

# Review of Nutrition and Human Health Research

July 2017



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# Foreword

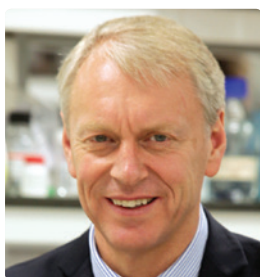
The UK has a long and distinguished track record in national and international nutrition research.

Good nutrition is fundamental for good health and the prevention, treatment and management of disease. Access to a sustainable and healthy diet is a key requirement across the life course and across the globe. The relationship between food, nutrition and health, however, is complex, dynamic, and multi-faceted and highly affected by biological as well as environmental, socio-economic, cultural and behavioural factors. Global population growth, climate change and pressure on natural resources, poor access to healthy foods, unhealthy lifestyles, and growing consumer demand, all present an increasing challenge. Paradoxically, whilst in the developing world around 800 million people suffer from chronic undernourishment, both developed and emerging economies are facing the problem of rising levels of obesity and diet related disease (heart disease, type 2 diabetes, cancer, high blood pressure and osteoarthritis). This is largely due to changes in patterns of consumption and the type of food consumed, as well as more sedentary lifestyles.

High quality, multidisciplinary nutrition research and effective collaborations are key to improving global health. We have made good progress but we must ensure that the field remains innovative and forward-looking. It is important to build on our strengths but also to identify and address areas of weakness.

In order to make greater advances, and more quickly, we will require transformative thinking and action. We must forge new or stronger cross-sector and cross-disciplinary partnerships to ensure that the research base is well-placed to tackle the major global nutrition research challenges. Above all, we must capitalise on the immense potential of the expertise and resources (both public and private) in the UK, thereby maximising the translation of research to improve human health and wellbeing, both nationally and globally.

This report sets out an exciting future vision for nutrition research and key recommendations to strengthen and revitalise and strengthen the research base to ensure we reach our goals.



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# Summary

## Background

Nutrition, diet and physical activity play an important role in the promotion of health and the protection from, and treatment of, disease.

All growth and development during early life and childhood is conditional upon the opportunity for good nutrition, which in itself determines the future resilience of the individual to everyday stresses and susceptibility to disease. Nutritional factors set the vulnerability to risk of chronic non-communicable disease during adulthood. Under-nutrition and obesity increases vulnerability to ill-health by decreasing resilience and the capacity to cope with any stress; infective, emotional or societal.

In addition to its causative role in under-nutrition and obesity, perturbed nutrition exacerbates many infectious and chronic non-communicable diseases. These problems cost lives, cost dignity and increasingly place an unsustainable economic burden on the individual and society as a whole. For example:

- Three million people in the UK are malnourished – 25% of those in hospital and 42% in long-term care (Russell and Elia 2008)<sup>1</sup>.
- In the United Kingdom, the Government currently spends about £6 billion a year on the direct medical costs of conditions related to being overweight or obese. These costs are expected to rise – by 2030 the estimate is for overweight/obesity to cost the NHS between £10 billion and £12 billion<sup>2</sup>.
- Annual gross domestic product (GDP) losses from low weight, poor child growth, and micronutrient deficiencies average 11% in Asia and Africa<sup>3</sup>.

With these concerns in mind, the Office of Strategic Coordination for Health Research (OSCHR) in the UK asked the Medical Research Council (MRC), in partnership with the National Institute for Health Research (NIHR), to conduct a strategic review of nutrition research.

## Approach and scope of the review

The review was overseen by a Review Group of experts in the field and was informed by a stakeholder workshop and written contributions from international experts.

Building on the Cross-Council Vision for Food, Nutrition and Health research, the review assessed the critical gaps in basic, translational and applied health research and the underpinning role of nutrition in individual health, public health and the development of disease to ensure that the available health research resources are coordinated at the strategic level. The review also considered how the UK can engage with the global food and nutrition science industry, particularly through research, to ensure that we maximise the opportunities to translate findings from nutrition science.

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1. Russell CA & Elia M (2008): Nutrition Screening Survey in the UK. Available from: [http://www.bapen.org.uk/pdfs/nsw/nsw07\\_report.pdf](http://www.bapen.org.uk/pdfs/nsw/nsw07_report.pdf).

2. McKinsey Global Institute Report: Overcoming Obesity: An initial economic analysis November 2014

3. *International Food Policy Research Institute*. 2016. Global Nutrition Report 2016: From Promise to Impact: Ending Malnutrition by 2030. Washington, DC. <http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/130354/filename/130565.pdf>

The review focused on nutrition research from a human health perspective. This focus has served to unite ‘food-facing’ and ‘health-facing’ aspects which have been treated as a continuum. The aim was to ensure that all relevant sectors were adequately supported to carry out relevant research that is both joined up and complementary. Whilst recognising the important connections to issues of primary food production, food security, sustainability and waste, food packaging, preservation and safety, these have not been examined and are covered by other ongoing UK and European initiatives.

The review did not look at behavioural science explicitly – although extremely important, this is in itself a huge research field and it would not have been possible to cover both areas in a single review. However, the interface with behavioural science was an important consideration and a key element of the review was the ‘pull-through’ of nutrition research into policy and practice.

## **Main review findings**

### **Unfulfilled potential**

The detrimental impact of poor nutrition on the health and wellbeing of individuals, healthcare systems and the economy is substantial. Nutrition research has the potential to make a profound positive impact on human health in the UK and globally. The failure to adequately address nutrition research in an organised and structured way seriously undermines the ability to achieve best health at lowest cost.

Despite the UK’s impressive track record in nutrition research, there is a general perception that the UK is moving towards a critical point in relation to nutrition research capacity, capability and training, as well as in clinical delivery. In parallel, there has been a gradual decline in the profile and standing of the nutrition field. The UK is failing to capitalise on its strengths and the field is not reaching its full potential. There are significant opportunities for more effective ‘pull-through’ of existing knowledge and understanding from the basic sciences into clinical and population research, new product development and service delivery that are not being realised. Urgent action is required to ensure a robust future for the field.

### **Profile and standing**

The field suffers from a number of perplexing paradoxes: despite the complex and challenging nature of nutrition research, it is sometimes regarded as a ‘soft’ and unexciting science with low recognition of its academic value. Although the field is broad and requires a multidisciplinary approach, more often than not it sits in isolation and is not sufficiently embedded in human health and disease research, or adequately connected to cognate and underpinning sciences.

Despite the UK’s excellent track record, in recent years both public and academic opinion have been critical of nutritional science. There is a view amongst some academics that nutrition research can lack quality and rigour. Equally, the public is often confused, or at worst cynical, about nutrition and dietary advice. Sensational or exaggerated nutrition-related health stories in newspapers, coupled with the premature dissemination of research findings, are damaging for the field and its researchers and have eroded the public’s trust of and nutrition science.

## Leadership

There is no single national strategy for nutrition and human health research – currently this relies on coordination and partnership by the individual funders, government departments and agencies.

Although there have been some cross-funder initiatives in recent years, a more top-down coordinated approach to funding, alongside response mode, could ensure that the UK investment in research and infrastructure is better organised leading to greater efficiency and effectiveness.

## Clinical nutrition and training

One particular challenge facing clinical nutrition is that it is not represented by a single professional grouping with specific responsibility to promote the discipline, set standards for capability, practice and service delivery. Without a defined and respected group who can act with authority as custodians for these aspects it will be difficult to establish and develop the coherent high quality translational research agenda that is needed in nutrition. The absence of a discrete speciality of nutrition militates against the development of a structured training programme from undergraduate through foundation training, to general or specialist practice. In turn, this hampers the development of competent clinical researchers and trainers.

## Critical mass, integration, and coordination

Despite areas of strength, overall the nutrition research community is fragmented, spread thinly and lacking in critical mass. Pockets of excellence exist but these are not well connected to cognate and underpinning sciences, food science (where appropriate), industrial interests (whether food or healthcare nutrition), or well embedded within disease disciplines. The lack of leadership and high-level strategy at a national level has led to suboptimal activity in key research areas and a lack of coordination in the 'food-nutrition-health' space, resulting in slower progress and lower impact than might have been expected.

Although there is widespread nutrition research activity taking place throughout the UK, the relevant infrastructure is of variable quality and fragmented, with little evidence of coordination or linkage. Additionally, some of the UK's key clinical research infrastructure (eg accredited clinical research facilities) is not well equipped to support nutrition and dietary research.

## Quality and rigour

Nutrition research studies in humans are undertaken across the UK but are of variable quality and intensity. There is a lack of high quality experimental medicine/physiology studies and of high quality hypothesis-led research in humans, particularly to improve mechanistic understanding. Progress is hampered by a lack of standardisation and robust measures eg for what people actually eat in the free living situation.

## Capacity and expertise

There is an overall lack of capacity in nutrition science. Nutrition scientists comprise a small (~2.5% contribution to the Life Science and Medicine Unit of Assessment in REF) and rather fragmented community which is overstretched in terms of the broad areas of expertise and translation it is expected to cover. The field is approaching a critical point as a cadre of nutrition scientists move towards retirement and new researchers are not entering the field due to perceived poor career progression and the challenges of undertaking high quality nutrition research. Difficulties in developing, promoting, and retaining greater numbers of skilled nutrition researchers have been highlighted.



Expertise and know-how at the interface between public health nutrition, food science and technology has been significantly weakened in recent years. Yet this interface is immensely important in ensuring the translation of evidence-based nutrition science into the food sector. A ‘valley of death’ between nutrition on the one hand and food science/technology and industry on the other, will seriously impair the ability to translate public health guidelines into achievable diets for the UK population.

### **Partnership with industry**

We cannot change what people eat solely through the route of dietary advice and public health guidelines. Industry must be seen as part of the solution. Partnership with the food/nutritional science industry is vital, not least because this sector is key to ensuring research advances are translated into healthier products, or improved nutritional support. It should also be remembered that the food industry is core to the economy and needs to remain competitive considering the uncertainties in relation to Brexit.

Despite some successful examples, partnership with the food/nutrition science industry is much less developed than interactions with the pharmaceutical industry. Much more could be done to improve the interface in relation to nutrition and human health.

Currently the lack of an agreed code of practice for joint working is considered (by both the academic and industry sectors) to be an obstacle to open, transparent and effective partnerships between academic researchers and the food industry. Further, there is significant risk here that early career researchers and others considering a career in nutrition research will be disinclined to enter an area where there is lack of adequate guidance to ensure independence in research findings.

### **Global nutrition and health research**

The changing burden of disease across the world has led to the emergence and increase in prevalence of chronic non-communicable diseases (NCDs), for example heart disease, obesity, cancer and diabetes, in developing countries. Nutrition, and its influence at all life stages, is likely to play a pivotal role in understanding NCDs and their prevention and treatment. There is a need to build on the UK's track record in international nutrition research. Every effort should be made to enhance the UK's research base and ensure its researchers are well-placed to work in partnership with low and middle-income countries to tackle the global health challenges of the 21st century.

## Future vision

The future vision is by nature broad and ambitious and focuses on scientific opportunity. It envisages a revitalised field which fully capitalises on the immense potential of the expertise and resources (both public and private) in the UK, thereby maximising the translation of research to improve human health and well-being, both nationally and globally.

## Recommendations

The recommendations made have been selected to provide the greatest and broadest impact for the nutrition research field. They aim to reinvigorate and strengthen the field by fully capitalising on existing strengths whilst providing new momentum through increased coordination and targeted strategic investments.

- The establishment of internationally leading cross-disciplinary Centres of Excellence in integrative nutrition to strengthen both research and training in key challenge areas and enhance scientific networking and cooperation across institutions.
- Nutrition research should be fully integrated within studies of health and disease to optimise health outcomes.
- More and better coordinated international effort to improve the reproducibility and robustness of animal and human nutrition research methodology.
- Greater linkage of expertise and resources in the public and private sectors to maximise value from existing public and industrial/commercial investments.
- To accelerate translation the report recommends the establishment of:
  - a nutrition network to unite the UK's leading academic and clinical nutrition research centres with clinical centres with expertise in physiology and experimental medicine. In the longer-term this might include the establishment of a Translational Research Partnership.
  - strong pre-competitive research collaborations with food and nutrition science industry (as already exist in in other European countries) to address key challenge areas. Academic – industry partnerships should be facilitated by the development of a transparent framework for engagement.
- Improvement and linkage of key infrastructure and platforms, such as national surveys and cohorts, 'omics including metagenomics, and deep phenotyping facilities and brain banks, to better support innovative nutrition research.
- Increased leadership and a more explicit role for nutrition education across health research (basic and clinical). Within the clinical context, this might include the establishment of a single professional medical body concerned with nutrition to foster the coherent development of systematic training and education, research and practice.

# Background and introduction

The Office of Strategic Coordination for Health Research (OSCHR)<sup>4</sup> in the UK asked the Medical Research Council (MRC), in partnership with the National Institute for Health Research (NIHR), to conduct a strategic review of nutrition research. The review was overseen by an expert Review Group<sup>5</sup> with the following aims:

- Provide a balanced view of the strengths and weaknesses of nutrition research relevant to human health in the UK
- Assess whether the research base is well placed to meet the current and envisaged needs of policy makers
- Identify opportunities for further interaction with the food/nutrition science industry both in the UK and globally
- Consider whether research capacity issues are being sufficiently well addressed to provide a sustainable future for nutrition research in the UK
- Formulate recommendations in a report to the OSCHR Board

## Scope of the review

Nutrition research can be defined as the study of the interaction between diet (as whole diets, dietary components, dietary patterns) and the human body at the individual (molecular through to whole-body) or population level. It covers the impact of diet, dietary pattern or food components on normal biological function, health status or the development of disease.

