Inequity and food insecurity and effects on obesity and associated co-morbidities: meeting report and research priorities

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Abstract

A Rank Forum was convened to discuss the evidence around food insecurity (FIS), its impact on health, and interventions which could make a difference both at individual and societal level, with a focus on the UK. This paper summarises the proceedings and recommendations. Speakers highlighted the growing issue of FIS due to current economic and social pressures. It was clear that the health implications of FIS varied geographically since food insecure women in higher income regions tend to be living with overweight or obesity, in contrast to those living in low-to-middle income countries. This paradox could be due to stress and/or metabolic or behavioural responses to an unpredictable food supply. The gut microbiota may play a role given the negative effects of low fibre diets on bacterial diversity, species balance and chronic disease risk. Solutions to FIS involve individual behavioural change, targeted services and societal/policy change. Obesity-related services are currently difficult to access. Whilst poverty is the root cause of FIS, it cannot be solved simply by making healthy food cheaper due to various ingrained beliefs, attitudes and behaviours in target groups. Person-centred models, such as Capability-Opportunity-Motivation Behavioural Change Techniques and *Elicit-Provide-Elicit* communication techniques are recommended. Societal change or improved resilience through psychological support may be more equitable ways to address FIS and can combine fiscal or food environment policies to shift purchasing towards healthier foods. However, policy implementation can be slow to enact due to the need for strong evidence, consultation and political will. Eradicating FIS must involve co-creation of interventions and policies to ensure that all stakeholders reach a consensus on solutions.

Abbreviations: BMI, body mass index; CI, confidence interval; FIS, food insecurity; HFSS, foods/drinks High in Fat Sugar and Salt.

Overview

Anderson[1] defines food insecurity (FIS) as: "not having access by all people at all times to enough food for an active, healthy life" and proposes this involves both the *availability* of nutritionally adequate and safe foods as well as socially acceptable means to *access* these, which precludes stealing, use of food banks or scavenging. Whilst FIS is intimately intertwined with poverty, low income is not the sole factor determining FIS. Other drivers and barriers include, for example, the psychological impact of awareness of supply issues including environmental or geopolitical stressors, which include impacts such as the war in Ukraine, Brexit and the cost-of-living crisis following the COVID-19 pandemic of 2020-2022. Since FIS is an important risk factor for obesity and certain non-communicable diseases, this RANK symposium sought to draw together experts from a range of backgrounds to explore factors driving FIS and the impact of food poverty, from basic molecular metabolic mechanisms through to impacts on populations and healthcare provision. The speaker and topic list for the symposium is shown in Table 1.

Food inequity: understanding the national landscape

Household FIS is a concept to describe "uncertainty about future food availability and access, insufficiency in the amount and kind of food required for a healthy lifestyle, or the need to use socially unacceptable ways to acquire food"[1]. The Food and Agricultural Organization (FAO) defines four dimensions of food security: physical availability of food, economic or physical access to food, food utilisation by people and the stability of the first three dimensions[2].

The study of household FIS in the UK has evolved considerably over the last two decades, from relatively little work before the rise of food banks in the 2010s, to a vibrant multidisciplinary field[3]. Government monitoring has also evolved over this time, and now central and devolved governments measure household food security routinely. Regular surveys are conducted by different organisations. For example, the Food Standards Agency (FSA)[4] tracks experiences over the past 12 months while the Department of Work and Pensions tracks over a 30-day recall period (Bates, 2017). Questions around FIS and related indicators are included in the Scottish Government's Scottish Health Survey[5] and the Welsh Government's National Survey for Wales[6]. The most recent results from the FSA's Food and You survey[7] found that 30% of consumers reported having marginal, low or very low food security over a 12-month period. The Department of Work and Pensions' Family

Resources Survey[8], using a survey window of 30 days, reported a lower proportion of consumers in this situation (12%). The Food Foundation's Food Insecurity tracker publishes data multiple times a year using a 30-day recall period[9]. Focussing on the June 2023 tracker, the proportion of households reporting moderate or severe FIS was 17% compared with the pre-pandemic baseline of 16%. Households more likely to report FIS are those with children (24%), receiving benefits (49%) or including an adult with disability (42%). Other research has identified further characteristics of those at higher risk of FIS[10] (Table 2).

