

# MRC Hot Topic workshop report: Reshaping the food environment – applying interdisciplinary perspectives in appetite research

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## Abstract

The prevalence of obesity, both worldwide and in the UK, continues to rise and has been classified by the NHS as a major public health issue with current public health survey data indicating that nearly two thirds of adults are living with overweight and obesity. We know from existing appetite research that it is easy to overconsume calories, but difficult to reduce calorie intake below requirements and we seek to expand this evidence base to seek future research themes to provide the evidence on how to manage obesity. This Medical Research Council (MRC)-funded hot topic workshop explored issues that are evolving from current literature to create discussion about potential future collaborative research around 4 themes: (i) Food reformulation/innovation – how appetite research can influence sustainable and healthy diets, (ii) One diet does not fit all – how should we conduct appetite research to embrace inter-individual differences (*e.g.* responder/non-responders), (iii) Environmental drivers of obesity/food choices – bridging the gap between appetite research and obesity services – future research themes, (iv) Big data approaches to develop understanding of drivers of appetite and food choice. Appetite forms a bridge to understanding the interaction between the internal and external environments and therefore has both biological and behavioural relevance for behaviour change associated with eating. This report summarises how future research can embrace this multidisciplinary challenge.

**Keywords:** appetite, behaviour change, big data, food insecurity, food reformulation, obesity research

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## Introduction

This workshop was funded by the Medical Research Council (MRC) as part of the UK Nutrition Research Partnership (UK NRP) awards. The UK NRP is a partnership between the MRC, the Biotechnology and Biological Sciences Research Council (BBSRC) and the

National Institute for Health Research (NIHR), which resulted as a direct implementation of the recommendations of the Office of Strategic Coordination for Health Research Review of Nutrition and Human Health Research (MRC & NIHR 2017). Hot topic workshops were funded to strengthen the UK nutrition research base by attracting new expertise and new partners into the field, with an overall objective to provide novel and robust insights into human nutrition, with the potential of transforming the long-term health of the population. Thus, this workshop was identified as having potential to support new linkages between different disciplines and to build research capacity by encouraging the formation of new multidisciplinary research teams able to address these health challenges, ultimately, with a view to build a strong pipeline of ideas and collaborative projects that could be competitive for response mode funding in the near future.

The workshop was organised by the principal investigators, Alex Johnstone and Adrian Brown, with 12 key collaborators, invited to work together for the first time to tackle novel topics, embracing a biomedical perspective as a team: Dr Giles Yeo, University of Cambridge, Professor Falko Sniehotta, Newcastle University, Professor Graham Finlayson, University of Leeds, Dr Gisela Helfer, University of Bradford, Professor Emma Frew, University of Birmingham, Professor Leanne Hodson, University of Oxford, Dr Abd Tahrani, University of Birmingham, Dr Emma Boyland, University of Liverpool, Dr Miriam Clegg, University of Reading, Professor Gary Frost, Imperial College London, Professor Paul Gately, Leeds Beckett University and Dr Mark Green, University of Liverpool.

Key stakeholders also invited were Ms Jenny Rosborough from the Jamie Oliver Group, Ms Sara Stanner and Dr Stacey Lockyer from the British Nutrition Foundation, Dr Glenys Jones from the Association for Nutrition, Dr Judy Lawrence from the British Dietetic Association, Ms Deidre Smyth from Kerry Group, and Miss Abigail O'Reilly from Novo Nordisk. In total, over 60 scientists from different disciplines attended the workshop.

A key objective of this online workshop was to bring together experienced and early career researchers (ECRs), alongside key stakeholders, to identify priorities for future appetite research with a focus on overweight and obesity. The vision was that the bringing together of academics from different backgrounds with stakeholders would help facilitate the sharing of new concepts, thoughts and ideas to shape future nutrition research towards improving obesity

management, policies and dissemination of recommendations. The workshop focused on the hot topic of appetite, while also embracing current discussion around overweight and obesity, within the context of eating as a form of behaviour. The workshop included evidence from 'molecules to man' to spark the delivery of scientifically robust discussion and facilitate the exchange of new ideas and collaborations to support future research. This report summarises the rationale for the workshop, the highlights from the pre-recorded presentations and the pre-recorded debate on the role of precision nutrition, played at the beginning of the workshop to stimulate discussion, and the breakout room discussions on potential research opportunities in four areas of appetite and obesity research.

## Rationale for the workshop

The prevalence of obesity, both worldwide and in the UK, continues to rise and has been classified by the NHS as a major public health issue. Current public health survey data shows that nearly two thirds (63%) of UK adults are living with overweight and obesity (Public Health England 2017). The 2007 Foresight report *Tackling Obesities: Future Choices' Project* identified multiple interlinked factors that lead to the development of obesity, where two key factors within this mapping process were the role of energy balance, which was demonstrated to interconnect all factors and the food environment. The report suggested that a whole systems approach could help address complex problems like obesity. A more recent 2019 Public Health England report *Health Matters: Whole systems approach to obesity* gives a definition of this scope, where local authorities and communities can work towards a health-promoting and food environment:

'A local whole systems approach responds to complexity through an ongoing, dynamic and flexible way of working. It enables local stakeholders, including communities, to come together, share an understanding of the reality of the challenge, consider how the local system is operating and where there are the greatest opportunities for change. Stakeholders agree actions and decide as a network how to work together in an integrated way to bring about sustainable, long term systems change'.

These reports highlight that multidisciplinary and partnership approaches can be useful for the implementation of public health strategies to address obesity. However, this has been challenging to implement,

not least because of the organisational difficulties, but also because excess bodyweight is regulated by a complex interplay of biology, genetics, psychology, environmental and societal factors.

