fully recognises these complex issues in the UK, where obesity and diet inequalities exist, and food system solutions must consider environmental impact.

Sustainable diets are being perceived as more expensive and inconvenient by consumers⁽⁷⁰⁾. There is still a limited understanding of what behaviours can be classified as sustainable, with the main connotations relating to the environmental impact of food production, local and organic food choices and ethical considerations⁽⁷⁰⁾. Especially in the context of the cost-of-living crisis, it becomes increasingly apparent that food affordability is becoming a key determinant of food choices and sustainability is of lower importance^(21,25,71). However, in our discussions with patient and public involvement advocate a theme of food waste is becoming apparent. Although reducing food waste is not initially associated with sustainable behaviours by the participants, families with low SES reported that the ability to purchase the desired amount of fresh produce (e.g. by weight rather than pre-packed) would allow them to buy the required amounts of food to prepare a healthier meal, reduce food waste and save money. It is often forgotten that one of the dimensions of a sustainable food system is ‘food and nutrition’ which consist of the following metrics: food security, food safety, food waste and nutrition⁽⁷²⁾. Hence, improving diet quality, reducing waste and targeting obesity among groups with low SES is in itself, a way of improving the sustainability of the whole food system.

The value of co-production

Co-production was conceptualised in the 1970s referring to the fact that service users were not recognised in the delivery of services⁽⁷³⁾. Subsequently, Edgar Cahn, a civil rights law professor, developed the concept further by creating a system of time banks, with input from the volunteers, who were also service users. Cahn’s work highlighted the importance of service users in the delivery of services and provided examples of how co-production

could be achieved⁽⁷⁴⁾. Since then, co-production has become an increasingly popular concept in the field of service delivery and has been used to improve the efficacy of services and reduce costs. It has also been used to ensure that service users are more actively involved in the process to foster greater collaboration between service providers and service users⁽⁷⁴⁾. Although, initially grounded in the health research settings, currently co-production is being applied to other research fields that are seeking to improve health and well-being, e.g. health promoting retail environment. In the FIO Food project, the term ‘service users’ refer to consumers, while ‘service providers’ translates to retailers and policymakers, with all parties expected to have an interest in the results of the research.

There are several definitions of co-production⁽⁷⁵⁾, however, for the purpose of the present paper, we will use the definition by Slattery *et al.*⁽⁷⁶⁾ who describes it as a ‘meaningful end-user engagement in research design and includes instances of engagement that occur across all stages of the research process and range in intensity from relatively passive to highly active and involved’. To simplify, co-producing means people who use services, members of the public and professionals working together in a ‘partnership’ to produce research, meaning that research is carried out ‘with’ or ‘by’ members of the public, rather than ‘to’, ‘about’ or ‘for them’⁽⁷⁷⁾. There are other terms used in the literature, such as patient-oriented research, integrated knowledge translation research, lay representation, citizen engagement or co-design, which often intersect with the co-production term, but are not necessarily equivalent to it⁽⁷⁸⁾.

Patient and public involvement is the most advanced form of co-production. Boote *et al.*⁽⁷⁹⁾ identified three distinct levels of involvement: (1) consultation (a process in which researchers seek public feedback on key aspects of the study); (2) collaboration (a continuous partnership between researchers and the public throughout the research process) and (3) public-led (where the public designs and oversees the research, and researchers are only invited to take part at public invitation). In the next section, we will describe how this concept was incorporated into our research.

The food inequalities and obesity: FIO Food project

The ‘Food Insecurity in People Living with Obesity’ (FIO Food) is a 3-year (2022–2025), £1.6m research project funded by the Transforming the UK Food System – Strategic Priority Fund⁽⁸⁰⁾. The overall aim of the FIO Food project is to improve environmentally sustainable and healthier food choices in the UK food system, and to provide actionable evidence for policy on retail strategies to address dietary inequalities in two vulnerable groups (people living with obesity and food insecurity). Reducing obesity levels has been a public health priority in the UK for decades but we have not yet managed to achieve that goal⁽⁸¹⁾. This is partly due to the range of factors that influence body weight. The FIO Food project supports the previously discussed whole-systems approach to consider this problem. A key challenge