There are now a range of interventions in place that are designed to promote better access to food from the state, charities, and local communities. National government interventions include Healthy Start vouchers[11] (run through the NHS in England, Northern Ireland and Wales), Best Start Grant and Best Start Foods (run by the Scottish Government[12], free school meal provision and Universal Free School Meals. Local Welfare Assistance payments (provided through local authorities in England), Crisis Grants through the Scottish Welfare Fund (Scottish Government), Discretionary Support (Northern Ireland) and Emergency Assistance Payments (Welsh Government) are short term financial payments designed to support people in financial crisis meet basic needs. Charitable and community provision has grown significantly in recent decades including food banks, social supermarkets and pantries, sometimes with the support for local and national businesses[3]. Increasingly, research is considering 'what works' to address FIS including projects funded through the UKRI Transforming UK Food Systems Strategic Priorities Fund[13] and the Salient Food Systems trials[14]. Evaluative research from these teams and others will be vital to inform future policy and practice across the UK Policy.

The metabolic and biological impacts of food insecurity

A study, albeit from the US, found that women experiencing FIS were characterised by greater variability in temporal patterns of eating both within and between days, lower consumption of fibre and protein and higher consumption of carbohydrates compared with food secure women[15]. Amongst these patterns, the one most strongly associated with FIS was a variable time gap between eating occasions, such as when breakfast is typically eaten. In a comparison of low-income UK adults (income below the UK median of £30,800 and not in full-time education), mean daily energy intake and inter-day variations in energy intake were similar regardless of whether individuals were classified as food secure or insecure which may suggest differences in eating patterns between the UK and US[16]. People who are

food insecure have increased odds of living with overweight or obesity, with the most marked differences seen in adult women from high-income countries who have 50% increased odds of obesity compared with women who are food secure[17]. This is sometimes called the '**food insecurity-obesity paradox**' but the phenomenon is less pronounced in men and children generally, or in women from low/middle income countries[17]. There is also evidence from some countries, such as Canada, that individuals experiencing FIS eat more highly processed foods[18].

Even after correcting for income and socio-economic status, people living with FIS have 40-70% increased odds of obesity and an increased chance of developing metabolic syndrome[19] as well as some non-communicable diseases[20]. This suggests that these enhanced risks are unlikely to be linked solely to poverty. Furthermore, FIS is associated with accelerated biological ageing estimated using telomere length[21]. As expected, given these findings, a greater all-cause mortality is observed in populations with FIS beginning at an odds ratio of 1.28 (CI = 1.08, 1.52) in those who are marginally food insecure rising to an odds ratio of 2.60 (CI = 2.17, 3.12) in those with severe FIS[22]. Data from animal models (such as starlings[23] or rats[24]) and human randomised controlled trials[25-27] strongly suggest that health and obesity associations with FIS are causal. Potential reasons may include irregular eating patterns and anticipated food scarcity leading to increases in body weight or disrupted energy balance, and preferences for energy dense foods favouring weight gain[28]. Research in starlings subjected to FIS found shorter telomere length and inhibited feather regrowth, indicating reduced investment in somatic maintenance and repair[23]. Variable or unpredictable food intake is sufficient to cause weight gain in the absence of changes to diet quality or total energy intake[23]. Therefore, it is hypothesised that FIS directly triggers reductions in energy expenditure or more efficient energy bioavailability from food. The biological mechanisms underlying this effect are unclear but may include a stress response to irregular food supply which impacts hunger, appetite and preference for energy dense foods; an adverse impact of fasting on dietary thermogenesis or voluntary energy expenditure; or an inability to develop the anticipatory hormonal responses to meals requisite for homeostatic control of blood glucose and fats, for example normal insulin release. It is also plausible that changes to the gut microbiota may be implicated in the altered metabolic response to FIS. The gut microbiome supports the extraction of energy and nutrients from foods, produces multiple metabolites with relevance to health, supporting normal immunity and protection of

the host against pathogens[29]. However, the gut microbiota is dependent upon a steady supply of substrate for its maintenance, with non-digestible carbohydrates a major substrate[30].