Building on the Cross-Council Vision for Food, Nutrition and Health research<sup>6</sup>, the review assessed the critical gaps in basic, translational and applied health research and the underpinning role of nutrition in individual health, public health and the development of disease to ensure that the available health research resources are coordinated at the strategic level. The review also considered how the UK can engage with the global food and nutrition science industry, particularly through research, to ensure that we maximise the opportunities to translate findings from nutrition science.

Although the review focused largely on UK research and infrastructure relevant to human health, it was informed by significant international activities and initiatives and opportunities for international partnering. In addition, consideration of how best to support researchers to contribute to global nutrition research was within scope.

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4. OSCHR's role is to develop a more coherent strategic approach to health research in the UK, particularly the research strategies of both the MRC and NIHR. The work of OSCHR is overseen by the OSCHR Board.

5. Chair: Professor Chris Day (Newcastle University), Deputy chair: Professor Alan Jackson (Southampton University), Members: Professors David Adams (Birmingham), Ian Charles (Institute of Food Research/Quadram Institute, Norwich), Hannelore Daniel (Technische Universität München, Germany), Sadaf Farooqi (MRC Metabolic Diseases Unit, Cambridge), Malcolm Jackson (University of Liverpool), Graham Lord (King's College London), John Mathers (Newcastle University), Peter Morgan (Rowett Institute, Aberdeen), Yolanda Sanz (Institute of Agrochemistry and Food Technology, Spain), Wim Saris (Maastricht University, The Netherlands), Christine Williams (University of Reading), Ian Young (Queens University Belfast, Northern Ireland)

6. A Cross-Council Vision for Food, Nutrition and Health Research BBSRC, ESRC and MRC March 2015

The review focused on nutrition research from a human health perspective. This focus has served to unite ‘food-facing’ and ‘health-facing’ aspects which have been treated as a continuum. The aim was to ensure that all relevant sectors were adequately supported to carry out relevant research that is both joined up and complementary. Whilst it recognised the important connections to issues of primary food production, food security, sustainability and waste, food packaging, preservation and safety, these are covered by other ongoing UK and European initiatives<sup>7</sup>.

The review did not look at behavioural science explicitly – although extremely important, this is in itself a huge research field and it would not have been possible to cover both areas in a single review. However, during the review process the interface with behavioural science remained an important consideration and a key element of the review was the ‘pull-through’ of nutrition research into policy and practice.

## The review process

The work of the expert Review Group was informed by a stakeholder workshop and written opinion pieces. The Review Group’s first meeting took place in March 2016 and it met for a second and final time in October 2016<sup>8</sup>. The review included:

- a survey of funder strategies and research portfolios in food, nutrition and health to better understand the research and infrastructure landscape of the UK
- the mapping of current and projected policy needs on to UK research capabilities to identify any significant gaps in the research base
- an exploration of the interface with key sectors of the UK and global food industry to consider how the offering to industry could be developed
- identification of the tractable challenges and how these might be met

## Key challenges and questions

Both the first Review Group meeting and the stakeholder workshop were structured around an interrelated set of key challenges and questions (details at **Annex 3**) related to four themes: research and infrastructure challenges, capability and expertise, and coordination and partnerships. These have been used as a framework to explore the strengths and weaknesses of the current UK nutrition research landscape, within an international context, and to identify key barriers and suggest potential solutions. Partnership with industry and two more cross-cutting themes: translation and global health emerged from the discussions.

## Stakeholder workshop

A two-day stakeholder workshop held on 7 and 8 July 2016 (details at **Annex 4**) formed a critical part of the review process. The meeting brought together experts from across the spectrum of research (academic, clinical and industry) and sought the community’s views on priority areas,

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7. UK: UK Global Food Security Programme -A multi-agency programme bringing together the interests of the Research Councils, Executive Agencies and Government Departments; DEFRA 25-year Food and Farming Plan – in development; European: Joint Programming Initiative: A Healthy Diet for a Healthy Life; SUSFOOD

8. Dr Alison Tedstone (National Lead for Diet and Obesity/Chief Nutritionist, Public Health England) and Professor Neena Modi (Professor of Neonatal Medicine at Imperial and President of the RCPCH) were both invited to attend the second meeting of the Review Group

taking into account current national and international initiatives and activities, opportunities, tractability, scientific, clinical and commercial relevance. The aim was to consider a broad range of views from nutritionists and experts in related fields and to encourage creative and cross-disciplinary thinking.

The interactive workshop was designed to build on the early discussions of the Review Group which took place at its first meeting in March. Short 'Key Challenges' presentations<sup>9</sup> were delivered by Review Group members, highlighting some of the key issues to stimulate constructive discussion and debate. Roundtable discussions provided an opportunity for participants to discuss the issues flagged in the presentations, or to raise any new points. For each 'Key Challenges' topic the six participant groups captured their top three challenges/issues for later presentation and discussion in open sessions.

The workshop papers included a portfolio analysis of UK nutrition research, and position statements from UK funding organisations and agencies<sup>10</sup>.

### Written consultation

National and international experts<sup>11</sup> were invited to make a short written submission (details at Annex 5) to assist the Review Group in making its recommendations to OSCHR. The written submissions received were considered by the Review Group at its second meeting and the views expressed have been taken into account in the report.

## Formulation of recommendations

Drawing upon the key outputs from the Review Group meetings, the workshop and the written consultations, the Review Group has formulated a vision for the future nutrition and human health research and set of research recommendations for consideration by the OSCHR Board. The expectation is that the report and recommendations will inform the research community, funding organisations and agencies and other stakeholders in the field.

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9. Key challenges topics were: Research challenges and opportunities; Infrastructure – current landscape and future needs; Building capability and expertise; Co-ordination and integration – partnering for success

10. Short summaries highlighting current and planned activity in relation to human nutrition research were provided by: Biotechnology and Biological Sciences Research Council (BBSRC), Department for International Development (DFID), Economic and Social Research Council (ESRC), Innovate UK, Public Health England (PHE), The British Heart Foundation (BHF), The Medical Research Council (MRC), The Wellcome Trust (WT), World Cancer Research Fund (WCRF)

11. Identified by the Review Group and funding organisations and agencies

# Nutrition for public health and clinical care – key considerations

## The nature of nutrition

It is clear that the term ‘nutrition’ means different things to different people. For the purpose of this review the following definition has been adopted<sup>12</sup>:

Nutrition is the set of integrated processes by which cells, tissues, organs and the whole body acquire the energy and nutrients for normal structure and function, which is achieved at body level through dietary supply, and the capacity of the body to transform the substrates and cofactors necessary for metabolism.

Diet, metabolic capacity, body composition and level of demand for energy and nutrients are all influenced by levels of physical activity and can vary according to different physiological and pathological or disease states.

Human nutrition represents an understanding of the nature and interaction of two major systems: one internal and one external. The external is represented by the food system and concerns the complicated factors that determine human ability to source, from the wider environment, a complete diet providing adequate energy and nutrients. It embraces the world created by the family and community and incorporates the complex social systems and interactions that influence lifestyle choices. The internal is represented by the body’s regulated biochemical, physiological and metabolic processes which together create an internal environment in which cells, tissues and organs can maintain their structure and function to ensure ongoing health. Health is enabled and protected when the two systems operate in balance and harmony.

## Nutrition across the life course

Healthy nutrition and growth is a complex subject. Nutritional requirements (both maximum and minimum) may vary according to factors including age, sex, body weight, genotype, level of activity, physiological status (eg growth, pregnancy and lactation) and the presence or absence of disease. During the early years of life nutritional needs are constantly changing and a growing body of research indicates that optimum nutrition, from preconception through to adulthood and later life, plays a key role in lifelong health including in healthy ageing. Thus, from preconception through to adulthood, nutrition is able to impact positively or negatively on the individual and population trajectories for health and disease.

The quality of human development and growth, as well as the quantity of growth is important. In her 1970 paper in *The Lancet*, “Harmony of Growth”<sup>13</sup>, Elsie Widdowson drew attention to the importance of pace and proportion, and the partitioning of nutrients to ensure normal growth and body composition and the appropriate proportions of lean and fat mass. This suggests that the energy in-energy out model is insufficient and incomplete. Both the quality (carbohydrate, lipid

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12. Adapted from Cancer and Nutrition NIHR infrastructure collaboration. Summary report of Phase One. July 2015

13. Widdowson, E. M. (1970) The harmony of growth. *The Lancet* i:901-905

[essential fatty acids], amino acids, minerals, vitamins, trace elements, water, oxygen) and quantity (energy from macronutrients, carbohydrate, lipid [fat], protein) of nutrients is important for ensuring optimal healthy growth and maximum functional capacity. Further, nutrition is not simply a matter of diet (energy, macronutrients, vitamins, minerals etc.) but must take into account physical activity (which sets demand for intake) and stressors and underlying pathology (physical, behavioural, social), which modulate nutrient availability and handling.

Imbalances are indicated through final common pathways which lead to structurally abnormal body composition; either underweight and inanition<sup>14</sup> or overweight and obesity. These markers of state and process are of clear value in population studies. More subtle changes in functional characteristics are less well determined, other than for example as poor glucose homeostasis or hyperlipidaemia, but are critical for the best quality clinical practice.

Good nutrition is not simply the absence of nutrient deficiencies, but defining the appropriate intake for growth and development across the life course, including immune development and function. Nutritional status has been shown to play a key role in relation to important physiological processes such as mucosal integrity and barrier function (eg respiratory, gastrointestinal), cognitive function and immune response, as well as immune disorders, chronic inflammation, frailty, sarcopenia and ageing, and cognitive decline. Nutritional status can also affect resilience, susceptibility and response to therapy – for example, body mass index (BMI) and obesity can affect the body's response to antiviral drugs. It is not surprising, therefore, that poor nutritional status, caused by either an unhealthy diet or malabsorption of nutrients, is a major risk factor for many chronic diseases.

## The public health challenge

Poor diet is a leading cause of ill-health worldwide. Whilst the number of people globally who are undernourished has fallen in the last decade, around 795 million still do not have access to adequate food to meet their nutritional needs<sup>15</sup>. Conversely, dramatic changes in consumption (both food and drink) and physical activity patterns across the globe over the past several decades has challenged physiological homeostasis and led to major shifts in body composition. Whilst a global trend towards an increase in height and weight is generally desirable, an increase in weight achieved before an increase in height can lead to an increase in childhood overweight and adiposity and also an increased risk of shortness/stunting and obesity. The double burden of childhood undernutrition and adult-onset obesity in transitioning societies in particular presents a significant public health challenge.

### Diet quality

Poor nutrition (both under and over nutrition) is not confined to developing or transitioning economies but also affects high income, industrialised countries. Despite well-publicised dietary guidance, data obtained from the National Diet and Nutrition Survey (NDNS) years 1-4 (2008/09-2011/12)<sup>16</sup> has indicated that the average diet in the UK is not in line with current advice.

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14. exhaustion caused by lack of nourishment

15. The State of Food Insecurity in the World 2015 Food and Agriculture Organisation of the United Nations; International Fund for Agricultural Development and World Food Programme

16. NDNS results from years 1-4 combined of the rolling programme for 2008 and 2009 to 2011 and 2012: report A survey carried out on behalf of Public Health England and the Food Standards Agency May 2014

In particular:

- Oily fish consumption was below recommendations in all age groups.
- Only 9% of children and 30% of adults (19-64 years) met the recommendation of consuming at least five portions of fruit and vegetables each day.
- Inadequate iron intakes in nearly half of teenage girls and a quarter of adult women, with evidence of low iron stores and iron deficiency anaemia in 5% of girls and 3% of women.
- In 8% of 11-18 year old girls folate intake from food sources was below the Lower Reference Nutrient Intake.
- There was evidence of an increased risk of vitamin D deficiency (which is obtained both from skin synthesis and from the diet) in all age/sex groups.

After smoking, diet is the major modifiable risk factor for cancer<sup>17</sup>, with 30-35% of cancers being attributed to poor diet<sup>18</sup>. It has been estimated that 70,000 premature deaths in the UK could be avoided each year if UK diets matched nutritional guidelines<sup>19</sup>.

The UK faces a double disease burden caused by dietary excess and imbalance and by nutritional deficiencies. Diet quality is poor across age groups and genders leading to serious public health problems such as obesity, diabetes and also malnutrition.

### Obesity and overweight

The proportion of people who are obese or overweight has risen significantly in recent years. In England, this increased from 53.1 per cent in 1993 to 62.15% in 2013-14<sup>20</sup>. Being overweight or obese increases the risk of high blood pressure, type 2 diabetes, stroke, coronary heart disease and several cancers<sup>21</sup>.

### Deficiency and malnutrition

Vitamin and mineral deficiencies, including iron, folate and vitamin D, are common and contribute to diseases such as osteoporosis, which affects more than three million people in the UK<sup>22</sup>. Over three million people across the UK (the majority living in the community) are either malnourished or at risk of malnutrition. Of these, over one million are over the age of 65. Recent studies in individuals of over 90 years old suggest that around 50% suffer from malnutrition and this population group is rapidly growing.