One of the biggest challenges over the last 50 years is that the food environment has changed dramatically, meaning that many of the calories consumed within the Western diet are highly refined and processed, which promotes overconsumption (Hall *et al.* 2019). We know from existing appetite research that it is easy to overconsume calories but difficult to reduce calorie intake below requirements, and we seek to expand this evidence base to explore future research themes to provide the evidence on how to prevent and manage obesity.

Overweight and obesity are not equally distributed in UK society. The Marmot Review *Fair Society, Healthy Lives* was a landmark study of health inequalities in the UK, and highlighted the link between social inequality and the prevalence of obesity in children age 10-11 years, with obesity being higher in areas of social deprivation (The Marmot Review 2010). Despite the recommendation to address the causes of obesity across the social gradient, the 2020 update has highlighted that the health gap has, in fact, widened between wealthy and deprived areas (The Health Foundation 2020).

There remain questions about how effectively the food environment can be manipulated to result in a reduction in energy intake at a population level that is both affordable and sustainable. Recent publications are emerging to support this ethos (Steen-son & Springmann *et al.* 2018; Buttriss 2020), but with greater emphasis on tackling environmental challenges rather than obesity (malnutrition) *per se*. The use of modelling or 'big data' to evaluate the likely impact of changing the food environment to alter the availability of food selection to positively influence dietary choices and reduce incidence of obesity and related non-communicable diseases (Timmins *et al.* 2018) is being applied to enhance our understanding of the potential of this approach. However, more research in the real-world setting, over sustained periods of time is required and importantly, a robust multidisciplinary approach is necessary in order to achieve this.

The regulation of human appetite is intimately linked to body composition and therefore is relevant for understanding and managing obesity. Appetite can broadly be considered as a system to cover the whole field involved with food intake, selection, motivation and preference (Blundell *et al.* 2010). It

more specifically refers to qualitative aspects of eating, sensory or hedonic aspects or responsiveness to environmental stimulation, which can be contrasted with the homeostatic view based on eating in response to physiological stimuli or energy deficit. The study of appetite forms a bridge between the internal and external environments and therefore has both biological and behavioural or psychological aspects associated with it. The workshop deliberately embraced this multidisciplinary challenge with the inclusion of experienced researchers, stakeholders from industry and ECRs from different fields.

The workshop was designed to explore issues that are evolving from the current literature to create discussion about potential future collaborative research and identify fruitful topics/questions for future research. To achieve this, we organised a virtual collaborative event to encourage the sharing of ideas and evidence-based discussion. We sought to find a range of speakers and lead experts from different universities with gender balance and representing different disciplines, with input from ECRs being pro-actively encouraged and planned. The workshop aimed to tackle four main themes in breakout groups to help identify future research themes around appetite research and obesity. These were:

- food reformulation and innovation as a means to influence healthy and sustainable diets;
- big data approaches to develop understanding of drivers of appetite and food choice;
- supporting behaviour change - environmental drivers of obesity and food choices;
- one diet does not fit all – bridging the gap between appetite research and obesity services.

To help foster discussion and reporting during the workshop, we identified two experienced researchers and two ECRs working in the area to facilitate each breakout session.

## Workshop structure

To maximise the productivity and facilitate discussion during the workshop, we created a series of pre-recorded lectures and shared these with workshop participants a week before the live event. Invited keynote speakers presented thought-provoking summaries on current evidence, with focus on identification of future gaps for appetite research in the context of nutrition and obesity. In total we had six lectures, which centred around the four key themes, to help inform the breakout room discussions.

### **Big data approaches in describing food intake to tackle obesity – future research perspectives**

The first two lectures centred around the use of big data in addressing appetite and obesity. Firstly, Dr Mark Green from the University of Liverpool presented an insightful lecture on big data for obesity research, which underlined the potential promise for new approaches and applications in the area, while also highlighting the importance of data linkage in order to add value and complement traditional approaches (Kitchin, 2014).

Professor Ehud Reiter from the University of Aberdeen spoke on about the use of mobile apps to encourage better lifestyle behaviour. He highlighted that e-health apps or artificial intelligence (AI) can be used to give insights on human behaviour, and potentially also give advice to consumers.

These two lectures gave an excellent introduction to how unique sources of big data can be used to advance obesity research (Green *et al.* 2020) and were an eloquent introduction to the application of data science to help track and predict human behaviour (Pauws *et al.* 2019).

### **Human appetite research and contribution to understanding obesity – future research perspectives**

The next two lectures centred around the understanding of human appetite with a particular focus on obesity. Professor Graham Finlayson from the University of Leeds presented current thinking on human appetite research, highlighting that the future of understanding appetite control could involve understanding behavioural phenotypes to describe individual variability (for example, low satiety phenotypes show a weakened satiety response to a test meal). Combining this with biomarkers of appetite or metabolomic analysis could help to create ‘metabotypes’, which may have clinical application in the management of patients with poor meal tolerance or meal-related symptoms (Malagelada *et al.* 2018).

Professor Rachel Batterham from University College London spoke on the use of bariatric surgery as a research tool to gain novel insights into appetite regulation. She highlighted that bariatric surgery alters the nutrient and/or biliary flow, which engenders changes in a multitude of gastro-intestinal signals, and these can act centrally to modulate brain regions that regulate eating behaviour and reduce energy intake. For example, she highlighted that the mechanisms associated with change in taste and reward after bariatric

surgery are not clearly understood (Nance *et al.* 2020; Smith *et al.* 2020). These experienced researchers presented a valuable update on food choice and reward in food reward (Beaulieu *et al.* 2020) and bariatric surgery (Makaronidis *et al.* 2016), respectively.