Although each person has a unique microbiome signature, it is known that the composition and activities of the microbiota can change in response to diet, medication, stress and illness[30]. The microbiome can therefore be altered in response to irregular eating patterns and poor-quality diets, which may, in turn, increase the risk of chronic disease, for example bowel cancer, inflammatory bowel disease, diabetes or allergy[31]. In contrast, higher fibre diets promote more beneficial species (particularly lactic acid bacteria) and their metabolites (particularly short-chain fatty acids) within the gut, which may lower disease and allergy risks[32]. However, whilst certain disease states are associated with reduced bacterial diversity and altered metabolic profiles in observational studies, there is a paucity of cause-and-effect data from well conducted longitudinal studies and clinical trials. A barrier to this is the innate variation in the gut microbiome which makes identifying specific and reproducible disease signatures challenging[33].

Literature on the relationship between FIS and the microbiome remains sparse, although differences in faecal metabolite profiles between food secure and insecure US students have been noted[34]. Underlying mechanisms to explain these could include the impact of lower fibre, nutrient-poor diets on the gut microbiota, as well as stress and environmental factors. Emerging research from animal studies[35-37] suggests negative effects of some of these components on the gut microbiota, glucose tolerance, inflammation and opportunistic pathogen expansion, although findings still need to be verified in humans.

As mentioned previously, lower fibre intakes are more common in populations experiencing FIS[15]. A lack of fibre may have long term health impacts for individuals since the breakdown of fibre by gut bacteria can promote gut mucosa integrity through various actions including (a) the utilisation of bacterial metabolites such as short-chain fatty acids; (b) more rapid gut transit which reduces colonic exposure to putrefactive microbiota fermentation products; (c) release of polyphenol compounds from plant fibres; and (d) microbial synthesis of nutrients including vitamin K, folate and riboflavin.

FIS, behaviour change and the care pathway

Obesity affects more than 60% of the UK adult population but is more common in populations experiencing FIS[19]. Prevention strategies do not appear to have been successful given the UK's static and high incidence of obesity. In the NHS in England, adult weight management is currently delivered via a tiered system. Individuals move between tiers depending on the intensity of intervention required, often needing to complete a lower tier to access a higher Tier (e.g. Tier 2 for referral to Tier 3) (Figure 1).

- Tier 1 interventions include public health campaigns, adverts, websites and brief interventions in primary care. Brief interventions in primary care can be effective as demonstrated in the BWeL trial[38].
- Tier 2 is aimed at individuals with a body mass index (BMI) ≥30kg/m^2. Interventions include group interventions and the prescription of Orlistat, a lipase inhibitor.
- Tier 3 involves more specialist one-to-one interventions, using multidisciplinary teams and typically in a hospital setting. It is aimed at individuals with severe or complex obesity (BMI≥ 40kg/m^2 or ≥35kg/m^2 with obesity related co-morbidities). Within this tier, options include very low-calorie diets or the prescription of glucagon-like peptide-1 (GLP-1) receptor agonists, such as Semaglutide or Liraglutide[39].
- Tier 4 includes bariatric (metabolic) surgery, but individuals are required to receive input from tier 3 multidisciplinary teams before being referred for this (typically 12 months[40].

Although the recent approvals by NICE for new pharmacotherapies, such as Liraglutide[41] and Semaglutide[42], may improve options for the treatment of obesity other barriers exist to effective clinical management of obesity. These include a patchy provision of tier 3 service[43] and a lack of GP confidence and training to initiate conversations about patients' weight[44]. From the patient perspective, misunderstanding or fear of stigmatisation can hamper engagement with health services[45]. One study reported that people take, on average, nine years to approach their GP about their weight[46]. Therefore, people living with FIS who may be at a high risk of obesity may face difficulty seeking and receiving help to manage their obesity.