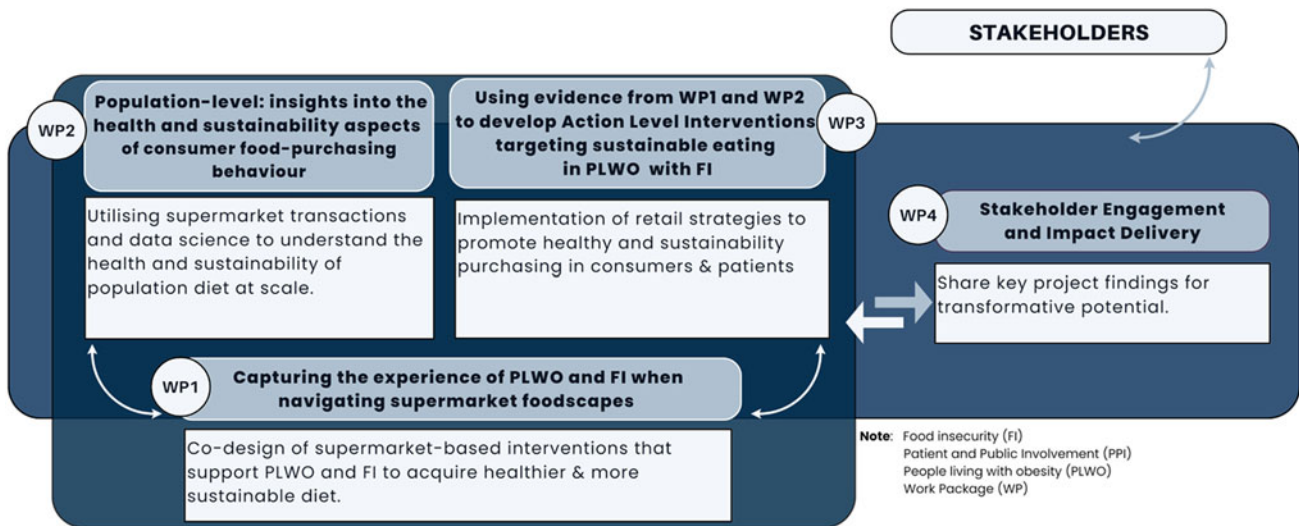


Fig. 1. Project outline.

facing people living with obesity is being able to afford a healthy, balanced diet. Nutritionally poor and energy-dense foods that are often ultra-processed, are cheaper and more readily available^(24,25). To start to address this challenge, we need better evidence on how to support healthier food purchasing patterns to improve their health and wellbeing, while considering environmental impact and sustainability.

Families on low incomes are more likely to be food insecure and they spend a greater proportion (three-quarters) of their monthly food budget in supermarkets⁽²³⁾. Supermarket promotions, advertising and online product placement decisions can impact this group's access to healthy foods. Our research is bringing together food-insecure people living with obesity, consumers, retailers, policymakers and academics to co-develop and test strategies that can support future transformative potential in the food system. To achieve this, we have designed an innovative four-part project (see Fig. 1).

Perspective

We will work with people living with obesity and food insecurity to understand the key issues facing them while shopping. We have set up patient and public involvement advocate groups to support this co-development approach throughout the lifetime of the project. We are also engaging with the retail sector and policymakers to understand their perspectives. This will identify limitations and barriers of current strategies and scope out future opportunities for our project to make sure our work remains relevant and useful.

Big data

We will use anonymous large-scale data (from >1.6 million shoppers) obtained from a national high-street retailer, to understand what foods people buy, how healthy these purchases are, their sustainability footprints and how these choices vary across different household types including those on low income. This will help

identify in-store changes that would encourage healthier and more sustainable food purchasing for people living with obesity and food insecurity.

Solution space

Because of the dynamic nature of the applied co-production approach, the methods of this work package can only be fully developed following the triangulation of WP1 and WP2 results. Based on these findings, together with insights provided by our retail partner, WP3 will review and evaluate intervention strategies designed to increase healthier, environmentally sustainable and cost-effective retail food purchasing in people living with obesity (PLWO) and food insecurity (FI), who are actively seeking treatment for obesity. These findings will feed into WP4 to support ongoing engagement with key stakeholders and formulation of policy recommendations.