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17. World Cancer Research Fund (2014) Preventability estimates. <http://www.wcrf-uk.org/uk/preventing-cancer/cancer-preventability-statistics>

18. Anand P et al. Cancer is a Preventable Disease that Requires Major Lifestyle Changes. *Pharm Res.* Sep 2008; 25(9): 2097-2116.

19. Strategy Unit. Food matters: towards a strategy for the 21st century. London: The Cabinet Office, 2008.

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## Interplay with physical activity

Although not the main focus of this report, the crucial link between nutrition, physical activity levels<sup>23</sup> and health cannot go unmentioned. Physical inactivity is the fourth leading cause of global mortality<sup>24</sup>, being linked to cancers, heart disease and diabetes. The World Health Organization estimates that around 3.2 million people die each year because of physical inactivity<sup>25</sup> and in the UK physical inactivity directly contributes to one in six deaths<sup>26</sup>. In 2014 Public Health England cautioned that half of women and one-third of men were damaging their health through insufficient physical activity<sup>27</sup>.

## A perfect storm

A systematic analysis of changes in health in England between the years 1990–2013 has indicated that the combination of unhealthy diets, physical inactivity, and high BMI is the biggest overall contributor to disability-adjusted life-years (DALYs). Important metabolic risks, including high blood pressure, high fasting plasma glucose, low glomerular filtration rate, and high cholesterol, overlap significantly with modifiable behavioural risk factors, such as diet and physical activity<sup>28</sup>. The financial costs are enormous. In the UK, poor diet related ill-health costs the NHS an estimated £5.8 billion each year and physical inactivity around £900 million<sup>29</sup>.

Analyses of large-scale prospective studies with prolonged follow-up generally indicate that underweight, as well as both overweight and obesity, are associated with increased mortality. Above 25 kg/m<sup>2</sup>, BMI is strongly positively related to coronary heart disease, stroke and respiratory disease mortality, and moderately positively related to cancer mortality. Underweight is associated with substantially higher respiratory disease mortality and somewhat higher mortality from coronary heart disease, stroke, and cancer<sup>30</sup>. The associations of both overweight and obesity with higher all-cause mortality are broadly consistent across four continents<sup>31</sup>.

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23. Impact of physical activity and diet on health March 2015 House of Commons Health Committee

24. World Health Organization [http://www.who.int/features/factfiles/physical\\_activity/en/](http://www.who.int/features/factfiles/physical_activity/en/)

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29. Scarborough P et al (2011). The economic burden of ill health due to diet, physical inactivity, smoking, alcohol and obesity in the UK: an update to 2006–07 NHS costs. *J Public Health*. doi: 10.1093/pubmed/fdr033

30. There is a possibility that reverse causality and confounding might at least partly explain these findings

31. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents The Global BMI Mortality Collaboration *The Lancet* published online 13 July 2016.

DOI: [http://dx.doi.org/10.1016/S0140-6736\(16\)30175-1](http://dx.doi.org/10.1016/S0140-6736(16)30175-1)

## Clinical nutrition

The provision of adequate nutritional support is vital for those with acute or long term health conditions, whether during treatment, recovery or palliative care. Those in need of special nutrition may include patients with poor appetite, dysphagia, malabsorption, chronic disease, frailty, learning disabilities, or poor cognitive function. Malnutrition is a serious condition which affects adults and children in all care settings (including hospitals, care homes and mental health units), pre-disposing to disease and delaying recovery from illness. Those at risk of malnutrition comprise 25-34% of hospital admissions, 30-42% of patients admitted to care homes, and 18-20% of patients admitted to mental health units<sup>32</sup>. The estimated cost (public health and social care) of malnutrition in adults and children in England in 2011-12 was £19.6 billion. If addressed correctly through high quality nutritional care, health and social care savings of between £172 and £229 million per annum have been estimated<sup>33</sup>.

## Supporting translation

The tendency to unhealthy lifestyles must be reversed as swiftly as possible. Long term, sustainable change will require a range of measures and will only be achieved through the active engagement of schools, communities, families and individuals<sup>34</sup>.

There is a need to consider diet and dietary patterns in a holistic way rather than at the level of individual (macro-)nutrients. Further, nutrition is one of many life course exposures, including biological, physical, social, and behavioural factors, and so the landscape is complex and will require sophisticated methods of data analyses to dissect individual and combined causative influences. The complexity is further increased by the need to translate findings from laboratory and controlled environments into day-to-day real world or clinical settings. A strong evidence base, therefore, is essential to improving population health across the life course.

The emerging knowledge of nutritional science can play an important role in informing public health programmes, policies, and clinical management and health service delivery. A more complete understanding of the physiological effects of nutrients and dietary patterns will better inform optimal nutritional care and disease prevention or management through diet. As pointed out in 'A Cross Council Vision for Food Nutrition and Health'<sup>35</sup>, 'mechanistic understanding of the relationships between diet and health will serve to underpin evidence for robust dietary guidelines, and a move towards better targeted advice which takes into account the biological and behavioural determinants of food intake. This is particularly important during critical phases of development and for groups whose dietary practices make them vulnerable to adverse health outcomes.'

A more detailed understanding of the role of diet, dietary patterns and individual nutrients in health and disease will also drive the development of healthier food products as well as novel therapeutic nutritional interventions to support differing healthcare needs.

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32. British Association for Parenteral and Enteral Nutrition website: Introduction to Malnutrition last updated 22 February 2016

33. The cost of malnutrition in England and potential cost savings from nutritional interventions 2015 Marinos Elia on behalf of the British Association for Parenteral and Enteral Nutrition and the NIHR Southampton Biomedical Research Centre

34. Childhood Obesity A Plan for Action August 2016 HM Government

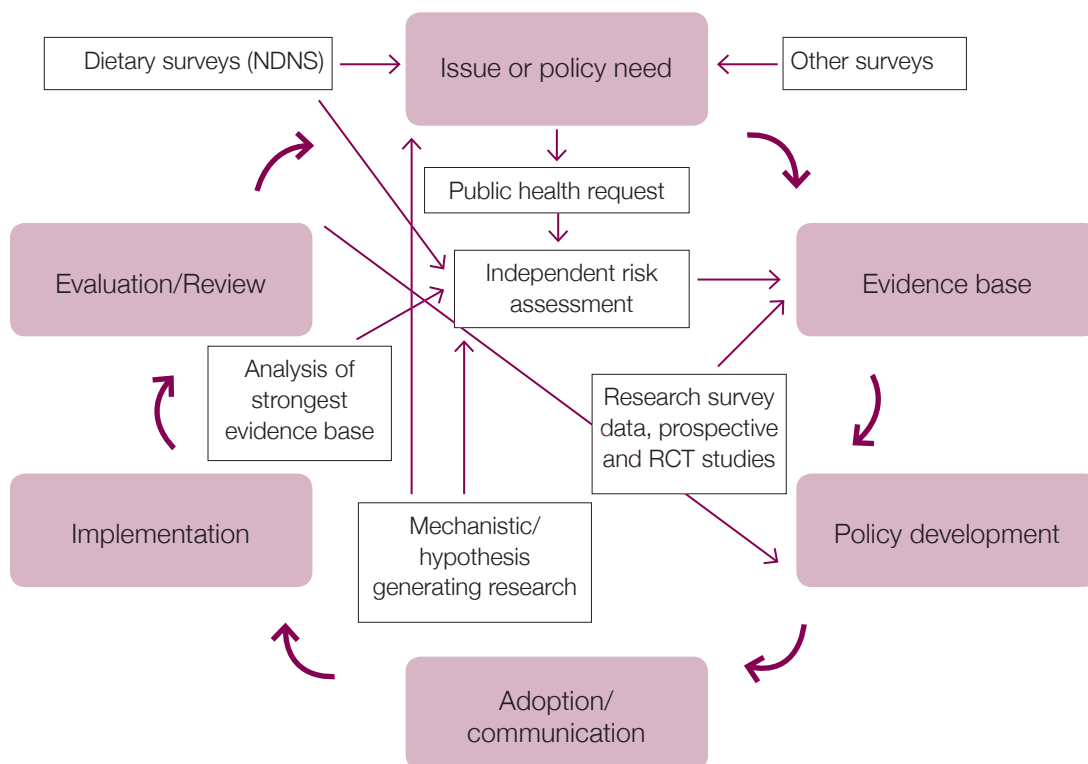
35. A Cross Council Vision for Food Nutrition and Health March 2015

## Informing policy formation

Important policy decisions need to be supported by robust impartial evidence if they are to command respect, acceptance and support. The policy formation process draws on multiple sources of evidence and the complex issues require the development of comprehensive frameworks/models to be developed. It is also reliant on a sustainable and enduring foundation of relevant multi disciplinary and cross-sector expertise.

Challenges in implementing and delivering policies such as reduced sugar intake arise due to the complex relationship between taste/palatability, marketing, behaviour, product sales and profit margins; there is a need to determine the appropriate balance between nudge and legislation to maximise policy impact on health.

**Figure 1: Nutrition research and the policy cycle**



Schematic: Courtesy of Dr Alison Tedstone (Public Health England)

# Main review findings

A summary of the review findings are set out below under four themes: research and infrastructure challenges, capability and expertise, and coordination and partnerships. Although these have been used as a framework to explore the strengths and weaknesses of the current UK nutrition research landscape, the areas are strongly related and highly interdependent. The report also includes a section on partnership with industry and sections on two more cross-cutting themes: translation and global health. These have been distilled from the discussions and written consultations and are sufficiently important to warrant sections in their own right.

Despite the UK's impressive track record in nutrition research there is a general perception that the UK is moving towards a critical point in relation to nutrition research capacity, capability and training, as well as clinical delivery. Urgent action is required to ensure a robust future for the field.

Although a significant part of the review focused on the current position of nutrition and human health research in the UK, international participants confirmed that a similar picture exists in Europe – particularly in The Netherlands, Germany and Spain. Further, the recent report and research roadmap to guide federal nutrition research in the USA<sup>36</sup>, indicates that many of the issues raised in the report are comparable to those being faced in the UK and Europe.

This review provides an opportunity to look forward and present a future strategic vision for UK nutrition and health research over the next 10 years, as well as recommending actions which will lay down the foundations for revitalising the field.

## Future vision

Presented below is a high level strategic vision for UK nutrition and health research over the next decade. The key points are drawn from the review findings which are set out below in later sections of the report.

The vision is by nature broad and ambitious and focuses on scientific opportunity. It envisages a revitalised field which fully capitalises on the immense potential of the expertise and resources (both public and private) in the UK, thereby maximising the translation of research to improve human health and well-being, both nationally and globally.

### A high-profile and re-energised field

- Nutrition viewed as a rigorous and exciting interdisciplinary field capable of attracting bright young scientists (genetics/genomics as an exemplar for raising the profile of the discipline)
- Ability to identify and address the important research and public health challenges, supported by networked, cutting edge research infrastructure (cohorts, databases, experimental facilities)

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36. Interagency Committee on Human Nutrition Research. *National Nutrition Research Roadmap 2016–2021: Advancing Nutrition Research to Improve and Sustain Health*. Washington, DC: Interagency Committee on Human Nutrition Research; 2016.

- A more explicit role for nutrition education across health research (basic and clinical)
- Outreach to other disciplines and –ologies (reflecting the cross-cutting relevance of nutrition) to bring fresh perspectives and methodologies
- A systems approach to research relating to health and the development and management of disease in which nutrition is embedded as a vital component
- Ability to respond in a flexible and agile way to new challenges as they arise and to ensure the field remains forward looking and at the leading edge
- Improved professionalism and standing, clear career pathways and opportunities for progression

### Critical linkage

- Critical mass of well-linked world-class groups/units able to provide a focus for high quality rigorous multidisciplinary, integrative nutrition research and training
- Defined key challenges, a focus on strengths and the development of infrastructure (new and/or better linked) which is strategically aligned to these. Ensuring the most appropriate facilities are available and easily accessed.
- New and improved tools and rigorous and standardised methodologies

### Effective coordination and partnering

- Effective partnerships (multidisciplinary and cross-sector, national and international) with well-defined aims and measurable outputs
- Improved (confident and transparent) partnerships with industry (food, diagnostics and healthcare nutrition) to facilitate translation to improve the health of the public and clinical practice

### Leadership

- Improved high level leadership and greater visibility
- Funders working together across sectors to shape the UK landscape through strategic engagement with relevant organisations and the provision of focused investments to re-invigorate the field
- Creation of nutrition as a clinical specialty with recognised leadership

## Research

### The UK nutrition research landscape

The food research and innovation landscape in the UK is complex. Funding for food, nutrition and health research is provided by a variety of government departments, public bodies, charities, the UK Research Councils and Innovate UK, operating in England, Scotland Wales, and Northern Ireland, all of which have their own priorities and strategies.

There is no single national strategy for nutrition and human health research – currently this relies on coordination and partnership by the individual funders, government departments and agencies. To date there has been some coordination via broader strategies for food and innovation<sup>37</sup>, and also the 2015 Cross-Council Vision for Food, Nutrition and Health.

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37. UK: UK Global Food Security Programme -A multi-agency programme bringing together the interests of the Research Councils, Executive Agencies and Government Departments; DEFRA 25-year Food and Farming Plan – in development;

## UK funding for nutrition and human health research

Research and infrastructure relevant to nutrition and human health is supported by a range of UK funders including the UK Research Councils (MRC, BBSRC, and ESRC), government departments and agencies (Department of Health, National Institute for Health Research, Public Health England, Food Standards Agency, Food Standards Scotland, Scottish Executive, Innovate UK), charitable organisations (Wellcome, Cancer Research UK, British Heart Foundation, World Cancer Research Fund) and industry.