Understanding and supporting behaviour change: Lower socio-economic status is associated with a higher body mass index (BMI)[47]. This relationship appears to be mediated by health motives, i.e. how much participants 'bought into' healthy eating and concerns about body weight , but not by executive functioning (i.e. an individual's capacity for planning ahead and monitoring their own behaviour). In the UK, FIS in adults was indirectly associated with higher BMI via greater psychological distress and 'eating to cope'[48]. Whilst the Theory of Planned Behaviour is a useful framework to study how beliefs, attitudes, perceived identity control and subjective norms influence behaviour[49], it is more useful to change health behaviour rather than simply observe it.

The Behaviour Change Wheel provides a conceptual framework[50] to analyse behavioural drivers with three layers of drivers likely to influence behaviour. These are (i) individual sources of behaviour e.g., social, physical, psychological (ii) interventions such as education, coercion, incentivisation and (iii) policy options including guidelines, fiscal measures, and service provision. As developed by the Behavioural Change Wheel, successful interventions focus on the COM-B dimensions, which are Capability, Opportunity and Motivation leading to Behavioural change[50]. In the context of healthier diet, 'capability' reflects an individual's psychological or physical ability to choose healthier diets; 'opportunity' refers to the food environment including enablers and barriers within this; 'motivation' encompasses reflective and automatic mechanisms which either activate or inhibit behaviour.

Qualitative research has examined current barriers to healthier diets in adults at risk of FIS. Poor mental health, financial stress and high food prices were barriers to change, while current food choice was influenced by social factors (e.g., child food preferences) and environmental factors (e.g., temptations in local food shops)[51]. Parents living with FIS commented that they bought treat foods or takeaways because this was affordable and made their children happy. Often healthy eating knowledge is overridden by desire or pressure for convenience, poor cooking facilities, time pressure, stress, and desire to avoid conflict at mealtimes. Population and policy interventions could help to address some of these barriers to healthier eating and may involve planning, legislation, regulation, and fiscal measures (Table 3).

Behavioural Change Techniques tested in weight management interventions suggest goal-setting approaches are effective. For example, a meta-analysis of 35 interventions found that

the most effective interventions were based at home or in community settings[61]. As noted in this study, healthy eating, self-monitoring, delivery through personal contact, and targeting multiple behaviours further increased effectiveness. Intervention designs are increasingly using co-production, where target communities, such as people experiencing FIS, are actively involved in the development of behavioural interventions. Effective co-production, according to authors who developed a children's health strategy, is guided by nine principles built on the values of equality, reciprocity, and agency[62].

Co-production is underpinning a new study – the CHarMINg project – to develop interventions to support multiple behaviour change[63]. So far, early insight has been gained into the misalignment between target community and intervention developers' goals, resulting in improved training and supportive conversations about behaviour change. Figure 2 summarises three steps that could be considered when working with groups experiencing FIS to instigate more supportive, client-centred conversations about health[63].

Achieving policy change

It is said that 'what surrounds us, shapes us'. Within Western food environments, there is an abundance of food and drink that is high in energy, saturated fat, free sugars, and salt. Foods high in saturated fat, salt and free sugars are heavily advertised, marketed, and promoted, encouraging consumers to buy more, or to make unplanned purchases[64]. In practice this has a disproportionately negative impact on lower income families, compounding inequalities in health and household budgets. Regulating the food environment is an equitable way of improving health. Evidence from Scotland suggests that discretionary foods account for 20% of total daily energy and half of daily sugar intake[65]. Discretionary items (confectionery, cakes, biscuits, pastries, savoury snacks, sugar-sweetened beverages, and alcoholic drinks) tend to be high in calories, low in nutritional value and are unnecessary for health. Mean daily intakes of discretionary foods do not appear to differ by deprivation score but there are significant differences in consumption of sugar-sweetened beverages (113g in most deprived vs. 59 g per day in least deprived) providing 9 g vs 3 g in daily intakes of free sugars respectively[66]. Cost is just one of the factors influencing food choice in lower income groups with transportation, energy costs and cooking/storage facilities also being important. FIS is greater in single parent and single adult households[5] which are more likely to be impacted by food costs, particularly those in lower socio-economic groups or with disabilities and long-term health conditions[67]. Furthermore, 34% of people blamed the cost-of-living

situation for their diets being less healthy, while 45% said they were deprioritising healthy eating.