Impact delivery with stakeholders

We will engage with food producers, food retailers, patient groups, policymakers and charity group representatives to ensure our project is relevant and transformative. We will do this by sharing the present findings with those groups, using webinars, social media, workshops and research briefing notes. The study has a website (<https://www.abdn.ac.uk/rowett/research/fio-food/index.php>) and regular newsletter and podcast features.

Conclusions

The current UK food system is contributing to the double burden of malnutrition, which includes people experiencing food insecurity and hunger, but also those who are living with obesity. It is the 75th anniversary of the National Health Service, and the challenges to address UK diet to improve inequalities in health are pressing. Approaches focusing solely on individuals' responsibility and consumer education are insufficient to improve

population health. To tackle the obesogenic environment, a whole system approach is needed with interventions that will be complementary and synergistic.

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Conflict of Interest

None.

Authorship

The authors had joint responsibility for all aspects of the preparation of the present paper.

References

- OHID (2022) Health disparities and health inequalities: applying All Our Health. <https://www.gov.uk/government/publications/health-disparities-and-health-inequalities-applying-all-our-health/health-disparities-and-health-inequalities-applying-all-our-health> (accessed June 2023).
- Molony E & Duncan C (2016) Income, wealth and health inequalities – a Scottish social justice perspective. *AIMS Public Health* **3**, 255–264. <https://doi.org/10.3934/publichealth.2016.2.255>
- Barnett K, Mercer SW, Norbury M *et al.* (2012) Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *Lancet* **380**, 37–43. [https://doi.org/10.1016/S0140-6736\(12\)60240-2](https://doi.org/10.1016/S0140-6736(12)60240-2)
- ONS (2021) Life expectancy for local areas of the UK: between 2001 to 2003 and 2018 to 2020. <https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandlifeexpectancies/bulletins/lifeexpectancyforlocalareasoftheuk/between2001to2003and2018to2020> (accessed June 2023).
- The Scottish Parliament (2023) Long-term monitoring of health inequalities March 2023 report. <https://www.gov.scot/publications/long-term-monitoring-health-inequalities-march-2023-report/documents/> (accessed October 2023).
- McCartney G, Walsh D, Whyte B *et al.* (2012) Has Scotland always been the ‘sick man’ of Europe? An observational study from 1855 to 2006. *Eur J Public Health* **22**, 756–760. <https://doi.org/10.1093/eurpub/ckr136>
- Hanlon P, Lawder RS, Buchanan D *et al.* (2005) Why is mortality higher in Scotland than in England and Wales? Decreasing influence of socioeconomic deprivation between 1981 and 2001 supports the existence of a ‘Scottish effect’. *J Public Health* **27**, 199–204. <https://doi.org/10.1093/pubmed/fdi002>
- Walsh D, McCartney G, Collins C *et al.* (2017) History, politics and vulnerability: explaining excess mortality in Scotland and Glasgow. *Public Health* **151**, 1–12. <https://doi.org/10.1016/j.puhe.2017.05.016>
- Branca F, Lartey A, Oenema S *et al.* (2019) Transforming the food system to fight non-communicable diseases. *BMJ* **364**, l296. <https://doi.org/10.1136/bmj.l296>
- UK Parliament (2022) Diet-related health inequalities. <https://post.parliament.uk/research-briefings/post-pn-0686/> (accessed June 2023).
- Bank of England (2023) Monetary policy report – May 2023. <https://www.bankofengland.co.uk/monetary-policy-report/2023/may-2023> (accessed June 2023).
- National Food Strategy (2021) The plan. <https://www.nationalfoodstrategy.org/> (accessed June 2023).
- Food and Agriculture Organization, United Nations (2009) Draft Declaration of the World Summit on Food Security, Rome, Document no. WSFS 2009/2. http://www.fao.org/fileadmin/templates/wsfs/Summit/Docs/Declaration/WSFS09_Draft_Declaration.pdf (accessed June 2023).
- Jones AD, Ngure FM, Pelto G *et al.* (2013) What are we assessing when we measure food security? A compendium and review of current metrics. *Adv Nutr* **4**, 481–505. <https://doi.org/10.3945/an.113.004119>
- FAO & UNICEF (2022) The state of food security and nutrition in the world 2022. <https://data.unicef.org/resources/sofi-2022/> (accessed June 2023).
- Nettle D, Andrews C & Bateson M (2017) Food insecurity as a driver of obesity in humans: the insurance hypothesis. *Behav Brain Sci* **2017**, e105. <https://doi.org/10.1017/S0140525X16000947>
- Carvajal-Aldaz D, Cucalon G & Ordonez C (2022) Food insecurity as a risk factor for obesity: a review. *Front Nutr* **9**, 1012734. <https://doi.org/10.3389/fnut.2022.1012734>
- Public Health England (2019) Whole systems approach to obesity: a guide to support local approaches to promoting a healthy weight. <https://www.gov.uk/government/publications/whole-systems-approach-to-obesity> (accessed June 2023).
- Butland B, Jebb S, Kopelman P *et al.* (2007) Foresight. Tackling obesity: Future choices – Project report. Government Office for Science, London, pp. 1–161. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/287937/07-1184x-tackling-obesity-future-choices-report.pdf (accessed June 2023).
- Hodgins M & Griffiths J (2012) Whole systems approach to working in settings. In *Health Promotion Settings. Principles and Practice*, pp. 87–91 [A Scriven and M Hodgins, editors]. London: Sage.
- The Food Foundation (2023) From purse to plate: implications of the cost of living crisis on health. <https://www.foodfoundation.org.uk/publication/purse-plate-implications-cost-living-crisis-health> (accessed June 2023).
- The Scottish Government (2022) Scottish Health Survey 2021 Edition. From Cabinet Secretary for NHS Recovery, Health and Social Care Directorate, Population Health Directorate, Part of Health and social care. <https://www.gov.scot/collections/scottish-health-survey/> (accessed June 2023).