A high level analysis of the UK funding has been provided in **Annex 2**. At 1 January 2016 the total value of live awards (whole life values<sup>38</sup>) across the funders included in the analysis was in excess of £265m<sup>39</sup>.

### Key messages

The analysis indicated that the MRC, NIHR, BBSRC and Wellcome are the major funders in this area. The largest proportion of funding was for grant awards, followed by research undertaken in units and institutes, and then training awards. With the exception of Public Health England funding for the National Diet and Nutrition Survey, the awards submitted and analysed did not include support for significant national research infrastructure. An analysis of the awards live on 1 January 2016 against the UKCRC Health Research Classification – Research Activity categories demonstrated that: over 50% of the funded work is looking at the cause of ill-health/disease (31%) or the prevention of disease (22%), followed by underpinning research looking at the normal state (18%), and the development of treatments (12%). The evaluation of treatments (9%), management of diseases (3%) and health and social care research (1%) received much smaller amounts of funding. It is quite possible however, that a large number of small studies funded by NIHR and other government funders have not been captured and analysed, particularly if awards are made using a more distributed and locally administered approach.

Existing MRC and Wellcome investments are largely focused on either mechanistic research or on population science and public health aspects of obesity/diabetes. There is scope, therefore, for further experimental medicine research, including high quality, small-scale studies in well-defined healthy, at risk, or clinical groups. The live portfolio analysis also shows that there is scope for increased work on the development and evaluation of interventions for disease prevention or management. An additional data gathering and analysis undertaken by NIHR in September 2016 has identified an extensive and wide pattern of clinically relevant nutrition-related research being supported by NIHR.

Overall, the analyses have indicated that there is a significant amount of nutrition related research being undertaken across a broad range of relevant contexts. Although there have been some cross-funder initiatives in recent years there are clearly opportunities for bringing greater coherence and complementarity to the nutrition-related research that is presently supported. A more top-down coordinated approach to funding, alongside response mode, could ensure that the UK investment in research and infrastructure is better organised leading to greater efficiency and effectiveness.

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38. The whole lifetime value of an award eg a 3-year project with an annual budget of £100k would have a whole life value of £300k.

39. With the exception of Public Health England funding for the National Diet and Nutrition Survey, this figure does not include support for significant national research infrastructure

## European funding

The information below provides some indication of the current level of European nutrition and food related funding. Due to the broad nature of European thematic research and innovation programmes, however, it is not easy to find published statistics related solely to nutrition or nutrition and health research funding. It should be noted therefore, that the figures provided below cover areas broader than nutrition and health research.

### European Research Council (ERC)

The European Research Council (ERC) was established by the European Union in 2007. It has a budget of over €13 billion for the period 2014 to 2020 and is part of the EU research and innovation programme, Horizon 2020. In all, about 140 ERC projects over the past decade have been or are related to food and nutrition research, totalling nearly €250 million<sup>40</sup>.

### Horizon 2020

The EU's framework programme for research and innovation, Horizon 2020, invests €3.851 billion on research on food security, sustainable agriculture, marine and maritime water research and the bioeconomy<sup>41</sup>.

### EU funding for food, nutrition and agriculture from 2007 to 2015<sup>42</sup>

The EU contribution to projects related to food, nutrition and agriculture from 2007 to 2015 total €3095 million for selected parts of Framework Programme 7<sup>43</sup> (2007-2013) and €1249.6 million for selected aspects of Horizon 2020<sup>44</sup> (2014-2015 calls).

### Joint Programming Initiative 'A Healthy Diet for a Healthy Life'

The JPI 'A Healthy Diet for a Healthy Life' (JPI HDHL) is a European initiative which focuses on research in the area of food, nutrition, health and physical activity. Its aim is to help prevent or minimise diet-related chronic diseases. JPI HDHL's membership comprises 26 countries with representatives from Ministries of Health, Agriculture, Food, and Research & Science. JPI HDHL has launched 11 different joint funding activities – a mixture of international research networks and research projects, as well as investing resources in activities related to research policy, data management/sharing and science dialogue. Funding is provided by the partner countries and includes co-funded calls with the European Commission under the ERA-NET funding instrument. Funding committed to date is in the region of €34m.

### US funding<sup>45</sup>

The NIH leads all federal agencies in funding nutrition research and training. The total NIH investment in nutrition research was approximately \$1.5 billion in FY 2013 and \$1.6 billion in FY 2014<sup>46</sup>. As a percentage of total NIH spending, nutrition research spending across FY2010-FY

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40. <http://www.sciencesquared.eu/news/new-online-report-launched-erc-funded-food-research>

41. European Union at Expo 2015 Factsheet

42. European Research & Innovation for Food & Nutrition Security. FOOD 2030 High-level Conference background document, European Commission European Union 2016

43. Theme 2 in FP7; European Research Council in FP7; Marie Curie Actions in FP7

44. Societal Challenge 2 in H2020 (including bioeconomy domains and food system components); European Research Council in H2020; Marie Skłodowska-Curie Actions in H2020

45. The United States federal government's fiscal year is the 12-month period ending on 30 September of that year, having begun on 1 October of the previous calendar year

46. NIH Nutrition Research Report 2013 & 2014 Across all NIH institutes and centres, projects categorized as nutrition are also likely to be categorized as prevention, obesity, and clinical research



2014 has been fairly stable at approximately 5%. The NIH nutrition research program includes extramural and intramural research as well as research training. The following NIH institutes and centres (ICs) supported the most nutrition research: the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), the National Heart Lung and Blood Institute (NHLBI), and the National Cancer Institute (NCI).

The United States Department of Agriculture (USDA) spends around \$115m a year on its nutrition programme. The USDA supports nutrition research through the Agricultural Research Service (ARS) Human Nutrition National Program at several locations in the US. The program defines the role of food and its components in optimising health throughout the lifecycle for all Americans by conducting high national priority research.

## UK nutrition research strengths

### Existing nutrition specific expertise

UK strengths in relation to nutrition and health research lie in the study of early life nutrition and its impact on later health outcomes, understanding diet and health interactions, nutrition and ageing, international (global) nutrition, and diet/gene interactions. Underpinning this is expertise in epidemiology, genetics, molecular biology, immunology and infection, biochemistry, micronutrient research and national surveys of health, dietary monitoring and food consumption (where the Public Health England funded National Diet and Nutrition Survey is a key resource), and nutritional status.

A recent analysis of publications in the years of 2007-2013 for the field of nutrition research<sup>47</sup> has indicated that England tops the European rankings, in terms of number of publications as well as overall citations. Over 4,800 papers were published in the “nutrition & dietetics” journals between 2007 and 2013, with at least one author from an English laboratory; up until April 2013 they were cited almost 109,000 times in total. Spain, Italy, Netherlands, Germany and France were ranked in positions 2-6, with Scotland and Ireland in 14th and 15th place in the table. When compared to the United States, European nutrition research had a higher output and more citations but the citation-per-article ratio was greater for the US. It should be noted however that the comparison of individual countries was restricted to an analysis of expert journals listed in the subject category “Nutrition & Dietetics” of *SCImago* and Thomson Reuters’ *Web of Science*. *Web of Science* does not facilitate the automatic extraction of relevant nutrition research articles from the multidisciplinary journals, meaning that some high profile papers in the field have been omitted from the analysis of publications/citations by country. In addition, the breadth of the topic is likely to mean that some relevant papers are omitted from the analyses. Despite the limitations the analysis provides a useful comparison of the relative productivity of the countries in nutrition research.

### The UK nutrition research landscape

The UK conducts very good to excellent (leading) nutrition research in individual centres and by individual scientists. These include<sup>48</sup>: nutritional epidemiology and large cohort studies (Cambridge, Southampton, Leeds, University of East Anglia [UEA], Oxford, Bristol); obesity, diabetes, lipidomics and metabolomics (Cambridge, Rowett Institute/University of Aberdeen, Manchester, Oxford, Imperial College London [ICL]); diet and developmental programming (Southampton, King’s College London [KCL], London School of Hygiene and Tropical Medicine [LSHTM], Cambridge, Rowett Institute/University of Aberdeen, Nottingham, Newcastle and Queen’s University Belfast [QUB]);

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47. Nutrition Research Publication Analysis 2007-2013 by Kathleen Gransalke, Labtimes March 2016

48. The list is illustrative and is not intended to be exhaustive



nutrition, ageing and systems biology (Newcastle and Liverpool); metabolism, chrono-nutrition, sleep, biorhythms (Surrey, Aberdeen, Reading and Newcastle); design and conduct of large-moderate scale controlled dietary interventions in free living settings (Aberdeen, KCL, ICL, Newcastle, QUB, Reading, Surrey); international (global) nutrition (Cambridge, Southampton, LSHTM/London and Sheffield; MRC Unit in The Gambia – bases in Keneba and LSHTM); flavonoids and bioactives (Reading, UEA and the Institute of Food Research [IFR]/Quadram Institute, Leeds, QUB); food composition data bases (IFR/ Quadram Institute); microbiome and gut health (Rowett Institute/University of Aberdeen, Reading, IFR/Quadram Institute, KCL and ICL); micronutrients – once a UK strength but expertise is now diminished, although some activity remains in Cambridge, UEA and Ulster.

Major MRC investments in life course growth/nutrition, epidemiology, obesity and metabolic research and related areas include the MRC Gambia Unit International Nutrition Group (Keneba/LSHTM), MRC Lifecourse Epidemiology Unit (Southampton), MRC Unit for Lifelong Health and Ageing (UCL, London), MRC Integrative Epidemiology Unit (Bristol), MRC Metabolic Diseases Unit and MRC Epidemiology Unit (both Cambridge) and the MRC/CSO Social and Public Health Sciences Unit (Glasgow). NIHR currently funds Biomedical Research Units (BRU) which include diet, lifestyle and physical activity at the Universities of Leicester and Loughborough, a BRU in nutrition at Bristol, a BRC in Nutrition, Growth and Development at Southampton, and BRCs covering obesity, diabetes and metabolic medicine at Imperial College and Oxford. Cambridge, Imperial, Oxford, UCL, Southampton, Bristol and Leicester have all received renewed funding as part of the recent NIHR BRC competition<sup>49</sup>.

## **Barriers to progression**

### **Leadership and fragmentation**

Despite areas of strength, the nutrition community overall is fragmented, spread thinly and lacking in critical mass. Pockets of excellence exist but these are not well connected to basic science, food science (where appropriate), industrial interests (whether food or healthcare nutrition), or well embedded within disease disciplines. The lack of leadership and high level strategy at a national level has led to suboptimal activity in key research areas and coordination in the “food-nutrition-health” space, resulting in slower progress and lower impact than might have otherwise been expected.

### **Integration**

Nutrition research is not well integrated into most clinical specialities or across research disciplines. This is a missed opportunity as nutrition is a crucial and potentially treatable complication of many diseases such as chronic inflammatory disease and cancer, as well as ageing.

### **Lack of experimental rigour**

It has been proposed that due to a number of factors (eg academic competition, suboptimal training and expertise, institutional, and economic factors) there has been a general decrease in good research practice and scientific rigour in the last few years. Whilst this is difficult to confirm or refute, there is a general perception, from within and outside of the nutrition research community, that this applies to the field of nutrition and metabolic research. Some common reasons for errors in nutrition research, flagged as part of this review process, are outlined below and are also discussed in more detail in an article by Professor David Allison and colleagues<sup>50</sup>:

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49. DH news story: <https://www.gov.uk/government/news/new-816-million-investment-in-health-research>

50. Insufficient expertise leading to poor study design David B Allison et al. 2015 <http://journal.frontiersin.org/article/10.3389/fnut.2015.00026/full>

### **i) Poor reproducibility**

There are significant issues relating to reproducibility and a lack of incentives for national and international standardisation efforts.

The absence of clearly defined and well-validated and internationally agreed measures and standard operating procedures for various aspects of nutrition is a major obstacle for the field. Whilst there is some work in this area, it has been pointed out that nutrition has fallen behind other related fields (eg psychology, physical activity, health-economics) where there are methodologies for measurement and a clear recognition of academics who work this area.

Nutrition experiments often lead to the creation of artificial experimental realities and inconsistencies in assessing nutrition at the whole organism and cellular level. Insufficient attention is given to the differences in metabolism between species (mouse, rat and human), or the differences in constituents of experimental diets which must be clearly specified. For example, when comparing the effects of chow with a high-fat defined diet, the effects of the dietary fat will be confounded by the effects of other components that differ between the diets<sup>51</sup>. Heterogeneity of the gut microbiome (whether inherent or caused by external influences such as the effect of different diets) can lead to different experimental outcomes<sup>52</sup>. Differences in analytical methods can also lead to variation in results where none should exist<sup>53</sup>, emphasising the need for uniform standard operating procedures.