Addressing barriers within the food environment is a more equitable way of improving population diets than relying on individual change: examples include reformulation[68], restricting promotion of foods/drinks High in Fat Sugar and Salt (HFSS)[69], nutrition guidance for the out-of-home sector and a code of practice for children's menus[70]. Food Standards Scotland is supporting and building on this work, as outlined in its new public health nutrition strategy[71] and the Eat Well Your Way online resource[72]. Future policy work will need to support sustainability goals, such as meat and dairy reduction[73], while considering the cost barriers experienced by lower income consumers.

Policy sits in a context of political, economic, sociological, technological, legal and environmental considerations that influence strategic organisations. Civil servants follow UK Government's Green book[74] which outlines the ROAMEF policy development cycle: this takes decision-makers through the Rationale, Objectives, Appraisal (of different options), Monitoring (of implementation), Evaluation (of outcomes) and, finally, the Feedback[74]. Good policymaking sets benefit against potential detriment, impact on inequalities, unintended consequences, cost/benefit, return for investment and opportunity costs. Successful policy depends on evidence, politics and delivery coming together. UK nutrition policy – with the Scientific Advisory Committee on Nutrition (SACN) at its core – follows the key steps of identifying a need to evaluate and review risks (Figure 3). The process of evidence gathering and consultation leading to policy change is not usually a quick outcome. One example is the folic acid fortification policy[75] which began in 1991 with the identification of a need (prevention of neural tube defects in infants), moved onto appraisal of policy options in 2001 but has, since then, seen ongoing cycles of requests for evidence, scrutiny and consultation. Indeed, despite agreement for mandatory fortification of non-wholemeal flour with folic acid in September 2021, at time of submission of this paper (summer 2024) policy still had not been implemented.

Regarding FIS, good policy depends on clear articulation of the issue with firm definitions; for example, 'sufficient food', 'nutritious food', 'normal growth', and 'food preferences' remain difficult to quantify and open to interpretation. If FIS is defined as lacking 'nutritious food', as proposed by several organisations, then most people in the UK are in this category

since very few meet current dietary recommendations. Another challenge is the lack of consistency in dietary messaging especially the proliferation of "healthy, sustainable diets" endorsed by expert bodies, such as Eat-Lancet, One Blue Dot, Mediterranean diet, which could create confusion since they add complexity to the basic principles defined by the Eatwell Guide. It is often assumed that eating a healthy diet is more expensive than the current average diet but this is not necessarily the case[76]. A whole systems approach to dietary recommendations with cross-government co-operation could be beneficial as this would help resolve current tensions between sustainability, nutrition and affordability.

DISCUSSION

It is clear that FIS has a causal impact on metabolic health and body weight control which, over time, could have a detrimental effect on disease risk. Altered temporal patterns of eating may have significant effects on body weight and disease risk. However, it remains unclear why some forms of fasting (e.g. intermittent fasting) can benefit weight management while short periods of fasting in the context of FIS in Westernised countries is linked with excess weight gain[77]. Analysis of the impact of FIS on the microbiome is in its infancy but there is emerging evidence that the health impacts of FIS may, in part, be mediated via the microbiome.

Future nutrition policy to reduce FIS needs to be effective, avoid widening existing inequalities and guard against unintended consequences. Supporting evidence will need to come from collaboration across different scientific disciplines and effective interventions will need to be based on participatory research. Solving FIS should be viewed within the context of the whole food system with the goal of making sustainable diets affordable and accessible to all.