23. The Food Foundation (2023) Food insecurity tracking. <https://foodfoundation.org.uk/initiatives/food-insecurity-tracking> (accessed June 2023).
24. The Food Foundation (2023) Food prices tracker – April 2023. <https://foodfoundation.org.uk/news/food-prices-tracker-april-2023> (accessed June 2023).
25. The Food Foundation (2023) Broken plate 2023: The State of the Nation's Food System <https://foodfoundation.org.uk/publication/broken-plate-2023> (accessed June 2023).
26. Hasnain S, Ingram J & Zurek M (2020) Mapping the UK Food System – a report for the UKRI Transforming UK Food Systems Programme. Environmental Change Institute, University of Oxford, Oxford. ISBN 978-1-874370-81-9. <https://www.foodsecurity.ac.uk/uk-food-mapping> (accessed June 2023).
27. Béné C, Oosterveer P, Lamotte, L *et al.* (2019) When food systems meet sustainability – current narratives and implications for actions. *World Development* **113**, 116–130. <https://doi.org/10.1016/j.worlddev.2018.08.011>.
28. Public Health Scotland (2022) Diet and healthy weight. <https://www.healthscotland.scot/health-topics/diet-and-healthy-weight/healthy-weight> (accessed June 2023).
29. UK Parliament (2023) Adult obesity in England. <https://commonslibrary.parliament.uk/research-briefings/sn03336/#:~:text=Adult%20obesity%20in%20England,is%20classified%20as%20'overweight'> (accessed June 2023).
30. Jayedi A, Soltani S, Motlagh SZ *et al.* (2022) Anthropometric and adiposity indicators and risk of type 2 diabetes: systematic review and dose-response meta-analysis of cohort studies. *Br Med J* **376**, e067516. <https://doi.org/10.1136/bmj-2021-067516>
31. Powell-Wiley TM, Poirier P, Burke LE *et al.* (2021) Obesity and cardiovascular disease: a scientific statement from the American heart association. *Circulation* **143**, e984–e1010. <https://doi.org/10.1161/CIR.0000000000000973>
32. Bann D, Johnson W, Li L *et al.* (2018) Socioeconomic inequalities in childhood and adolescent body-mass index, weight, and height from 1953 to 2015: an analysis of four longitudinal, observational, British birth cohort studies. *Lancet Public health* **3**, e194–e203. [https://doi.org/10.1016/S2468-2667\(18\)30045-8](https://doi.org/10.1016/S2468-2667(18)30045-8)
33. Diabetes UK (2009) Diabetes in the UK 2009: Key statistics on diabetes. https://www.diabetes.org.uk/about_us/news_landing_page/uks-poorest-twice-as-likely-to-have-diabetes-and-its-complications (accessed June 2023).
34. Johnstone A & Lonnie M & FIO-Food project team (2023) The cost-of-living crisis is feeding the paradox of obesity and food insecurities in the UK. *Obesity* **31**, 1461–1462. <https://doi.org/10.1002/oby.23740>
35. Dinour LM, Bergen D & Yeh MC (2007) The food insecurity-obesity paradox: a review of the literature and the role food stamps may play. *J Am Diet Assoc* **107**, 1952–1961. <https://doi.org/10.1016/j.jada.2007.08.006>
36. Dietz WH (1995) Does hunger cause obesity? *Pediatrics* **95**, 766–767.
37. Larson NI & Story MT (2011) Food insecurity and weight status among U.S. children and families: a review of the literature. *Am J Prev Med* **40**, 166–173. <https://doi.org/10.1016/j.amepre.2010.10.028>
38. Adams EJ, Grummer-Strawn L & Chavez G (2003) Food insecurity is associated with increased risk of obesity in California women. *J Nutr* **133**, 1070–1074. <https://doi.org/10.1093/jn/133.4.1070>
39. Martin MA & Lippert AM (2012) Feeding her children, but risking her health: the intersection of gender, household food insecurity, and obesity. *Soc Sci Med* **74**, 1754–1764. <https://doi.org/10.1016/j.socscimed.2011.11.013>