### **Non-nutritional influences on appetite (sleep, stress) as modifiable behaviours that impact on appetite – future research perspectives**

Dr Abd Tahrani from the University of Birmingham presented a comprehensive lecture on sleep and obesity emphasising that there are knowledge gaps in sleep disorders and circadian alignment on metabolic outcomes (Adderley *et al.* 2020). For example, there is a paucity of data on the impact of sleep extension in people with obesity or type 2 diabetes, and how short sleep duration impacts on health-related outcomes.

Professor Daryl O’Connor from the University of Leeds presented an eloquent summary of the role of stress on appetite control (Clancy *et al.* 2016). He highlighted the need to improve the precision of real time assessment to assess daily stress, eating and cortisol levels. This can be applied to understand both hyperphagia (eating more in response to stress) and also eating less in response to stress, both in adults and in children and young people. Furthermore, the role of stress management as an intervention for behaviour change was highlighted as an example of a non-nutritional approach to tackling obesity (O’Connor *et al.* 2015).

In addition, there were six short presentations as elevator pitches from ECRs and experienced researchers to share their ‘big idea’ on future research within the area of appetite and obesity [Alex Johnstone, Adrian Brown, Suzanne Zaremba (University of Dundee), David Clayton (Nottingham Trent University), Louis Goffe (Newcastle University), Katie Hanna (University of Bradford)]. Each elevator pitch was 5 minutes in length, involved an introduction, summary of current understanding and gaps and then a big idea. This allowed for the ECRs to practice sharing and summarising their big idea in a coherent and succinct manner.

### **Pre-recorded debate topic - ‘Does Precision Nutrition offer a future for individualised appetite control?’**

On the day of the workshop, a pre-recorded debate was played between Professor John Mathers (JM, Newcastle University) who argued for, and Dr Emily Oliver (EO, Durham University) who argued against

the question. JM and EO firstly discussed their work within the area from their different perspectives and aimed to stimulate ideas about approaches to addressing obesity and for these to help feed into discussion within the planned breakout rooms.

Firstly, the issue of variability in response was addressed, with JM discussing the *DIETFITS* study (Gardner *et al.* 2018), which showed large variability in weight change in response to two weight loss interventions, with up to a third having little or no weight change. This presents a problem but also an opportunity. Understanding what causes this inter-individual variability can help us design better weight loss studies and interventions. EO agreed that this is important data and furthered the point to highlight that the variability could also be explained by factors that reside outside the individual's control. This would mean that broader predictors need to be considered including physical, social, economic and political environments enabling, or inhibiting, individuals' ability to implement and adopt change.

JM discussed the genetics of bodyweight and noted that at least 100 genetic variants have been associated with weight gain or body fatness (Yeo 2017). JM focused on the *FTO* gene which has the biggest effect in population studies. If variants in *FTO* increase the likelihood of weight gain, do those same variants make it more difficult to lose weight? From his work on 9500 people involved in weight loss trials, there was no evidence that *FTO* had any impact on weight loss (Livingstone *et al.* 2016). Therefore, he suggested that biology may play less of a role in long-term weight loss and instead that psychological and sociological factors may dominate. EO agreed this was a very interesting null finding, and that these broader factors need to be considered. However, she took this further, suggesting that targeting some factors such as motivation, which may be symptoms, rather than focusing on root social or environmental causes, could result in difficulty supporting these at an individual level. Further, she argued that obesity treatment is currently focused on the 'individual' rather than the environment and that treatment needs to be not only tailored but differentiated enough to be proportionate to need. She stressed that there was a need to improve tailoring of service-led interventions at the point of delivery, recognising that this is where the precision nutrition ideal sits.

Finally, the challenges of implementation were discussed with JM highlighting that there is no one solution and that discussions today were only one part of a range of different approaches that would need to be deployed by society to make a real difference in addressing overweight and obesity on a national scale.

JM then identified the challenges of delivering precision nutrition at a population level and suggested the solution is to go digital, by using evidence-based algorithms to provide the advice and support needed at an individual level. He suggested that going digital might enable better access to help for those who struggle to attend conventional face-to-face appointments, and so reduce health inequalities. EO countered with a cautionary tale, where the use of digital was actually shown to increase inequalities in physical activity interventions, with digital literacy being a particular challenge even for a simple platform. She argued that we need to have a much broader and integrated system of health support services which identifies wider problems earlier on, meaning that the most relevant issues to individuals are addressed at any given time. Finally, both agreed there was a need to upskill people across society to use digital platforms generally.

To conclude JM highlighted that precision nutrition remains an exciting way forward, though there is not yet enough information to generate robust individual level advice on changing dietary behaviours. We need evidence-based algorithms that use individual psychology and sociological factors to formulate robust individualised advice. JM finally concluded that the future for weight loss research is bright and the future is digital.

EO closed by echoing JM's points in that the integration of health and social datasets provides a real opportunity to deepen our understanding of the determinants of health outcomes, not only from what advice can be offered but what support is needed by the individual to enable them to adopt any advice or guidelines, thus ending a fantastic debate on the potential opportunities offered by precision nutrition.

### Workshop findings: Key ideas are summarised

Following the debate, the attendees were split into four breakout rooms based on the previous four themes. The two leads for the breakout rooms chaired discussions around the following basic structure: (i) where we are with science right now; (ii) research opportunities; (iii) barriers for future research; (iv) the role of stakeholders (not reported). This allowed for each breakout room to have a structured approach and for effective feedback.

#### Breakout room 1

Food reformulation and innovation as a means to influence healthy and sustainable diets. Chaired by

Professor Gary Frost (Imperial College London) and Professor Graham Finlayson (University of Leeds), with assistance from ECRs Dr Aaron Lett (Imperial College London) and Dr Jose Areta (Liverpool John Moore University).