Research gaps

Forum participants identified key research gaps in understanding the impacts of FIS and determining which interventions could make sustainable diets affordable, accessible and acceptable to all. These were:

- **Improved experimental methods and models** that can more reliably and precisely capture the different components of FIS, e.g., food and nutrient intakes, unpredictability of food supply, anxiety, emotional distress, and chaotic eating, so that these can be

examined separately for their impact on health. Both human and animal models should be considered, and mechanistic work is important.

- Evidence is needed on what makes people more **susceptible or resilient to the health effects of FIS.** For example, why are women experiencing FIS in higher income regions at a greater risk of obesity than women experiencing FIS in low-to-middle income countries? What psychological interventions could help people to become more resilient? Evaluation of the long-term health effects of FIS, including health effects other than obesity is merited, and any potential transgenerational (epigenetic) impacts of FIS should be tracked.

- Research should capture **the views of those directly affected by FIS** and living with obesity. Greater use of co-creation in research and policy development is recommended to meet the needs, priorities and health aspirations of communities affected by FIS. Exploration of how technologies, such as artificial intelligence is merited, to support data collection, identify novel interventions, and drive behavioural change.

- We need **more robust evidence to support future policy options** which can include high-quality interventions to test the impact of recommended diets or trade policies on health and climate, and how advice lands in real world settings especially in groups experiencing FIS. There is also a need for more evaluation of existing policy implementation and how this relates to dietary and health inequalities. Exploration of behaviourally relevant **alternatives to food banks** would be useful.

- Given the emerging data on the microbiota, **dietary components such as fibre** could be investigated as a useful intervention to ameliorate some of the health impacts of FIS.

Finally, the ultimate goal of research and policy development should be the eradication of FIS without widening existing health inequalities. Evaluation of policy actions taking place in similarly sized countries with less inequity would be helpful.

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CONFLICT OF INTEREST

None to declare.

AUTHORSHIP

All authors reviewed the manuscript and agreed its content;
CHSR attended and contributed to the forum and wrote the first draft of the manuscript;
MB, NG, KH, HL-M, LL, AMcD, HP and AWW contributed presentations (as indicated in Table 1) and to the discussion, LL's contribution was made in an independent capacity;
KP attended the forum and contributed to the Discussion;
FT, AMM, SFT, JVW JCM, co-designed the meeting and contributed to the Discussion;
JAL and BMC co designed the meeting, contributed to the Discussion and edited the final version of the manuscript.

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Table 1. Speakers and talk titles at the Rank Symposium on "Inequity and food insecurity: effects on obesity and associated co-morbidities"

Inequity and food insecurity (setting the scene)	
Hannah Lambie-Mumford (Sheffield)	Food inequity: understanding the national landscape.
Metabolic impacts of food insecurity	
Melissa Bateson (Newcastle)	The metabolic impacts of food insecurity.
Alan Walker (Aberdeen)	Food insecurity and the microbiome.
Design considerations and Behaviour Change	
Kate Harvey (Reading)	Achieving behaviour change through consumer acceptance.
Nikki Garner (UEA)	Supporting behaviour change in practice.
Helen Parretti (UEA)	Obesity and weight management in primary care.
Achieving Policy change	
Alana McDonald (Food Standards Scotland)	Improving health through diet: the Scottish perspective.
Louis Levy (Independent Expert)	Shifting nutrition policy to improve health: the evidence needs of policy makers.

Table 2. Characteristics most associated with self-reported FIS at different severity

Any food insecurity	**Severe food insecurity**
Younger age (16-34 years)	Unemployment
Non-white identity	Disability or life-limiting health problems
Children in the household	Income in the lowest quartile
Lower educational level	
Unemployment	
Disability or life-limiting health problems	
Income in the lowest quartile	

Table 3. Policy opportunities to influence food choice in populations with FIS

Policy area	**Examples**
Environmental/Social Planning	Restricting hot food takeaways near schools[52]
Communication/Marketing	Health messaging[53]; marketing[54]; calorie reduction[55]
Legislation	Restrictions on placement and promotion of HFSS products[56]
Service Provision	Weight management services[57]; interventions including bariatric surgery and pharmacotherapy
Regulation	Calorie labelling on menus[58]
Fiscal Measures	Soft Drinks Industry Levy[59]
Guidelines	Obesity-related guidance e.g., NICE, FSA[60]