40. Pan L, Sherry B, Njai R *et al.* (2012) Food insecurity is associated with obesity among US adults in 12 states. *J Acad Nutr Diet* **112**, 1403–1409.
41. Dhurandhar EJ (2016) The food-insecurity obesity paradox: a resource scarcity hypothesis. *Physiol Behav* **162**, 88–92. <https://doi.org/10.1016/j.physbeh.2016.04.025>
42. Kendall A, Olson CM & Frongillo EA (1996) Relationship of hunger and food insecurity to food availability and consumption. *J Am Diet Assoc* **96**, 1019–1024. [https://doi.org/10.1016/S0002-8223\(96\)00271-4](https://doi.org/10.1016/S0002-8223(96)00271-4)
43. Drewnowski A & Darmon N (2005) The economics of obesity: dietary energy density and energy cost. *Am J Clin Nutr* **82**(Suppl. 1), 265S–273S. <https://doi.org/10.1093/ajcn/82.1.265S>
44. Rauber F, da Costa Louzada ML, Steele EM *et al.* (2018) Ultra-processed food consumption and chronic non-communicable diseases-related dietary nutrient profile in the UK (2008–2014). *Nutrients* **10**, 587. <https://doi.org/10.3390/nu10050>
45. Rauber F, Chang K, Vamos EP *et al.* (2021) Ultra-processed food consumption and risk of obesity: a prospective cohort study of UK Biobank. *Eur J Nutr* **60**, 2169–2180. <https://doi.org/10.1007/s00394-020-02367-1>
46. Rauber F, Steele EM, Louzada MLDC *et al.* (2020) Ultra-processed food consumption and indicators of obesity in the United Kingdom population (2008–2016). *PLoS ONE* **15**, e0232676. <https://doi.org/10.1371/journal.pone.0232676>
47. Sawyer ADM, van Lenthe F, Kamphuis CBM *et al.* (2021) Dynamics of the complex food environment underlying dietary intake in low-income groups: a systems map of associations extracted from a systematic umbrella literature review. *Int J Behav Nutr Phys Act* **18**, 96. <https://doi.org/10.1186/s12966-021-01164-1>
48. U.S. Department of Agriculture (2022) SNAP and the Thrifty Food Plan. <https://www.fns.usda.gov/snap/thrifty-foodplan#:~:text=The%20Thrifty%20Food%20Plan%20is%20one%20of%20four%20food%20plans,lowest%20cost%20of%20the%20four> (accessed June 2023).
49. U.S. Department of Agriculture (2009) Access to affordable and nutritious food: measuring and understanding food deserts and their consequences – Report to Congress, AP-036, USDA, Economic Research Service. <http://www.ers.usda.gov/Publications/AP/AP036/> (accessed June 2023).
50. Social Market Foundation (2018) What are the barriers to eating healthily in the UK? <http://www.smf.co.uk/publications/barriers-eating-healthily-uk/> (accessed June 2023).
51. Rose D, Bodor N, Swalm C *et al.* (2009) Deserts in New Orleans? Illustrations of urban food access and implications for policy. University of Michigan National Poverty Center; USDA Economic Research Service Research; Ann Arbor, MI, USA.
52. Cooksey-Stowers K, Schwartz MB & Brownell KD (2017) Food swamps predict obesity rates better than food deserts in the United States. *Int J Environ Res Public Health* **14**, 1366. <https://doi.org/10.3390/ijerph14111366>
53. Burgoine T, Sarkar C, Webster CJ *et al.* (2018) Examining the interaction of fast-food outlet exposure and income on diet and obesity: evidence from 51,361 UK Biobank participants. *Int J Behav Nutr Phys Act* **15**, 71. <https://doi.org/10.1186/s12966-018-0699-8>
54. Anversa RG, Muthmainah M, Sketriene D *et al.* (2021) A review of sex differences in the mechanisms and drivers of overeating. *Front Neuroendocrinol* **63**, 100941. <https://doi.org/10.1016/j.yfrne.2021.100941>