### **ii) Insufficient expertise leading to poor study design**

Whether due to a general lack of investigators entering the field, suboptimal training and expertise or everyday familiarity with aspects of those topics which is mistaken for expertise<sup>50</sup>, traditional areas of nutrition expertise strength are decreasing in the UK and across Europe. As a result, resources, time and effort may be wasted on inappropriate study design (including poor statistical design and analysis), or research that is not probative for the questions asked and fails to meaningfully advance knowledge. A good deal of work is undertaken in humans across the UK but this is of variable quality and intensity. There is an overreliance (as opposed to reasonable reliance) on observational studies, and observational studies of weak design. In general, there is a lack of high quality experimental medicine/physiology studies and nutritional interventions far too often fail to take account of the need to control variables other than the nutrient or food under investigation. This reflects lack of deep expertise in dietary design and food composition as well as ability to reformulate experimental foods in order to achieve the required degree of control of the dietary variable under investigation. In addition, well-controlled and powered dietary intervention studies of acceptable length are extremely expensive, similar to drug trials.

Anthropometric measures such as BMI (or other more sophisticated methods) are necessary and valuable as markers of nutritional risk or ill-health for population studies or for the purpose of individual screening. However, they are insufficient for the (necessary) understanding of the mechanisms or the processes that underlie the patho-physiology of any specific disease. The integrity of the biological systems within which nutrients operate to enable adequate control, regulation and balance for cellular and intermediary metabolism is seldom explored in any detail, even though this integrative systems approach is required for an accurate and precise diagnosis in clinical practice and then effective stratified intervention.

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51. Warden CH and Fiser JS Comparisons of diets used in animal models of high fat feeding *Cell Metab.* 2008 Apr; 7(4): 277. doi: 10.1016/j.cmet.2008.03.014

52. Laukens D et al. Heterogeneity of the gut microbiome in mice: guidelines for optimizing experimental design *FEMS Microbiol Rev.* 2016 Jan; 40(1): 117–132. doi: 10.1093/femsre/fuv036

53. Hiegeist A Reischl U Multicenter quality assessment of 16S ribosomal DNA-sequencing for microbiome analyses reveals high inter-center variability. *Int J Med Microbiol.* 2016 Mar 21. pii: S1438-4221(16)30020-0 DOI:10.1016/j.ijmm.2016.03.005

### **Challenges of the field and the perceived need for ‘quick wins’**

Disease aetiology involves both genes and environment but a large focus of the research effort has been on genes and genetic studies, as these are perceived as easier to undertake and more likely to lead to publications in high impact journals. Studies on diet and nutrition are more complex, hard to control (dietary intake is very hard to determine particularly in real life settings with greatest risk being bias and under reporting), and more difficult to perform well. This is coupled to the lack of incentive to undertake more challenging transdisciplinary research, driven by the desire for ‘quick wins’ and a research culture driven by H-index, publications, citations etc (although it is recognised that this issue also affects other areas of science). Academic impact is important but often there is a bias towards media engagement rather than policy impact. Pressure to publicise research findings prematurely, often single studies, is driven by the career progression system and a desire to raise the profile of the host organisation, or by the journal itself which may be competing in a crowded market.

### **Opportunities**

#### **Build on what we have**

The UK has an impressive track record in nutrition research but that this could be further strengthened if the breadth of nutrition-related scientific expertise across the UK (epidemiology, food, biomarkers etc) was more integrated and connected. Nutrition centres should focus on specific research areas in order to increase the level of expertise and collaborate with other institutes to cover the broad range of nutritional topics at the highest scientific level. Nutrition researchers in universities can provide leadership to embed nutrition training into the curricula across a range of subjects and disciplines.

#### **Address research grand challenges (as identified at the workshop)**

The review identified a number of research grand challenges, representing areas of fundamental importance to the field which, if addressed, could lead to significant advances in public health and healthcare (see **Box 1**).

#### **Capitalise on, and strengthen, emerging research areas**

The review identified a number of research areas (similar to those identified in the BBSRC, ESRC and MRC Cross Council Vision for Food Nutrition and Health) which provide opportunities for multidisciplinary investigation and underpin the grand challenges (examples are listed in **Box 2**).

Other areas include:

- The opportunity to link and enhance nutrition and neuroscience research by linking brain samples to appropriate clinical data (eg blood metabolites, MRI and body composition).
- An increase in big data approaches to link cohorts, national diet surveys and clinical data/health outcomes in meaningful ways. Population genetics, epigenetics, and other ‘omics’, have the potential to advance understanding in nutritional science. It should be recognised, however, that results from ‘omics’ technologies are best combined with other clinical outcome measures. Linking biological data to both exposure and phenotype will improve clinical applicability and translation to improve health outcomes.
- Exciting opportunities offered by ‘citizen science’. The use of shopping loyalty cards and new mobile technologies (eg apps) and other web-based tools will make it easier to undertake large scale studies where the participants input the data, although concerns about data quality were voiced. This area should serve to unite disciplines eg nutrition scientists, bioinformaticians, engineers etc, as well as offer opportunities to consumers for personal healthcare management.
- The development of new technologies such as quantitative food intake measurements, sensory science with MRI, digital phenotyping, non-invasive measurements and personal “smart devices” to register and store individual health and nutrition-relevant data.

## Nutrition research grand challenges (Box 1)

### Complexity of growth and relationship with health and disease

Improved understanding of the relationship between achieved height, weight, metabolic characteristics and the predisposition to, and development of, disease and the role played by nutrition. *To what extent does altered body composition act as a disease marker and at what stage does it become a specific pathology that requires intervention?*

### Maximising human potential through nutrition

Combining nutrition with other lifestyle factors, to achieve optimal growth and development and delaying frailty and sarcopenia

- **Role of nutrition in brain development and ageing**

Understanding how nutrition can support good cognitive function and mental wellbeing and maintain this into later life

Other initiatives are ongoing (eg EU Joint Programme – Neurodegenerative Disease Research, EU Human Brain Project, US BRAIN Initiative) but the UK could ensure that nutrition was at the heart of the research effort in this area

- **Role of nutrition in the maintenance of health, resilience to disease, response to treatment and recovery from illness/disease**

*What role does nutrition play in the functionality of the microbiome and the immune system?*

### Metabolic homeostasis and the biology of transition

- **Obesity**

A key challenge given economic and related health consequences (eg diabetes, cancer) but can also serve as a way in to tackling other important questions concerning the complex interplay between nutrition and growth (weight and height) and the pathways in health and the development of disorders ie the biology of transition. Nutrition is only one part of the obesity jigsaw and a more holistic and broad approach to tackle sedentary behaviour and ‘obesogenic’ environments is required to make effective inroads into addressing the issue.

- **Prevention of weight gain**

Defining the healthy phenotype over the life course.

Appetite and metabolic settings in early life and the role of nutrition in pathophysiology and movement away from homeostatic norms. Mechanistic understanding to improve the feasibility and success of dietary interventions.

## Research opportunities (Box 2)

Examples of research areas which should be capitalised on and strengthened:

### Molecular/cellular nutrition:

- nutrient sensing and cellular decision making
- host-microbe mutualism – the need to fully understand the interplay between nutrition, immunology/mucosal immunity and the microbiome – particularly in terms of shaping the normal immune response and resilience to infection and other diseases, as well as the relationship of component parts in dysbiosis; the therapeutic potential of targeting the microbiome and the human microbiome as a reservoir of antimicrobial resistance
- the effect of biological rhythms on nutritional response
- the use of nanotechnology and specific nutrients to manipulate molecular pathways
- the role of nuclear factors in immune-metabolic regulation
- epigenetic memory and the role of nutritional components in transcriptional (dys)regulation (eg role of non-coding RNAs)
- interplay between nutrients and regulatory networks controlling energy homeostasis

### Stratified/personalised nutrition:

- stratified medicine approaches to understand differing nutritional needs and responses to interventions
- interplay between poor nutrition and predisposition to disease
- personalised nutrition for health – interplay between diet and genetics; nutritional regulation of genes/transcription

### Nutrition across the life course:

- key time points in developmental programming (including adolescence and high risk/vulnerable stages/populations) where susceptibility to poor nutrition has long term consequences
- interplay between nutrition and cognition/brain ageing
- interaction between nutrition and physical activity across the life course
- understanding of micronutrient requirement and metabolic impact at different life stages and in the prevention or treatment of specific diseases
- special nutrient needs in relation to ageing (eg effect of nutrition in relation to cellular and tissue homeostasis, cell senescence and loss); polypharmacy – understanding of the interaction of nutrition and drug exposure and the effects on appetite, taste, smell etc

### Prevention:

- “prevention-related” mechanistic nutritional physiology

### Tools:

- assisted reproductive technology as an experimental tool – the manipulation of embryos in unphysiological conditions
- biomarker (dietary intake, nutritional status, disease risk and efficacy of nutritional interventions) discovery and validation
- development of improved robust biological measures of dietary exposure
- improved in vitro and in vivo models (eg 3D organoids; animal models)

## Approaches to strengthen the research base

### General considerations

A strong basic science research base is fundamental to delivering the very best translation. In general, there needs to be a balance between high quality curiosity driven research and studies to address policy need. It is also important to understand what the public and patients see as important priorities.

The field would benefit from increased multidisciplinary to strengthen the research base, drive innovation and, ultimately, improve clinical applicability. There is a need to ensure cognate disciplines are working together effectively and that nutrition is fully integrated within studies of health and disease.

A strengthening of the research base must include increased robust mechanistic research (eg studies of the interplay of nutrients, genes and metabolites and the microbiome and effects on cell function using physiologically relevant conditions and doses of nutrients), the development of high quality integrative physiology and experimental medicine studies, and increased capacity for well-designed and well-controlled executed interventions.

Approaches may include:

### Integrative systems approach to nutrition

A systems approach to better understand:

- Nutritional needs and the role of nutrients as major modulators:
  - at the cellular and molecular levels, through intermediary metabolism and integrative physiology to the system and whole body level
  - in the healthy state (health maintenance and resilience), pathways to dysregulation, susceptibility and the development of ill-health and disease
- Response to prevention strategies
- Quality of life and health status in patients with disease and response to therapy and care

### Nutritional status and characterisation of the metabolic phenotype

- A recognised and agreed set of parameters for the nutritional status of study participants and patients which could include any or all of: diet (for recent consumption); a measure of anthropometry or body composition (as a form of integrated statement of how well nutritional demands have been satisfied by the supply over an extended period of time); measures or markers of physiological, metabolic or biochemical function; assessment of physical activity; assessment of allostatic load or stressors (including indicators of inflammatory, immune and infective status). Together these underpin the ability to conduct research of quality, to a consistent standard within a quality assured framework.
- Improved understanding of how best to capture the metabolic phenotype from a nutritional perspective
- Determination of the extent to which differences in nutritional status interact with other genotypic/phenotypic variables to determine risk of disease, susceptibility to infection/ disease and variability in response to care

### **Improved models and study design**

- The development of improved interdisciplinary whole systems life course approaches, integrating biological, physiological, social and economic influences to study trajectories for health and the development of disease
- Better and appropriate study design and experimental approaches. An agreed hierarchy of evidence from trials to other ways of demonstrating robust outcomes
- Improved understanding of the strengths and limitations of animal models and what they are able to tell us about human nutrition; where appropriate, the development of better animal models
- Use (alongside in vivo approaches) of newer in vitro models such as those based on stem-cell technologies for the production of 3D organoids (eg 'mini-guts')

### **Mechanistic studies and experimental medicine**

- Increased mechanistic research to robustly ascribe cause and effect from epidemiological correlations and nutritional interventions; increase understanding of the role that foods and nutrients play in health and disease
- More high quality, well-controlled human physiology and experimental medicine studies utilising more sophisticated approaches and with clear endpoints/read-outs (eg better biomarkers for nutritional intake, nutritional status, diet-related disease risk)
- Well-designed adequately powered studies that address important nutritional issues in adults and children with disease

### **Interventions**

A broad range of well-designed and executed intervention studies including:

- Stratified/personalised approaches to develop enhanced randomised controlled trials (RCTs) based on defined phenotypes
- Large scale dietary intervention studies in free living populations to shed light on causal pathways and identify what can reasonably be achieved with dietary changes
- Adequately designed and powered clinical trials and intervention studies with inbuilt experimental medicine/mechanistic studies which could be transformative in disorders such as cancer, inflammation and ageing/frailty
- A range of clinical trials from controlled efficacy studies, especially where metabolic effects remain uncertain, to behavioural interventions to implement dietary change in routine healthcare settings and in community settings (eg retail outlets or local authority premises)
- Upstream interventions that change the food environment, progressing from modelling studies to 'real-life' evaluations

Interventions need to be developed in collaboration with health professionals, public health experts, policy makers, and econometrists to ensure they are generalisable to real life situations, take account of behaviour, motivation and (personal or population) constraints, with sufficient attention paid to the heterogeneity of the studied population.

Where gold standard RCTs are not possible it may be necessary to map and assess available evidence from a range of study designs. Robust analysis of the effectiveness of health interventions should be undertaken to ensure they remain appropriate and cost effective.



### Scientific rigour and reproducibility

Because of widely heterogeneous phenotypic responses to diets in humans, the standardisation of experimental protocols, including use of physiological challenges, is key to obtaining reproducible findings. It is essential to:

- Establish uniform internationally agreed standard operating procedures throughout laboratories and to initiate regular proficiency testing. Standardisation should occur at all levels, from fundamental research to clinical and population studies. National and international cooperation and partnerships will be required and the analytics industry will be important in developing a stable, efficient and effective quality assurance (QA) framework.
- Develop improved robust biological measures of dietary exposure and validated intermediate biomarkers for testing the efficacy of nutritional interventions
- Systematically capture good practice and promote/share this via networks (eg through the BRCs)
- Standardise the collection, analysis, archiving and sharing of biological samples
- Encourage transparency at all levels – protocols registered in advance, a greater use of ‘meta-methods’ such as clinical trials registries and the deposition of primary data

The inclusion of nutrition within a greater number of NIHR-funded centres, and the linking of non-NIHR nutrition groups to the NIHR centres will be important and may provide the impetus for greater standardisation efforts.