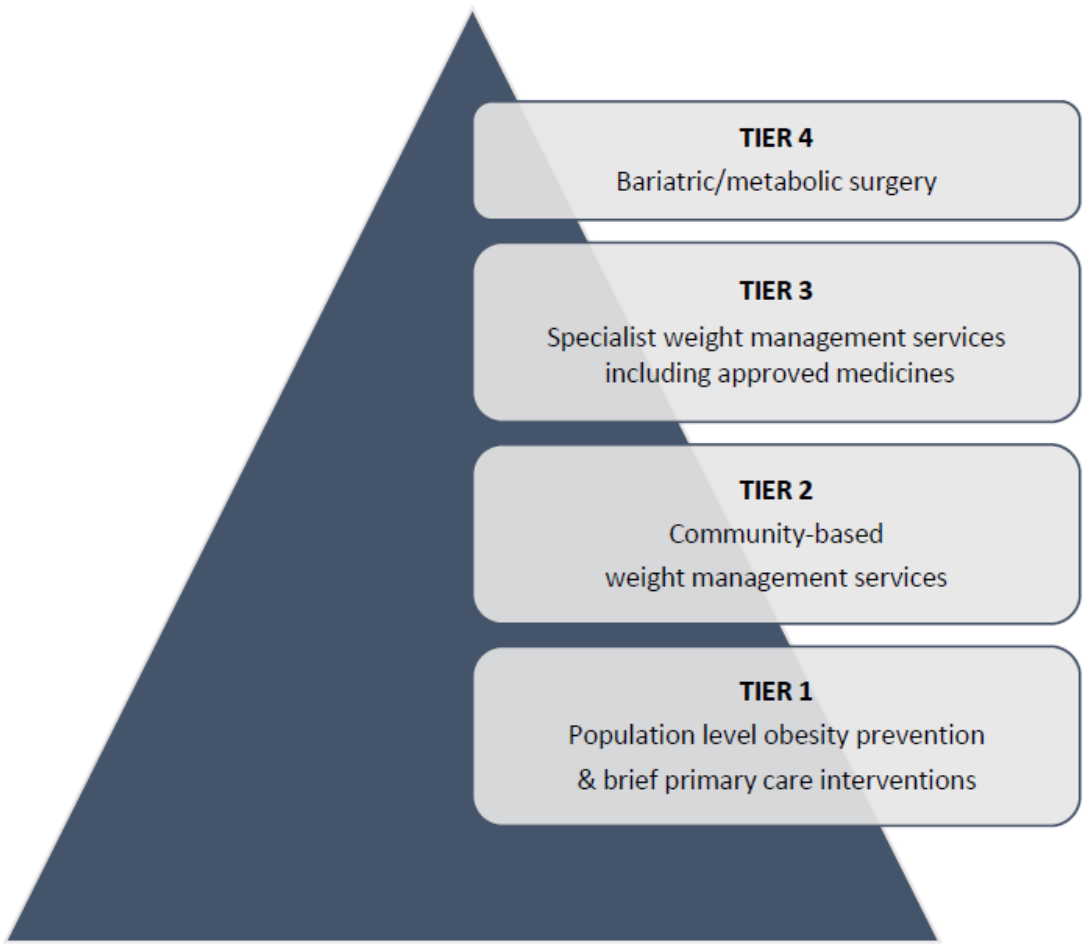

Figure 1: Weight management tiers in adult clinical settings (NICE, 2025; ref. 39)