### *Where we are with science right now?*

In the UK, the nutritional environment is replete with a huge range of highly processed, cheap foods engineered with strong sensory appeal and backed up by intensive marketing. Many observers believe that the food environment is largely responsible for the current high prevalence of obesity. The role of dietary components (palatability, portion size, hedonic influence) can be considered in the context of foods that are satiating or promote satiety. There has been growing interest in the potential of 'big data' for enhancing our understanding of a wide array of societal challenges including medicine and public health (Timmins *et al.* 2018). Research by the Food Foundation (2018) on the affordability of the UK's Eatwell Guide shows

that for those living on the lowest incomes, meeting the Eatwell requirements takes up to 42% of household budgets after housing costs. Blake (2019) report that food is the most flexible part of the household budget and is bought after other fixed costs are addressed. This means that while 42% of the budget would need to be spent to achieve a healthy diet, after other costs are accounted for, a much smaller budgetary proportion is available for purchasing food. Table 1 summarises the discussion notes.

### *Research opportunities - key notes:*

- There needs to be more understanding on the reward value of high calorie foods; they taste good, they are comforting and they are palatable. There is opportunity for the food industry and academia to work together to create healthier options, that taste good, are satiating and are affordable.
  - (a) It was accepted that there has already been some change towards a healthier food system,

**Table 1** Breakout room 1 discussion notes: Food reformulation and innovation as a means to influence healthy and sustainable diets

#### **Research Opportunities**

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| <ul style="list-style-type: none"> <li>• Cheap, conveniently available, healthy food which tastes good is sought. Innovative ingredients could be used to alter nutrient profile to facilitate reduction in sugar and saturated fat and conversely to increase the amount of fibre and healthy fats in products.</li> <li>• If you are living in circumstances where healthy eating is lower on the priority list compared to safety, security or housing, the food planning required to cook food with long cooking times does not fit within these issues.</li> </ul> | <ul style="list-style-type: none"> <li>• More than just 'healthy food reformulation' is required as a driver of change. Behaviour changes in consumers is a huge component to ensure people purchase the healthier options.</li> <li>• Portion size could be examined with the concept of, 'consumer backlash' over 'shrinkflation' as being cheated of pleasure/indulgence associated with brand loyalty.</li> </ul> | <ul style="list-style-type: none"> <li>• The role of labelling and marketing - is there less possibility to market reformulated convenience food?</li> <li>• It was identified that those snack foods that have been designed to aid satiety are expensive and this therefore limits their use by those in lower socio-economics groups. There is a lot of unseen costs with foods (e.g. cooking process), with decisions on foods being made at times on other wider social determinants rather than 'is it healthy?'</li> </ul> |
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#### **Barriers for future research - what are the barriers to changing the food portfolio in the UK?**

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| <ul style="list-style-type: none"> <li>• Do we think it's more about behaviour and nudging? People align themselves with a certain way of eating, like a 'tribe', that is not where 'I' sit. Is it much more about finding new ways of behaviour change rather than reformulation?</li> <li>• Technical challenges:           <ul style="list-style-type: none"> <li>- There is pressure to reduce salt, fat, sugar but also to keep foods 'clean' with suspicion existing of 'processing' and additives.</li> <li>- The feasibility of reducing sugar and energy is very limited. Also, there is the issue of a too high fibre content which can create a palatability dilemma.</li> </ul> </li> <li>• - However, advances in processing can help improve stability etc.</li> </ul> | <ul style="list-style-type: none"> <li>• A huge issue is the cost of reformulation to producers. More complex ingredients may be used as replacement ingredients but then come up against problems with consumers' poor perceptions of the reformulated product.</li> <li>• More partnership is needed between psychology, academia, clinician/healthcare professionals and research &amp; development, food science and technology experts.</li> <li>• Consideration is required for the dilemma of taxation versus consumer demand versus corporate responsibility and public health.</li> </ul> | <ul style="list-style-type: none"> <li>• Reformulation is going on but when the new product is put on the shelf next to the original this presents a challenge, there is not enough interest in repeat purchases. Foods need to have a longer shelf-life and less energy density to make them healthier.</li> <li>• Initial acceptance may not translate into long-term uptake (i.e. repeat purchases).</li> </ul> |
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through ‘health by stealth’. This has led to big reductions already happening in some foods in terms of a reduction in saturated fat, *trans* fat and salt in food (Buttriss 2020). This may remove the need for behavioural change but instead there is a need for governmental policy, alongside a combination of government incentives and industry compliance to achieve further change.

- (b) More evidence-based information on so-called ultra-processing of food and its impact on obesity is needed. Reformulation is harder in food than in beverages and so may be it is more about building the evidence base around processed foods.
- The majority of the UK population is now living with overweight or obesity and although there is a higher prevalence in lower socio-economic groups, we need to remember that it cuts across socio-economic classes.
  - (a) The need to increase the number and range of healthier products to provide choice for consumers to incorporate into a healthy diet.
- How can we nudge or switch the population to healthier diets?
  - (a) Where do incentives come from for reformulation to be taken up on the scale to reduce obesity – the majority of the UK population stand to benefit from reformulation, particularly those products high in fat sugar and salt; but is there a demand from consumers? Where is the demand coming from? Is this from a small fraction of the population that is already eating healthily and not from those who would benefit the most? We need to identify the sort of incentives that benefit different types of people.

## Breakout room 2

Big data approaches to develop understanding of drivers of appetite and food choice. Chaired by Dr Giles Yeo (University of Cambridge) and Dr Charlotte Hardman (University of Liverpool), with assistance from ECRs Dr Beverley O’Hara (University of Leeds) and Dr Chris McLeod (Loughborough University).