## Infrastructure

### General considerations

Infrastructure provision must balance relevance to contemporary research questions with resilience against trends – it must also be responsive to new opportunities.

Infrastructure investment must take account of the general decline of the ‘institute model’ in the nutrition field, the cost recovery model of universities, and the high costs of human intervention studies (due to infrastructure requirements). Factors shaping infrastructure investment and maintenance include:

- Policy needs in diet and health research (eg population studies/surveys such as the National Diet and Nutrition Survey – NDNS)
- Support for the food and nutrition healthcare industries to produce healthier or more effective products
- The need for further research in areas of public health importance eg obesity and metabolic health, inter-individual variation in dietary response, or areas of research opportunity eg diet–gut microbiome interaction and health, epigenetics in diet and health, biological rhythms and the metabolic response to stressors

The decision whether to make a new investment, enhance existing infrastructure, mothball a facility or close it completely depend on a number of factors including current and future usage and whether the investment remains cutting-edge or has outlived its usefulness.

The establishment of a coherent national infrastructure for nutrition research will require the coordinated development of cutting-edge, linked, accessible, shared capabilities and resources.



## The UK landscape – dietary intervention studies and nutritional epidemiology

Set out below are strengths, weaknesses/barriers, and opportunities in relation to infrastructure for two main types of nutrition study – **dietary intervention studies and nutritional epidemiology**, together with overall future requirements which relate to both of these.

### Dietary intervention studies

Well-founded dietary intervention studies require:

- Facilities to undertake human intervention studies (consulting rooms, nurses, clinical cover and, where relevant, associated phenotyping facilities including energy expenditure, vascular, endoscopic and brain imaging measurements)
- Capacity and capability to provide experimental diets (eg food kitchens, research dieticians/nutritionists, and storage for experimental foods and clinical samples)
- Supporting analytical equipment (imaging, biological sample collection, metabolite and tissue analysis eg mass spectrometry & clinical assays)
- Technical expertise and support

### UK Strengths

#### Existing infrastructure for dietary intervention studies

Identified centres of expertise include:

- NIHR Biomedical Research Centres with expertise in nutrition and metabolic medicine: (Bristol – nutrition, diet and lifestyle and obesity; Cambridge – metabolism, nutrition, diet and lifestyle; ICL – metabolic medicine and endocrine; Leicester – lifestyle; Oxford – diabetes and metabolism, obesity, diet and lifestyle; Southampton – life course nutrition, lifestyle and health; UCL Hospitals – obesity). Such centres are able to provide health-facing nutrition research within an integrated clinical research system.
- Universities of Glasgow, Newcastle, Sheffield, Nottingham, IFR/UEA, Norwich, Reading, University of Leicester/Loughborough; Cambridge/MRC Elsie Widdowson Laboratory, KCL, ICL, Bristol, Southampton and Ulster. Surrey's infrastructure to study sleep, biological rhythms and nutrition/metabolism is almost unique.
- Clinical trials expertise and infrastructure; clinical research facilities (eg NIHR and Wellcome funded) for experimental medicine<sup>54</sup>
- Food composition data banks

### New developments

- The merger of the Rowett Institute and the University of Aberdeen in 2008 created new opportunities and a world-class facility. The Institute is now located in a new building on the medical school campus in close proximity to the Aberdeen Royal Infirmary. The building includes a Human Intervention Unit with residential facility capable of complex long term studies. In addition to trained dieticians and clinical staff, the unit includes a bespoke diet kitchen and canteen, mass spectrometry platforms, stable isotope analysis and facilities for the measurement of body composition/resting metabolic rate, clinical/nutrients and metabolomics.
- The Quadram Institute, a new £81.6 million food and health research centre representing a joint venture between the Institute of Food Research, Norfolk and Norwich University Hospitals NHS Trust, and University of East Anglia. The Institute will unite basic and clinical researchers working across four themes: the gut and the microbiome; healthy ageing; food innovation; and food safety. It will provide cutting-edge facilities for trials with human participants and have outreach to industry.

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54. In general, this infrastructure is a UK strength. However, whether or not they can be identified as centres of expertise for dietary intervention studies will depend on whether or not they have relevant nutrition expertise and bespoke facilities.

## **Barriers to progression**

### **Fragmentation**

Although there is widespread nutrition research activity throughout the UK, the relevant infrastructure is of variable quality and fragmented, with little evidence of coordination or linkage. Infrastructure relevant to nutrition research within different institutions is generally small scale and focused on different research areas, and is often linked to specific expertise (eg use of stable isotope technologies). Imaging offers significant opportunities for nutrition research but many research groups are not situated in medical schools and are disconnected from such facilities.

### **A lack of bespoke facilities**

In general, existing clinical research facilities are good for biomedical drug studies but most lack appropriate staff (eg. dieticians and cooks) and adequate facilities for diet and nutrition research and dietary trials (adequate space for food storage and food preparation/diet suites). Many NIHR funded CRFs, and Biomedical Research Centres provide infrastructure to conduct clinical research studies, but most are not purpose designed for dietary trials.

### **Funding**

Review participants flagged a current lack of funding streams to upgrade infrastructure. Of particular note was the loss of the Food Standards Agency (FSA) funding stream for nutrition research when responsibility for nutrition was transferred to DH. This is seen as detrimental as FSA had supported a sustained and systematic approach to controlled dietary interventions, bolstering infrastructure and collaboration between research groups. For many years, European Union (EU) funding has been important for building capacity and in sustaining large-scale nutrition research, but nutrition-related research has had lower visibility in Horizon 2020. Following the outcome of the UK European Union membership referendum in June 2016, and the decision to leave the EU, there is now some uncertainty regarding the continuity and level of future funding from EU programmes which will be available to UK nutrition researchers.

## **Opportunities**

### **Build on what we have**

There is still some unit and institute funding in the UK which provides critical mass and longevity/continuity of support. Whilst there has been some loss of unit support eg the closure of the MRC Dunn Nutrition Unit and more recently MRC Human Nutrition Research, other investments have, or are being, established (eg the Quadram Institute – Norwich) and provide an opportunity to build a critical mass of high quality nutrition research. Universities are now providing more long-term infrastructure (eg nutrition units or CRFs) which may operate on a cost recovery basis. Nevertheless, overall strategic coordination is still absent and there is a need to work across sectors/institutes to maximise this investment. The embedding of nutrition research in healthcare settings would encourage greater use of the NHS research infrastructure and also expose health professionals to the potential benefits of dietary interventions. For example, the collocation of research teams with hospitals/NIHR BRCs/NIHR CRFs can help with some types of clinical infrastructure (eg imaging, endoscopy/gut biopsies etc). The possibility of linking to infrastructure within the food industry, where this can be made available, would provide access to a broader set of specialist platforms and also encourage new cross-sector partnerships.

Some initiatives are in place, examples include MRC/ESRC CLOSER (Cohort & Longitudinal Studies Enhancement Resources) and UK Biobank, to maximise the use, value and impact of the UK's national resources/infrastructure, as well as stimulating collaboration and interdisciplinary research. National platforms, such as the NIHR-MRC funded National Phenome Centre, can be game changing provided they have sufficient capacity to deal with demand.

## Nutritional epidemiology

Robust studies require:

- Cohorts (with well-defined dietary characterisation tracked over time)
- Well-resourced and managed biobanks
- Quality assured cutting-edge analytical capabilities
- Databases and good data linkage

## UK Strengths

### Existing infrastructure and expertise for nutritional epidemiology

Nutritional epidemiology provides an important tool for contributing to the evidence base to support policy development. The UK is seen as strong in this area (eg Leeds, Cambridge, Oxford, Bristol, Southampton – with capability also at the Rowett Institute in Aberdeen, Newcastle, Manchester and ICL). The field is well-supported by:

- Population cohorts with information on height, weight and dietary habits (eg EPIC Norfolk and Oxford, ALSPAC, MRC National Survey of Health and Development Cohort /1946 Birth Cohort (NSHD), UK Biobank)
- NHS data and clinical informatics
- NIHR Biorepository
- National diet surveys, food composition databases (with caveats)
- Analytical platforms – there is a need to safeguard against loss of important research platforms in the UK and across Europe (eg micronutrient analyses; stable isotope expertise). There are NHS clinical service laboratories which are accredited for micronutrient analyses but these sit outside of the research infrastructure and are able to handle human samples but not analyse foodstuffs.

## Barriers to progression

### Limitations of methodologies and data

The following weaknesses regarding methodologies and data have been identified:

- Recall methods are blunt instruments for the collection of dietary data
- National surveillance studies are still reliant on surveys and large scale prospective studies and are not yet employing new technologies (eg for dietary assessment) as these are not tried and tested
- Population cohorts are good for hypothesis generation but their nutrition data are limited and lack a degree of robustness due to the use of diet questionnaires and self-reporting; in the UK and Europe access to data can be difficult at times and cohort leaders are not keen for intervention studies to be undertaken as this changes the nature of the cohort
- The UK food composition databases are clearly an asset. The data critically underpins the National Diet and Nutrition Survey and the UK's nutrition research. However, the both the consumption pattern and composition of foods shift over time and it is important to ensure that the data is fully validated, as comprehensive as possible, and updated in a timely manner. Consideration should be given to closer working and pooling of effort between public and private providers, both nationally and internationally, to standardise and integrate generic and branded food composition data.

## Future infrastructure requirements to strengthen the field

### Better coordination

High quality nutrition research requires ambition and scale and underpinning by appropriate well-founded infrastructure. There is a need to define key research challenges and build infrastructure around these. Ideally, this would comprise: strong expertise in nutrition, health, disease and cognate disciplines alongside clinical units, imaging facilities and analytical platforms, good data handling/analyses capabilities and sample storage. Where this is not possible there needs to be good signposting of available infrastructure and increased strategic collaboration and the sharing of facilities and expertise – both within the UK and beyond. Key requirements therefore include:

- Detailed knowledge of the landscape to maximise public and commercial investment – for example, an online nutritional research tool kit ‘Knowledge network’ which maps infrastructure and expertise (‘what, where, who’), including food composition databases
- Less fragmented capacity to undertake carefully controlled bespoke long-term dietary intervention studies around big questions
- A more joined up network of centres to deliver dietary intervention studies of greater scale and impact and supported by deeper capability in dietary design (improved standardisation and reproducibility)
- Collocation of infrastructure at sites of intervention studies where required, but where not, then easy access is key (eg National Phenome Centre)
- Linkage of nutritionists with cutting edge infrastructure in interface areas (eg gut microbiome; chrononutrition; brain imaging)

### Analytical know-how

Development of cutting-edge analytical capabilities and methods including:

- Analytical platforms to service the needs of future diet and health surveys and for the deeper phenotyping of cohorts
- Deep phenotyping to understand differences in risk, health outcomes (ie routes towards disease in multiple organs) and response to intervention (study of inter-individual variation, including metagenomics/microbiome)
- A national capability (either central or a dispersed model) to assess the nutritional status (energy and macronutrients status and also micronutrients) of volunteers or patients when undertaking clinical research
- Better measures of dietary assessment/exposure; utilising what we know from ongoing initiatives (eg diet and physical activity measurement toolkits; DIETary Assessment Tools network – DIET@NET; Determinants of Diet and Physical Activity knowledge hub – DEDIPAC) and the development of smart new technologies eg based on urine metabolomics to assist in dietary assessment

### Developing population based approaches

Epidemiological studies, data linkage and informatics approaches offer tremendous opportunities to take a broad approach to studying multiple diet-health relationships.

Approaches to ensure the nutrition field capitalises on population-based approaches and opportunities may include:

- The extension of big data approaches to nutrition and diet, food systems and the environment
- Improved/wider access to databases among researchers – this is not always the case, even for publicly-funded resources. One solution would be to encourage a greater use of a virtual federated data analysis approach where the constituent autonomous databases remain at separate locations. Through data abstraction, federated database systems allow the user to store and retrieve data from multiple non-contiguous databases with a single query – even if the constituent databases are heterogeneous.
- National dietary surveys need to be fully utilised by the research community, embedded in stable and strong research environments and ensured that they are ‘fit for the future’ and using the most appropriate cutting edge methodology. Governance of the dedicated survey capabilities and data generated should be strengthened to ensure they remain cutting-edge in approach and interact with UK-wide major centres of excellence through a planned programme of activity.
- Continued maintenance and development of cohorts; of particular importance is the prioritisation of nutritional phenotyping within large existing cohorts

### **Developing experimental medicine approaches**

Requirements include:

- Experts in biology/physiology embedded together with nutrition researchers in leading university and hospital partnerships
- Translational research infrastructure (highly controlled experimental environments and diet kitchens) collocated in clinical settings
- Access to volunteers and well characterised cohorts of patients available for clinical studies
- A range of “infrastructure” facilities linked in experimental medicine networks

## **Capacity and expertise**

### **Current UK landscape**

A high-level analysis of UK universities shows that:

- Seven research intensive universities have undergraduate and postgraduate programmes in nutrition (KCL, Leeds, Nottingham, Newcastle, Reading, Surrey, Ulster)
- A further six research led universities have postgraduate programmes (Aberdeen, Glasgow, LSTHM, Sheffield, Southampton, Surrey)
- There are eight other HEI medical schools with expertise in nutrition (Bristol, Cambridge, ICL, Leicester, Manchester, Oxford, Queens University Belfast, UEA)

In total, there are 21 HEIs with formal nutrition teaching and around 250 PIs directly involved in nutrition-related teaching and research across the UK.