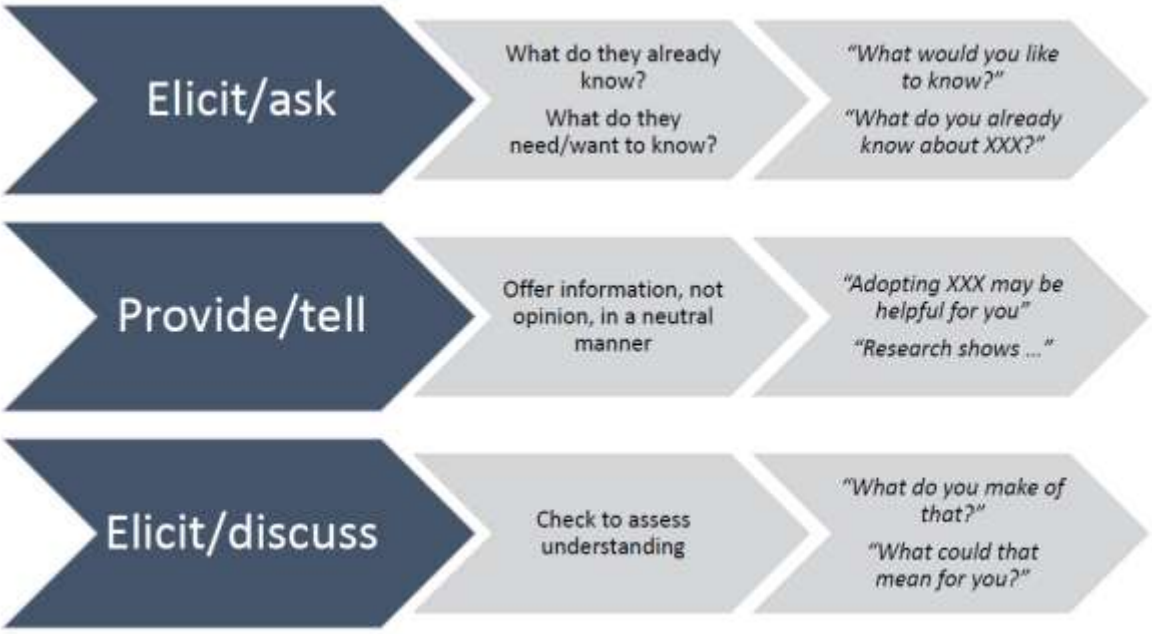

Figure 2: Key steps to delivering client-centred conversations about health

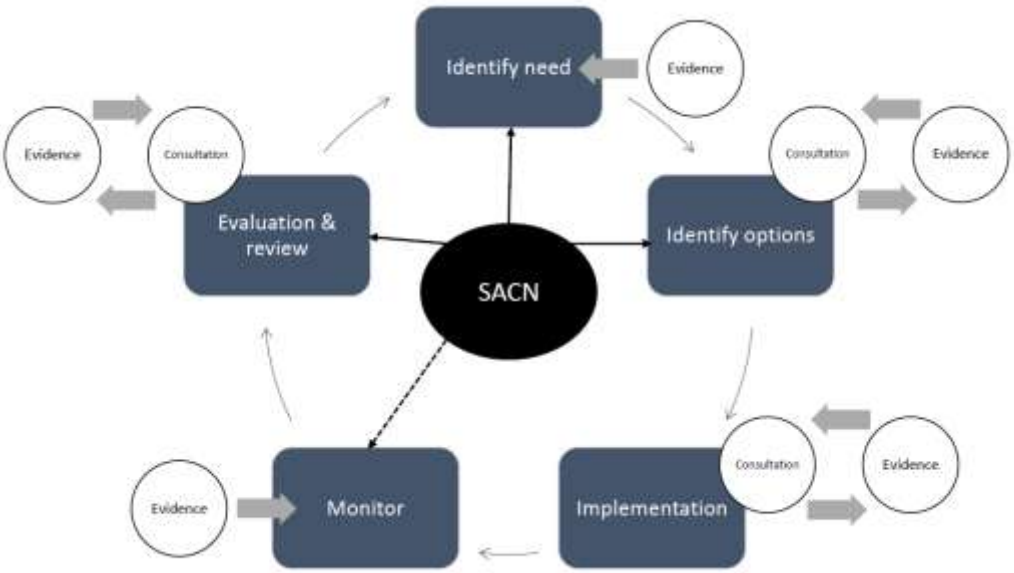

Figure 3: How nutrition research fits into the policy cycle