55. Feinberg E, Kavanagh PL, Young RL *et al.* (2008) Food insecurity and compensatory feeding practices among urban black families. *Pediatrics* **122**, e854–e860. <https://doi.org/10.1542/peds.2008-0831>
56. Conry MC, Morgan K, Curry P *et al.* (2011) The clustering of health behaviours in Ireland and their relationship with mental health, self-rated health and quality of life. *BMC Public Health* **11**, 692. <https://doi.org/10.1186/1471-2458-11-692>
57. Hudson CG (2005) Socioeconomic status and mental illness: tests of the social causation and selection hypotheses. *Am J Orthopsychiatry* **75**, 3–18. <https://doi.org/10.1037/0002-9432.75.1.3>
58. Kivimäki M, Batty GD, Pentti J *et al.* (2020) Association between socioeconomic status and the development of mental and physical health conditions in adulthood: a multi-cohort study. *Lancet Public Health* **5**, e140–e149. [https://doi.org/10.1016/S2468-2667\(19\)30248-8](https://doi.org/10.1016/S2468-2667(19)30248-8)
59. ONS (2023) Characteristics of adults experiencing energy and food insecurity in Great Britain: 22 November to 18 December 2022. <https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/characteristicsofadultsexperiencingenergyandfoodinsecuritygreatbritain/latest> (accessed June 2023).
60. Canizares M, Hogg-Johnson S, Gignac MAM *et al.* (2018) Increasing trajectories of multimorbidity over time: birth cohort differences and the role of changes in obesity and income. *J Gerontol B Psychol Sci Soc Sci* **73**, 1303–1314. <https://doi.org/10.1093/geronb/gbx004>
61. Cezard G, McHale CT, Sullivan F *et al.* (2021) Studying trajectories of multimorbidity: a systematic scoping review of longitudinal approaches and evidence. *BMJ Open* **11**, e048485. <https://doi.org/10.1136/bmjopen-2020-048485>
62. Bull ER, Dombrowski SU, McCleary N *et al.* (2014) Are interventions for low-income groups effective in changing healthy eating, physical activity and smoking behaviours? A systematic review and meta-analysis. *BMJ Open* **4**, e006046. <https://doi.org/10.1136/bmjopen-2014-006046>
63. Leroy JL, Gadsden P, González de Cossío T *et al.* (2013) Cash and in-kind transfers lead to excess weight gain in a population of women with a high prevalence of overweight in rural Mexico. *J Nutr* **143**, 378–383. <https://doi.org/10.3945/jn.112.167627>
64. FAO and WHO (2019) Sustainable healthy diets – guiding principles. Rome.
65. Willett W, Rockström J, Loken B *et al.* (2019) Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. *Lancet* **393**, 447–492. [https://doi.org/10.1016/S0140-6736\(18\)31788-4](https://doi.org/10.1016/S0140-6736(18)31788-4)
66. BDA (2020) One Blue Dot – the BDA’s Environmentally Sustainable Diet Project. <https://www.bda.uk.com/resource/one-blue-dot.html> (accessed June 2023).
67. UK Committee for Climate Change (2020) Net zero report. <https://www.gov.uk/government/publications/net-zero-strategy> (accessed June 2023).