Research Council, government funded institutes and strategic centre investments include:

- Rowett Institute, Aberdeen (Scottish Funding Council; ~30-35 PIs)
- Quadram Institute, Norwich (previously IFR; projected total of 40 PIs)
- NIHR Biomedical Research Centres related to nutrition – Southampton, Cambridge, Imperial College; Biomedical Research Units – Bristol, Leicester/Loughborough. NIHR BRCs/BRUs are playing an important role in building capacity and expertise and career development pathways.

The analyses indicated a total of around 300-350 research intensive PIs involved in nutrition research. There were around 13,500 Life Science and Medicine submissions to REF 2014, of which the nutrition submissions comprised ~ 2.5% volume.

## **Barriers to progression**

### **Fragmentation and critical mass**

There is an overall lack of capacity in nutrition science. Nutrition scientists comprise a small and rather fragmented community which is overstretched in terms of the broad areas of expertise and translation it is expected to cover.

Food science capability in UK is limited and has been eroded in recent years. The main research led centres in the UK offering coherent training in food science, food processing and nutrition are limited to QUB, Leeds, Leicester, Nottingham and Reading. However, the low intake of food science undergraduates has eroded capability.

### **Low/poor profile**

There are a number of reasons for the poor profile of the field:

Both public and academic opinion have been critical of nutritional science. There is a view amongst some academics that nutrition research can lack quality and rigour. Equally, the public is often confused, or at worst cynical, about nutrition and dietary advice<sup>55</sup>. Sensational or exaggerated nutrition-related health stories in newspapers, coupled with the premature dissemination of research findings, are damaging for the field and its researchers and have eroded the public's trust of nutrition science. In addition, there is often hostile reporting in the press in relation to academics working with the food industry – a much bigger issue in the UK than in Germany, the Netherlands and Spain.

There is no clinical specialty identified as nutrition; instead it is dispersed across other specialities leading to a lack of visibility and profile and a perceived downgrading of the discipline.

### **Clinical training**

One particular challenge facing clinical nutrition is that it is not represented by a single professional grouping with specific responsibility to promote the discipline, set standards for capability, practice and service delivery.

Adequate nutrition is a fundamental and important component of care of the sick. The provision of excellent nutritional care of patients requires a competent trained workforce able to identify risk and manage care through appropriate pathways and according to defined guidelines based upon context specific evidence. This includes doctors, nutritionists and dieticians but encompasses all other health professionals, even if their main focus is not nutrition. Specialist expertise (including a full appreciation of the extent to which nutritional factors contribute to the variability in presentation and response to treatment) offers considerable opportunity for better translational research through appropriate stratification, and potentially more effective personalised care.

Medical training is currently structured around the conventional anatomical systems. This means that important aspects of care that are not well-defined by such systems are often poorly addressed. This

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55. BBSRC public dialogue event:<http://www.bbsrc.ac.uk/web/FILES/Reviews/1404-food-nutrition-health-final-report.pdf>

is the case for nutrition, which acts as a coherent and integrated system to regulate and maintain homeostasis, but is not anatomically bounded. Although nutritional aspects of care may appear in most curricula this is not in a structured way and so learning and practice are impaired.

There is evidence of harm, high financial and social cost from poor nutritional care. Although nutritional issues are common in clinical practice, they are often not recognised or adequately managed. Equally, questions pertaining to the role of nutrition in clinical management are often not identified, and the research effort directed at such matters is hindered by the lack of awareness and training among the potential research community.

The Intercollegiate Group on Nutrition, until 2016 a group of the Academy of Medical Royal Colleges, has been the only national professional body that has nutrition as its primary concern. Under its auspices a foundation course in human nutrition has been developed and delivered, and an undergraduate curriculum in nutrition for medical students has been developed, but there is no structured nutritional curriculum for postgraduate doctors in their generalist years. Although some medical specialties have nutritional aspects in their specialist curricula, there is no formal body able to accredit or regulate this aspect.

The absence of a discrete specialty of nutrition militates against the development of a structured training pathway from undergraduate through foundation training, to general or specialist practice. This hampers the development of competent researchers and trainers, setting up a vicious cycle.

Adequate provision of nutritional services within the NHS and public health systems and within community services, requires a comprehensive approach incorporating education and training and effective translational research. The prosecution of such an agenda, against a complex landscape of responsibilities for training and service provision<sup>56</sup>, needs a clear focus, and a group of dedicated professionals to carry it forward.

### **Succession planning and career progression**

The field is approaching a critical point as a cadre of nutrition researchers move towards retirement and new excellent researchers are not entering the field in sufficient numbers due to perceived poor career progression and the challenges of undertaking high quality nutrition research. Whilst there are a sufficient numbers of studentships and early postdoctoral researchers there is a perceived lack of opportunity, including fellowships, for the career development and progression of outstanding senior post-doctoral researchers. This is coupled with a general lack of appropriate mentoring and the absence of standardised training to foster the next generation of researchers well positioned to undertake high quality integrative nutrition research. Further, in relation to the private sector, there is a perception that research careers in the food industry are not an attractive option, compared for example, to the pharmaceutical industry. Taken together, these issues are eroding the nutrition research base and leading to a lack of capability and expertise. For example, traditional areas of strength, such as micronutrient research capability, are decreasing both in the UK and across Europe.

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56. Undergraduate training in medicine falls to Medical Schools, overseen by the Medical Schools Council. Postgraduate training falls to Colleges and Health Education England. Accreditation and regulation of professionals fall across the GMC, the Health Professions Council and the Association for Nutrition, with involvement of Colleges. Service provision is the responsibility of the NHS England, clinical commissioners and Public Health England and appropriate bodies in the devolved administrations. Separate but overlapping arrangements apply to other health professionals with nutrition as a concern.



A number of the barriers outlined above were also raised as part of a review of vulnerable skills and capabilities<sup>57</sup> undertaken in 2014 by BBSRC and MRC, in collaboration with the Society of Biology. ‘Vulnerable’ areas, flagged by the academic research community, businesses and professional bodies, covered interdisciplinarity, maths, statistics and computation, physiology and pathology and agriculture and food security (including food and nutrition). Particular issues in relation to food and nutrition included: a general lack of capacity particularly of suitably qualified UK postdoctoral and senior researchers; difficulties for industry to recruit at undergraduate or masters level (not seen as an attractive career choice at the undergraduate level); a perception by industry that the UK lacks well-equipped facilities to undertake high quality nutritional research on an appropriate scale.

## Opportunities

### Training environments

Units and institutes are able to provide good training environments, particularly in areas which may be under-represented in the University sector. They offer the combination of both in-depth research training with day-to-day exposure to a range of nutrition topics and expertise. They are also able to provide a national focus and profile for nutrition research which is hard for individual research groups to achieve. A good example of this is the Human Nutrition MSc run at the University of Aberdeen, where students are taught by and can do research projects, with nutrition staff within the Rowett Institute.

Further opportunities for training may arise in relation to the recent NIHR competition for BRCs in which nutrition, diet and lifestyle (including obesity) was one of the highlighted areas, and also as part of the new interdisciplinary Quadram Institute (Norwich).

Links between primary production (crops and animals) and nutrition have traditionally been very poor but the BBSRC is putting more emphasis on this now including through its institutes.

### Training opportunities

Although there are few training schemes devoted to nutrition research, there are some which offer particular opportunities to researchers in this field. For example, the following MRC schemes are particularly relevant to those wishing to enhance their nutrition-related expertise:

- Skills development fellowships – support capacity building for researchers at all career stages who wish to transform their career by developing new skills in the priority areas (quantitative capabilities or skills at the social science interface)
- Proximity to Discovery: Industry Engagement Fund – to provide flexible funding for innovative ways to enable the initial development of academic-industry collaborations. This can include people exchange to allow for an exchange of skills or knowledge which will enable new collaborative projects to develop.

In the wider field of food and nutrition sciences and food systems a number of organisations are beginning to address the interdisciplinary skills required.

Following a 2010 cross-departmental government assessment of the status of high level skills in the UK agri-food sector<sup>58</sup> the BBSRC responded to the need to increase the skills level and

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57. BBSRC and MRC review of vulnerable skills and capabilities (2014)

58. High Level Skills for Food Report from the Food Research Partnership Skills Subgroup January 2010



professionalism of this sector by establishing Advanced Training Partnerships. Three partnerships totalling £13 million (led by the universities of Aberystwyth, Nottingham and Reading) were established bringing together companies with research and training organisations, and collectively covering the full range of food production from farm to fork.

Innovative Food Systems Teaching and Learning (IFSTAL), funded by the Higher Education Funding Council for England, addresses the urgent need for a workforce skilled in food systems thinking. IFSTAL is a collaboration of five higher education institutions<sup>59</sup> pioneering a learning community and interactive resource designed to improve postgraduate level knowledge and understanding of the food system.

### **Future requirements to build capacity and expertise**

There is a need to re-energise the field to increase capability as well as critical mass. A long term (10-20 years) approach will be required to reach sufficient capacity and therefore this should be a phased, strategic development over time.

#### **Greater critical mass**

The achievement of a critical mass sufficient in scale and ambition to meet the key research challenges will require:

- a well-trained cohort of undergraduate, postgraduate and medical students to support long term appointments
- international programs to recruit the best students (MSc, PhD, postdocs) into the field
- the identification and provision of support for health workers eg dieticians who are interested in research
- strategic investment by the public sector funders (eg NIHR, Research Councils); a critical mass of highly competitive research, and adequate investment in infrastructure
- a peer review process which includes suitably knowledgeable experts to ensure the best projects and most promising up and coming early career researchers are identified and supported
- incentives to attract early career researchers from other disciplines, including funding and HEI support to bridge the post doc to PI 'valley of death'
- support for 'future leaders' development programmes

#### **Improved standardised education and training**

Clear pathways and competency-based approaches are required, including:

- a coherent (minimal) education programme for life science researchers in diet, nutrition and health research
- a cross-centres education programmes (national and international) to overcome fragmentation and raise the profile of the field
- a more structured approach to training based on competencies as employed at the NIH Centre for Translational Sciences

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59. Environmental Change Institute, School of Geography & the Environment, University of Oxford; The Centre for Food Policy, School of Arts and Social Sciences, City, University of London; The Leverhulme Centre for Integrative Research on Agriculture and Health (LCIRAH); The Centre for Food Security, University of Reading; The University of Warwick

### **The creation of an inclusive and global mindset**

Highly connected multidisciplinary collaboration across the UK and global partners facilitated by:

- dedicated multidisciplinary calls to target funding for research and training to areas of global importance
- forging strong mutually beneficial research and training partnerships between institutions in the UK and LMICs
- embedding of nutrition training in biomedicine, medical and social sciences. The training of social scientists as well as life sciences researchers to provide both with appropriate nutrition related skill sets
- joint supervision of PhD students across different disciplines to encourage integrative research and multi- and interdisciplinary partnerships

### **Training for improved engagement in translational research**

It is essential to ensure researchers possess the breadth of knowledge required to synthesise evidence for external stakeholders and so inform and underpin policy, the food supply chain, public health practitioners and public understanding. This might be achieved by:

- increased opportunities for secondments and/or exchanges (between academic HEIs or with industry) to provide researchers of all levels with specialist nutrition expertise and/or analytical skills
- provision of a cohort of trained research translators with a broad knowledge of nutrition science who understand the changing nature of translational pathways and can facilitate the effective translation of research to policy makers, industry, public health practitioners and clinicians

## **Coordination and partnerships**

Nutrition research provides the best example in the life science field of where different disciplines, from basic to applied sciences must work together to achieve health impact as well as scientific excellence.

A cohesive strategy is required to fully support integrative research and a whole system approach in both experimental animals and humans. There are new exciting opportunities to firmly embed nutritional and metabolic science into the biological sciences related to human health, as well as disease-based disciplines. These include epigenetic mechanisms (early life nutrition and aging), immune mechanisms, gut health and the microbiome, cancer, immune disorders and sarcopenia.

There is a need to capitalise on opportunities for closer joint working across disciplines and in partnership with other funding organisations, policy makers and industry to ensure that the evidence base generated will deliver public health benefits and drive positive change within health policy and practice.

## Barriers to progression

Over the last five years there has been significant interest and strategic shaping by the Government/government departments but this has been focused on agri-food or social science and behaviour change; the key area of nutrition and human health has been neglected. To a large extent, UK funders have operated separately with respect to nutrition research leading to unconnected research communities. This is now recognised and is being addressed but more could be done to provide national leadership, increase funding partnerships and promote multidisciplinary and collaborative working.

## Opportunities

### Increased willingness to work together

There is now increased willingness of key sectors including universities, government departments, funders, public sector organisations and industry to work together on important challenges in the field.

### Positive promotion of collaborative research

There is increasing recognition that research collaboration is important and steps are being made by funders, the REF etc, to more fully credit this mode of working.