### *Where we are with science right now?*

The group discussed, ‘What is big data?’ A distinction was made that it was ‘found’ data as opposed to ‘made’ data. Found data is often collected for other purposes but can have benefit to research. Made data

include data collected to investigate a defined hypothesis. Examples of big data include retail sales (checkout scanners, club cards, online sales), transport data, commercial weight management programmes, geospatial (web mapping platforms, social media, smartphones/wearables) (Green *et al.* 2020). The group considered that the field was at a similar point to where it was 10 years ago. There was lots of talk and excitement about the concept, but this has not been backed up with actual research studies/papers. There was then a lot of discussion around the inequalities issue in obesity and that researchers must actively try to change this bias. Specifically, how do we access the populations that are not currently being reached? We need to consider this to target helping those in the lower socio-economic groups. We are developing a range of impressive new approaches to obesity research but none of these are likely to reach the groups that are most at risk of developing obesity. The group agreed that although the potential of big data creates a lot of excitement, there are considerable barriers which need to be considered. These range from getting access to data sets, building stakeholder engagement to generating novel data from ‘scraping techniques’ but there are huge technological barrier and data governance issues. There was acknowledgement that data quality is an issue of ‘garbage in garbage out’, and that it was hard to get data on individual dietary intake from big data sources to generate individual advice as a reliable output. Big data is an amazing opportunity for a precision nutrition approach, but the group also acknowledged that the integration of datasets is a challenge for this to be fully integrated into effective smart technology for individuals. For this we need to have accurate data. Methods for measuring food intake and expenditure for obesity research have not developed using big data, and new approaches may include ‘passive measures’ such as ear mounted or wrist worn devices which may offer new approaches to tracking individuals. Table 2 summarises the discussion notes.

### *Research opportunities - key notes:*

- Making big data smaller – data quality is a core issue and rather than rushing solutions, time should be spent on groundwork to consider *who* are represented in data sets and *what* populations are examined to eliminate potential bias.
  - (a) If we want to use AI and machine learning (such as natural language processing), we don’t want to exacerbate health inequalities within data set(s) with these approaches.

**Table 2** Breakout room 2 discussion notes: Big data approaches to develop understanding of drivers of appetite and food choice**Research Opportunities**

- Socio-economic disparity and the impact of digital poverty could be examined by focusing on data from our phones (e.g. using wearables to analyse movement/rotation of wrist to measure eating behaviours).
- Citizen science is a fantastic opportunity that can give the general public the opportunity to generate data for scientists. There are exciting opportunities for the use of this in the future.
- The smartphone is a real opportunity to help move this area forward, but the challenge is around the algorithm, how can we use information in our phones to tell us about our behaviours? There is a need for understanding the individual response and triggers which may be different for everyone (biopsychology). We need to understand how we can use information from our phones to tailor individual approaches.
- Opportunities may lie within 'data linkage', by linking the two sources of current big data ('found' and 'made')\* together to show their validity and utility. For example, how to link biobank data with other datasets.
- A consumer research data centre (CRDC) could act as a stakeholder to bridge the gap between researcher and consumers.

**Barriers for future research**

- There may be potential fees/contractual issues for the use of data when accessing a dataset. Building relationships with stakeholders and industry is key, but this can take time to develop.
- Ethical issues need to be considered, for example if purchasing or selling data.
- Companies need to protect their commercial data and may require that research benefits the company and/or their customers. This may not align with the goal of the researcher to help treat obesity.
- There may be biases due to inequalities when data is only available for part of the population. We have a major digital divide in the world, and this might play a role particularly in terms of the context of big data and how we measure things. The question was posed to the group 'how do you feel about this?' Ultimately, precision nutrition may be producing a new toy for the 'worried well' and this will increase the health divide rather than address the public health issue of obesity. We may not be addressing those at greatest need.

\*'Found' data is data collected for research or study for analysis secondary to the intended purpose; 'made' data is created in a specific area rather than using data that has already been collected.

**Breakout room 3**

One diet does not fit all – bridging the gap between appetite research and obesity services. Chaired by Dr Gisela Helfer (University of Bradford) and Dr Jennifer Logue (Lancaster University), with assistance from ECRs Dr Miriam Clegg (University of Reading) and Dr Sarah Sauchelli Toran (University of Bristol).

**Where we are with science right now?**

Biological variability in human appetite is emerging as a recognised factor relevant to obesity, with individual differences in the profiles of hunger, peptides and food choices. This means that there is no single statement about appetite that explains obesity, giving opportunity to identify appetite mechanisms for such differences (Gibbons *et al.* 2019). Quality obesity services should reflect inter-individual differences. The group discussed ways to create a platform for exploring new methods to apply appetite expertise to support innovative means of working to prevent and deliver treatment in tier 1-4 obesity services. Quality

individual services should be able to offer personalised approaches to patients. Table 3 summarises the discussion notes.

This breakout room embraced both prevention and treatment aspects with links to the publication from Public Health England *Health Matters: addressing the food environment as part of a local whole systems approach to obesity* (Public Health England 2019).

The discussion included clinicians and academics and began by clarifying the current UK obesity services [The NICE Clinical Guidance (CG189) published in 2014 (NICE 2014) and the NICE Quality Standard (QS127) published in 2016 (NICE 2016)].

Tier 1 is delivered by local and regional authorities led by the public health teams, together with the identification and advice, often carried out in a primary care setting, by healthcare professionals such as GPs, nurses, health visitors, school nurses, but together with support from pharmacists, local leisure providers and allied organisations. This tends to be a behavioural approach targeted at a population level, with

**Table 3** Breakout room 3 discussion notes: One diet does not fit all – bridging the gap between appetite research and obesity services**Research Opportunities**

- The group identified that there is a bi-directional influence for appetite research. There are novel insights to be gained, from lab-based research investigating eating behaviour and that in turn, research following clinical procedures (e.g. bariatric surgery) may inform the understanding of human appetite control.
- There is an opportunity to work with stakeholders and food industry to help regulate appetite through affecting taste and experiencing food.
- A virtual network to facilitate basic appetite researchers to translate their research into clinical services & intervention(s). Also for clinicians to contribute to basic research.
- There was an agreement that we need to get to a point where every patient that enters a weight management service is a research participant to enable real-world testing to facilitate quick translation of science into practice.
- Better multidisciplinary communication would assist with translation of science to benefit patients and clinical services. Opportunities for training Early Career Researchers and clinical researchers.
- More communication is needed with healthcare commissioners.