68. Scottish Government (2014) Good Food Nation, <https://www.gov.scot/publications/recipe-success-scotlands-national-food-drink-policy-becoming-good-food/> (accessed June 2023).
69. Carbon Trust (2016) The Eatwell guide: a more sustainable diet. <https://www.carbontrust.com/our-work-and-impact/guides-reports-and-tools/the-eatwell-guide-a-more-sustainable-diet#:~:text=According%20to%20the%20Carbon%20Trust,waste%20reduction%20will%20help%20too> (accessed June 2023).
70. van Bussel LM, Kuijsten A, Mars M *et al.* (2022) Consumers’ perceptions on food-related sustainability: a systematic review. *J Cleaner Prod* **341**, 130904. <https://doi.org/10.1016/j.jclepro.2022.130904>
71. IGD (2022) Could the cost of living crisis derail sustainable shopping habits? <https://www.igd.com/articles/article-viewer/t/could-the-cost-of-living-crisis-derail-sustainable-shopping-habits/i/29783> (accessed October 2023).
72. Béné C, Prager SD, Achicanoy HAE *et al.* (2019) Global map and indicators of food system sustainability. *Sci Data* **6**, 279. <https://doi.org/10.1038/s41597-019-0301-5>
73. Parks RB, Baker PC, Kiser L *et al.* (1981) Consumers as co-producers of public services: some economic and institutional considerations. *Policy Stud J* **9**, 1001–1011.
74. Needham C (2008) Realising the potential of co-production: negotiating improvements in public services. *Soc Policy Soc* **7**, 221–231.
75. Smith H, Budworth L, Grindey C *et al.* (2022) Co-production practice and future research priorities in United Kingdom-funded applied health research: a scoping review. *Health Res Policy Syst* **20**, 36. <https://doi.org/10.1186/s12961-022-00838-x>
76. Slattery P, Saeri AK & Bragge P (2020) Research co-design in health: a rapid overview of reviews. *Health Res Policy Syst* **18**, 17. <https://doi.org/10.1186/s12961-020-0528-9>
77. NIHR (2021) Briefing notes for researchers – public involvement in NHS, health and social care research. <https://www.nihr.ac.uk/documents/briefing-notes-for-researchers-public-involvement-in-nhs-health-and-social-care-research/27371> (accessed June 2023).
78. Boote J, Baird W & Sutton A (2011) Public involvement in the systematic review process in health and social care: a narrative review of case examples. *Health Policy* **102**, 105–116. <https://doi.org/10.1016/j.healthpol.2011.05.002>
79. Russell J, Fudge N & Greenhalgh T (2020) The impact of public involvement in health research: what are we measuring? Why are we measuring it? Should we stop measuring it? *Res Involvement Engagement* **6**, 63. <https://doi.org/10.1186/s40900-020-00239-w>
80. Lonnie M, Hunter E, Stone RA *et al.* (2023) Food insecurity in people living with obesity: improving sustainable and healthier food choices in the retail food environment – the FIO Food project. *Nutr Bull* **48**, 390–399. <https://doi.org/10.1111/nbu.12626>
81. Theis DRZ & White M (2021) Is obesity policy in England fit for purpose? Analysis of government strategies and policies, 1992–2020. *Milbank Q* **99**, 126–170. <https://doi.org/10.1111/1468-0009.12498>