**Barriers for future research**

- The key barrier identified was that it is considered to be extremely difficult to implement appetite research into clinical practice.
- Embedding research within a clinical service is very challenging, as there can be a change from a commissioning point of view, which impacts on the research continuing in the long-term.
- There is little flexibility in healthcare commissioning. There is an expectation that a change in a randomly controlled trial when implemented may influence evidence effectiveness (e.g. DIRECT trial).
- There is often a lack of communication between the lab and the clinical services to allow translation of basic research meaning that things never come together.
- Standardised nationwide consent forms, a national bio-bank and standardised reporting are required.
- The time required for the administration associated with clinical trials research is a barrier.

universal interventions (prevention and reinforcement of healthy eating and physical activity messages), which includes public health and national campaigns, providing brief advice or policy initiatives such as legislation on advertising of foods high in fat, salt or sugar before the 9 pm watershed, or the sugar levy.

Tier 2 services are delivered by the local authority's community weight management services and provide community-based diet, nutrition, lifestyle and behaviour change advice, usually in a group setting environment. Normally people can only access these services for a time-limited period (often only 12 weeks). Further recent recommendations have suggested that commercial providers may be an effective choice for commissioners for this level of intervention. This is very much a one-size-fits-all service with a lack of tailoring for individual patients. An example is the NHS *Better Health* campaign (<https://www.nhs.uk/better-health/>).

Tier 3 is led by Clinical Commissioning Groups, a specialised hospital service as a clinician-led multidisciplinary team. The multidisciplinary team approach will potentially include a physician (including consultant or GP with a specialist interest), specialist nurse, specialist dietitian, psychologist, psychiatrist, and physiotherapist.

Often anecdotal evidence is applied for individual patient treatment and this gives opportunity for a

bi-directional approach for progression of evidence-based data. This could be where individual patient data is collected as part of research and this data can contribute to effective assessment and future delivery of obesity treatments. Some centres adopt a practice of routinely enrolling patients into research, but this approach is not consistent within obesity services. Personalised treatment for patients is often dependent on resources; and restrictions can often be related to the availability of specialist staff to deliver this. This can limit achievements in practice as it is focussed on delivery rather than research.

Tier 4 is for severe and complex obesity services including obesity surgery and obesity medicine and specialist weight management programmes, post-surgical and annual follow up. It is important to note that Tier 4 includes not only bariatric surgery but also bariatric medicine.

Part of the constraints of applying basic research into clinical pathways is the pragmatism of taking research and developing that into larger 'real life' clinical service delivery. For example, integrating additional burdens into primary care settings that are already very busy presents a real barrier. There is a need to take research forward rather than to replicate it. Patient involvement in appetite research is an

important issue and some clinical services enrol everyone into research; future appetite studies could involve genotyping everyone in clinical services and they are then bio-banked to allow comprehensive phenotyping of individuals. Recommendations for overcoming barriers to the integration of academia and the clinical approach were summarised as:

- we need to switch to a model where every patient is a participant, especially in weight management services;
- a platform and standardised methods are required, including a more general consent system;
- future commissioning: data has to go to NHS Digital and be made available for research;
- there needs to be a secure data environment.

#### *Research opportunities - key notes:*

The group considered ‘How could appetite research be useful for weight management?’ and identified key research opportunities.

- There was discussion about the use of chrono-nutrition and why eating at different times of the day influences how our body responds to the food. Understanding mechanisms to translate this into a therapeutic application is important, but evolutionary biology makes this challenging. Simple interventions such as timing of meals and avoiding social jetlag can potentially have an important impact on everyday life.
- Large datasets of people undergoing weight loss and the role of genetics could feed forward to an ‘intelligent prescription’ (a precision nutrition approach).
- ‘Taste changes’ might be able to be invoked with surgical intervention although research is needed to be clear whether we are talking about ‘taste’ or ‘flavour’. Taste changing is a key driver of weight loss after bariatric surgery and this could be a direct novel treatment in weight management services.
- Engagement with patients is key, for example, with people who have severe and complex obesity.

#### **Breakout room 4**

Supporting behaviour change - environmental drivers of obesity and food choices. Chaired by Professor Paul Gately (Leeds Beckett University) and Professor Falko Sniehotta (University of Newcastle), with assistance from ECRs Dr Maxine Sharps (De Montfort University) and Dr Sion Parry (University of Oxford).

#### *Where we are with science right now?:*

The group discussed the Public Health England (2019) document and explored the Leeds Beckett

University guide with supporting resources to enable Local Authorities in England and the wider UK to implement a whole systems approach (WSA) to tackling obesity within their local area (<https://www.leedsbeckett.ac.uk/research/centre-for-applied-obesity/whole-system-approach/>). An applied example of the whole system approach was discussed. The Bristol Good Food Alliance (<https://www.bristolfoodnetwork.org/blog/bristol-good-food-alliance/>), initiated by the Bristol Food Policy Council, linking with Bristol Food Network and Bristol Green Capital Partnership. The Alliance welcomed any organisation, project, or individual working to improve the food system for the city. Through this process, it was not clear whether different groups were talking to one another to develop a whole systems approach. Also, it was highlighted that there are challenges of evaluating the system and with all stakeholders completing this, which can be problematic as these evaluations are needed by funders and to potentially show the activities are beneficial (Table 4).

#### *Research opportunities - key notes:*

The discussion progressed into looking at the importance of having a good infrastructure for future research. You can have a good approach/research question but if you do not have a team to move this forward then it will not work. In addition, researchers that put better infrastructure and financial resources into place were more successful at implementation. It was felt that there was now greater support from funders to promote the interdisciplinary systems-based thinking, for example, with UK Research and Innovation releasing the global food strategy (<https://www.foodsecurity.ac.uk/>) and a whole systems approach is now starting to be built into policy and national strategies. For example, *VegPower* (<https://vegpower.org.uk/>) embeds a combination of government policy alongside social media campaigns, both operating at a macro level of the system, demonstrating there is starting to be a shift in mindset.

The delivery of a whole systems approach is challenging for obesity management as there is a postcode lottery of interventions across the country, despite us having good evidence-based interventions. When delivering and bidding for services, those local authorities with more resources provide better services and these tend to be in less deprived areas. The question was posed as ‘is this due to central government issues or local authority issues?’.

Finally, it was commented that when looking at a whole systems approach in a local area it is

**Table 4** Breakout room 4 discussion notes: Supporting behaviour change - environmental drivers of obesity and food choices

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**Research Opportunities**

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- There are very different methods applied across the UK when looking at a whole systems approach. Interacting with specialist colleagues across the country, particularly those who work with vulnerable groups (e.g. eating disorders or mental health issues), were considered.
  - It was suggested that there are multiple questions, but the opportunity and challenge is how we pick out the key topics. There is a need to understand the complexity of the whole system approach, and at a granular level if possible.
  - One of the big questions is around 'how to make the idea of whole systems more feasible?', because system science is challenging. There is a lack of strong evaluative tools that identify part of the system, or the system as a whole. This was identified as an opportunity, to welcome people to critique and develop further Public Health England tools.
  - The importance of knowing your place in the system was discussed. It was identified that following this there is a need to work out who to collaborate and work with. Many people are already doing this, but the idea of the whole system is to do it in a more systematic way.
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**Barriers for future research**

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- A key challenge within weight management when looking at the whole system approach is that across the country the system works in very different ways. This can enable and disable us to interact with the appropriate stakeholders to work effectively across the system. An infrastructure is required to be in place to begin with, therefore there are greater challenges to put a whole systems approach in a more deprived area, and across the country.
  - It was questioned whether addressing a whole systems approach is actually feasible with so many factors impacting on appetite and obesity. With both the logistics, and the need of multiple stakeholders, behind buying into a whole system approach does it mean the approach would breakdown in terms of feasibility?
  - If there is political will and effort this could be achieved but it is a valid point that the underlying systems of academia and funding drive us down to a reductionist approach. It is much easier to support this type of intervention rather than whole systems. It is due to the complexity and the unpredictability that this presents that this is a particular challenge.
  - Food insecurity in the UK was identified to be the highest in Europe and is more prevalent, and highest, in the North East of the country. However, a lot of initiatives and responses have been focussed in London, on the doorstep of policy makers. There is a feeling by key stakeholders that there is a lot of missed opportunity in other areas of the country. This has resulted in some third sector organisations being better set up in other parts of the country to fill in these gaps. This involves a good network of providers to fill these gaps in policy.
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important to include a range of stakeholders in the dialogue (including local government, business, food sector and commercial sectors) around physical activity or any other wider obesity determinant. This presented an interesting issue on how we get a more diverse group of stakeholders discussing these issues. Also, stakeholders should be involved at all stages, right from the question to the solution, to allow co-production of interventions. Finally, governance was explored, in that, how do you create a group that is in regular contact with a regular process of engagement and development of the ideas/concepts? Where do you identify gaps in the system to enable collaborative working? The whole systems approach is trying to create a supportive framework about how this can be done. This workshop created this opportunity for multidisciplinary thinking in a supportive environment.

**Summary session after the breakout rooms**

Following the end of the breakout sessions one of the ECRs from each room led a summary of the discussions that were had, to share the key ideas and themes with the rest of the workshop.

**Concluding remarks**

The final remarks of the day emphasised the stimulating discussions during the workshop and highlighted the appetite for multidisciplinary research. The aim of the workshop was to bring together people from different backgrounds so that they could share their research themes and experiences, so that new or expanded areas of research could be suggested to the MRC that would be of interest for future research. To have over 60 people sharing ideas on obesity and

appetite, with their wealth of experience, and allowing ECRs to be involved was fantastic. It was wonderful to do this in a supportive environment with great scientists. Finally, we encouraged people to attend a follow up session in breakout rooms where we discussed and expanded on the topics discussed during the workshop to build, and hopefully put forward, future grant applications. These notes reflect the findings from all the sessions and we gratefully acknowledge the input from attendees.

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AJ has received funding as a consultant and principal investigator for the food sector for commercial research. AB has received funding for investigator-initiated research through an educational grant and travel awards from Cambridge Weight Plan Ltd, received support to attend an obesity conference from Novo Nordisk and is on the scientific advisory board and shareholder of Reset Health Clinics Ltd.

## References

- Adderley NJ, Subramanian A, Toulis K *et al.* (2020). Obstructive Sleep Apnea, a Risk Factor for Cardiovascular and Microvascular Disease in Patients With Type 2 Diabetes: Findings From a Population-Based Cohort Study. *Diabetes Care* 43: 1868–77.
- Beaulieu K, Oustric P & Finlayson G (2020) The Impact of Physical Activity on Food Reward: Review and Conceptual Synthesis of Evidence from Observational, Acute, and Chronic Exercise Training Studies. *Current Obesity Reports* 9: 63–80.
- Blake M (2019) More than Just Food: Food Insecurity and Resilient Place Making through Community Self-Organising. *Sustainability* 2019: 2942.
- Blundell J, de Graaf C, Hulshof T *et al.* (2010) Appetite control: methodological aspects of the evaluation of foods. *Obesity Reviews* 11: 251–70.
- Buttriss JL (2020) Why food reformulation and innovation are key to a healthier and more sustainable diet. *Nutrition Bulletin* 3: 244–252
- Clancy F, Prestwich A, Caperon L *et al.* (2016) Perseverative Cognition and Health Behaviors: A Systematic Review and Meta-Analysis. *Frontiers in human neuroscience* 10: 534.
- Gardner CD, Trepanowski JF, Del Gobbo LC *et al.* (2018) Effect of Low-Fat vs Low-Carbohydrate Diet on 12-Month Weight Loss in Overweight Adults and the Association With Genotype Pattern or Insulin Secretion: The DIETFITS Randomized Clinical Trial. *Journal of the American Medical Association*. 319: 667–79.
- Gibbons C, Hopkins M, Beaulieu K *et al.* (2019) Issues in measuring and interpreting human appetite (satiety/satiation) and its contribution to obesity. *Current Obesity Reports* 8: 77–87.
- Green MA, Watson AW, Brunstrom JM *et al.* (2020) Comparing supermarket loyalty card data with traditional diet survey data for understanding how protein is purchased and consumed in older adults for the UK, 2014–16. *Nutrition Journal* 19: 83.
- Hall K, Ayuketah A, Brychta R *et al.* (2019) Ultra-Processed Diets Cause Excess Calorie Intake and Weight Gain: An Inpatient Randomized Controlled Trial of Ad Libitum Food Intake. *Cell Metabolism* 30: 67–77.
- Kitchin R (2014) Big Data, new epistemologies and paradigm shifts. *Big Data & Society* 1: 205395171452848.
- Livingstone KM, Celis-Morales C, Papandonatos GD *et al.* (2016) FTO genotype and weight loss: systematic review and meta-analysis of 9563 individual participant data from eight randomised controlled trials. *British Medical Journal* 354: i4707.
- Makaronidis JM, Neilson S, Cheung W *et al.* (2016) Reported appetite, taste and smell changes following Roux-en-Y gastric bypass and sleeve gastrectomy: Effect of gender, type 2 diabetes and relationship to post-operative weight loss. *Appetite* 107: 93–105.
- Malagelada C, Pribic T, Ciccantelli B *et al.* (2018) Metabolomic signature of the postprandial experience. *Neurogastroenterology & Motility* 30: e13447.
- MRC & NIHR (Medical Research Council & National Institute of Health Research) (2017) *Review of Nutrition and Human Health Research*. Available at: <https://www.mrc.ac.uk/documents/pdf/review-of-nutrition-and-human-health>. (accessed 22 March 2021).
- Nance K, Belén Acevedo M & Pepino Y (2020) Changes in taste function and ingestive behavior following bariatric surgery. *Appetite* 146: 104423.
- NICE (National Institute for Health and Care Excellence) (2014) *NICE Clinical Guidance (CG189) Obesity: Identification, assessment and management*. Available at: <https://www.nice.org.uk/guidance/cg189> (accessed 2 January 2021).
- NICE (National Institute for Health and Care Excellence) (2016) *NICE Quality Standard (QS127) Obesity: Clinical assessment and management*. <https://www.nice.org.uk/guidance/qs127> (accessed 2 January 2021).
- O'Connor DB, Armitage CJ & Ferguson E (2015) Randomized Test of an Implementation Intention-Based Tool to Reduce Stress-Induced Eating. *Annals of Behavioral Medicine* 49: 331–43.
- Pauws S, Gatt A, Kraemer E & *et al.* (2019) Making Effective Use of Healthcare Data Using Data-to-Text Technology. In: *Data Science for Healthcare: Methodologies and Applications* (S Consoli, DR Recupero & M Petkovic eds), 4, pp. 119–45. Berlin: Springer.

- Public Health England (2017) *Health Matters: obesity and the food environment*. Available at: <https://www.gov.uk/government/publications/health-matters-obesity-and-the-food-environment/health-matters-obesity-and-the-food-environment--2>. (accessed 2 January 2021).
- Public Health England (2019) *Health Matters: Whole systems approach to obesity*. Available at: <https://publichealthmatters.blog.gov.uk/2019/07/25/health-matters-whole-systems-approach-to-obesity/> (accessed 2 January 2021).
- Smith K, Papantoni A, Veldhuizen MG *et al.* (2020) Taste-related reward is associated with weight loss following bariatric surgery. *The Journal of Clinical Investigation* **130**: 4370–81.
- Springmann M, Wiebe K, Mason-D'Croz D *et al.* (2018) Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail. *Lancet Planet Health* **2**: e451–61.
- The Food Foundation (2018) *Affordability of the UK's Eatwell Guide*. Available at: <http://foodfoundation.org.uk/publication/affordability-eatwell-guide/> (accessed 2 January 2021).
- The Health Foundation (2020) *Health Equity in England: The Marmot Review 10 Years On*. Available at: <https://www.health.org.uk/publications/reports/the-marmot-review-10-years-on> (accessed 2 January 2021).
- The Marmot Review (2010) *Fair Society Healthy Lives*. The Institute of Health Equity by Michael Marmot, Peter Goldblatt, Jessica Allen *et al.* Available at: <http://www.instituteoftheequity.org/resources-reports/fair-society-healthy-lives-the-marmot-review> (accessed 2 January 2021)
- Timmins K, Green MA, Radley D *et al.* (2018) How has big data contributed to obesity research? A review of the literature. *International Journal of Obesity* **42**: 1951–62.
- Yeo GSH (2017) Genetics of obesity: can an old dog teach us new tricks? *Diabetologia* **60**: 778–83.