The broad range of skills and expertise in university settings provides excellent opportunities for the development of interdisciplinary research teams in which nutrition scientists work closely with laboratory, clinical, behavioural, social scientists and bioinformaticians. In addition, the growth of research infrastructure within the NHS under the auspices of NIHR and the recognition of the importance of nutritional status, diet and weight management, for the prevention and management of disease has created tremendous opportunities to conduct high quality studies in clinical settings with the potential for rapid patient benefit. In all cases, whilst it is important to bring disciplines together, groupings must include those with strong nutrition expertise and understanding to ensure research is robust. Too often there is a rush to adopt new techniques and methodologies without a sound understanding of normal physiology and nutritional relevance.

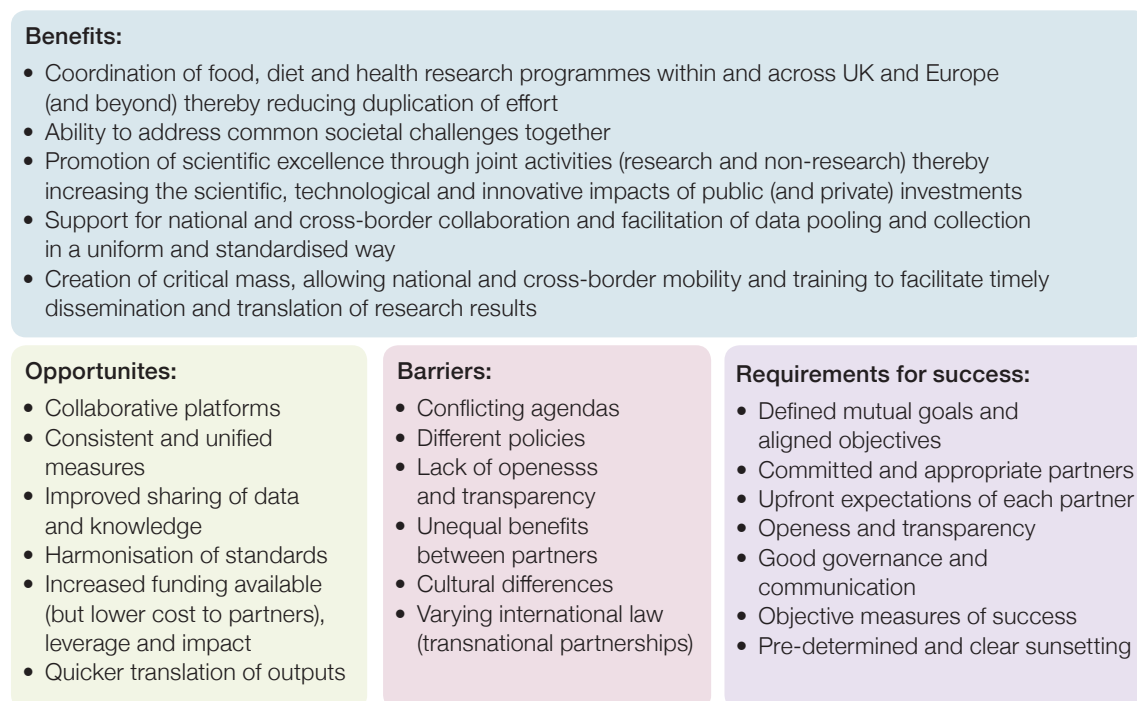
## Future requirements for effective partnership and coordination

Without greater high level leadership and coordination of the field the academic value of human nutritional research will be further eroded and essential parts of nutritional science may increasingly be absorbed by other research disciplines with a higher profile.

A range of new initiatives are required to raise the profile and standing of nutrition research and unite disciplines far more effectively than we have to date. These may include the stimulation of challenge-based research to address major nutrition questions (national and global), supported by research councils and other funders, potentially including industry. There is great potential in bringing researchers together around national/international resources, as well as technologies and methods development, not only to stimulate advances in these areas, but also to maximise collaborations and know-how. In particular, there should be a full exploration of opportunities for academia to tap into industry knowledge and expertise eg data obtained in the retail context, as well as other resources such as the Kantar database, and the ESRC Consumer Data Research Centre at UCL.

A summary of the key determinants and benefits of partnership working can be found in **Figure 2**.

**Figure 2: Partnership working**



## Partnership with industry

### Benefits of partnership

The Government's focus on science and research as a driver of economic growth, the continuing need to improve translation, and the potential to influence the public health agenda, reinforce the need to work collaboratively with industry.

Optimal organisation and coordination of the UK's research expertise, unique resources and integrated health system will not only help to accelerate nutrition science but will also provide a coherent platform for engaging the global food and nutrition science industry. Opportunities must be maximised to increase partnership with companies based in the UK as well as attracting inward investment from those based overseas.

True partnership working and cross-fertilisation between academic and industry sectors can provide benefits to both parties including:

**Leverage** – The research opportunities are growing as the need to understand human nutrition grows. However, this need may not be met in the short term with sufficient additional resource from the public purse to undertake new, large scale research studies. Working in partnership with industry could be a route to leverage additional funding to support nutrition research in the UK.

**Translation** – Industry is best placed to ensure that basic cellular and physiological studies of nutrition are translated into healthy, nutritious but also palatable foods. A stronger engagement between the industry and academic sectors will ensure that the basic research on which the food industry bases its products is robust.

Sharing of knowledge and resources – In the same way as the pharmaceutical industry, the food industry employs its own scientists with a number of research labs across the world possessing capabilities, capacity and knowledge which can be useful for academic researchers. For the academic researchers, working with industry provides opportunities to access capabilities that do not exist in the academic sector, and to work with scientists who can move discoveries towards public health and patient benefit, as well as societal impact.

Capacity building – In addition to addressing key scientific challenges, working in partnership could also help develop capacity in the UK.

True partnership between academia and food industry will lead to scientific excellence and industrial relevance.

### The food industry

The food industry is a significant contributor to the economy of the UK and Europe. It is the single largest manufacturing sector in the UK, employing 3.5 million people in Great Britain (12% of GB employment) in a broad range of activities (sub-sectors) including food manufacture, wholesaling, food retailing and catering<sup>60</sup>. In Europe the food and drink sector has a turnover of around €1061 billion<sup>61</sup>. The sector is intensely competitive and, apart from a small number of large businesses (eg Unilever, PepsiCo), it is dominated by small companies (SMEs) operating on low margins and research capacity is therefore limited. Within the food industry most product development proceeds incrementally, and (outside the very large multinationals) large research centres do not exist. In the UK industry, particularly SMEs, makes use of the Food Research Associations (Campden BRI and Leatherhead) which provide integrated scientific and technical expertise, bespoke research services and regulatory advice, and so enable companies to join together to fund research and collectively share the outputs. Hence there is scope for improved linkages with centres of academic excellence coupled with mechanisms to disseminate the results of research back to both the companies and the Food Research Associations.

### Models of engagement

Effective engagement with the private sector, either through top-down or bottom-up approaches, can increase entrepreneurship and innovation and so help address grand challenges in the field. The major characteristics of these two approaches are outlined below.

#### Top-down approach

To address nutritional challenges effectively an integrated approach should be encouraged in which science and industry, supported by government and funders, share their knowledge, expertise and resources to deliver game changing results. The gap between fundamental academic research and industry research may be bridged by bringing together industry and public sector partners to support precompetitive strategic nutrition research. Good examples include:

- **Food for Health Ireland** – Collaboration between Enterprise Ireland, industry and academia. Competitors in the market place engaging in pre-competitive food and nutrition research. Direct industry input into the science programme to ensure translational relevance.

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60. Food Statistics Pocketbook 2016. Department for Environment, Food and Rural Affairs  
<https://www.gov.uk/government/statistics/food-statistics-pocketbook-2016>

61. The competitive position of the European food and drink industry Final Report. European Competitiveness and Sustainable Industrial Policy Consortium. February 2016 <http://ec.europa.eu/DocsRoom/documents/15496/attachments/1/translations>

- **TI Food Nutrition** – Pre-competitive research platform collaboration in The Netherlands between the Department of Economic Affairs (35%), industry (35%) and academia (30%) (budget ~ €20m per annum) to create breakthrough innovations in food and nutrition.

### Bottom-up approach

Scientists should be encouraged to work with industry to access the necessary expertise (eg provision of well-defined foods with pre-determined nutritional components for human intervention studies), technology (including analytical capabilities), resources and funding to enhance their research. Where funding is received, strict contracts must be agreed to ensure the academic freedom of the researchers and to enable their independence to be protected.

For both approaches it is prudent to consider what, if anything<sup>62</sup>, might be learned from a long track record of interaction between the academic research base and the pharmaceutical sector.

### Recent UK activities

Government funded collaborations (led by the Research Councils) between academia and food industry aimed at strengthening links include:

- Diet and Health Research Industry Club (DRINC)<sup>63</sup>
- Innovate UK 'Nutrition for Life' competitions<sup>64</sup>
- Priming Food Partnerships<sup>65</sup>

These initiatives have facilitated high quality innovative pre-competitive research into diet and health within UK universities and research institutes. The first two aimed to help the food industry develop products that deliver enhanced health benefits for consumers. They formed part of a research pipeline to provide an opportunity for industry led projects designed to improve public health to be developed based on outputs from earlier phase pre-competitive research carried out in academia. The third and most recent initiative aimed to pump-prime industry connections with the research base on specific topic areas identified by industry (eg how food structures modulate psychological and biological signals to influence food choice and preferences, appetite, satiety, reward, and palatability). The majority of projects funded by these initiatives were multi-company/multi-funder rather than one to one collaborations.

Despite some successful examples, partnership with the food/nutrition science industry is much less developed than interactions with the pharmaceutical industry. Much more could be done to improve the interface in relation to nutrition and human health.

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62. There are both similarities and some key differences between the way that pharma and the food industry operate and so comparison is not straightforward

63. DRINC is a partnership between BBSRC, MRC and ESRC and a consortium of leading food and drink companies which has committed £22m to pre-competitive research that investigates the link between diet and health

64. Partnership between RCs and Government departments led by Innovate UK. Collaborative academic/industry research and development to deliver improved nutritional outcomes to the UK population. Two competitions (2011 and 2013) funded 82 projects

65. BBSRC, EPSRC, MRC and ESRC call to forge new academic industry partnerships to investigate how food structure modulates parameters such as food choice and preferences, appetite, satiety, reward, and palatability

## Barriers to progression

Research collaborations and other joint working between academic researchers and industry have long given rise to concerns about industry's motivation and the potential for conflicts of interest to introduce bias, whether conscious or unconscious, in research study designs and outcomes. Journalists tend to portray industry funded research as designed to promote specific agendas and assume it is inevitably biased. Despite these concerns, there are indications that the public can understand why medical researchers need to collaborate with pharmaceutical and diagnostics companies in order to translate advances in medical research into new treatments and diagnostics tests and to deliver benefits for health. It is potentially more difficult for the public to understand the rationale for working with other types of companies, and thus it is likely that such collaborations bring with them a higher potential reputational risk. The past behaviour of the tobacco industry is notorious, and research funded by or undertaken in partnership with the food industry has recently been subject to similarly negative attention in the British press<sup>66</sup>. This has led to increased sensitivities (and anxiety) concerning academic and industry collaboration, particularly in relation to population health studies and trials of food products.

Currently the lack of an agreed code of practice is considered (by both the academic and industry sectors) to be an obstacle to open, transparent and effective partnerships between academic researchers and the food industry.

## Opportunities

A good deal of food research has focused on food production (particularly in relation to improving yield) and food processing. In addition, for many years nutrition and consumer health was perceived as the end-point of the food chain<sup>67</sup>, rather than the driver for R&D. There are real opportunities, however, to forge research partnerships to develop innovative approaches which may lead to novel healthier products. This might be to enhance nutritional quality of mainstream food and drink products (with this in turn contributing to an improvement in diet quality), or to develop more specialised products to alleviate nutritional deficiencies or support patients with specific illnesses.

Health and wellness has had a growing influence on the food industry in recent years; key priorities include efforts to meet guidelines on the reduction of salt, fat and sugar (and to understand consumer behaviour in relation to this type of product), as well as the development of 'free-from' and 'health promoting' foods with functional ingredients.

Additionally the food industry has shown a willingness to enter into pre-competitive research partnerships designed to investigate broad topic areas.

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66. Sugar: spinning a web of influence J Gornall BMJ 2015;350:h231 <http://www.bmj.com/content/350/bmj.h231>

67. the network of stakeholders involved in growing, processing, and selling the food

## Future requirements to improve partnership working

### Support for academic industry partnerships

There are compelling reasons for the promotion and support of academic and industry partnerships. The establishment of strong pre-competitive research collaborations with the food and nutrition science industry will ensure that key challenge areas are addressed in a rigorous manner. It will also enhance sharing of expertise and resources, and build capacity in the field.

Because public trust in industry, and in industry-funded research, is low, there is a need to be clear why and how academic researchers work with industry, what the potential benefits are for companies, researchers and for the public. It is also important to understand the potential risks and to develop transparent processes that provide confidence that these risks are managed.

Any agreements and joint working between academics and industry, particularly on a one to one basis, must be open and transparent and follow publicly defensible rules of engagement which prevent bias and/or undue influence. The review has highlighted that research funders, such as the Research Councils, could be seen as independent arbiters ensuring research excellence as well as providing an open framework for funding decisions which ensure that the benefits of collaboration are sufficient to justify the use of public funds.

### Transparent framework for engagement

There is an urgent need for an independent organisation to develop a set of shared guidelines and/or principles to be used as a trusted framework for engagement between academic researchers and the food/nutrition science industry (including manufacturers and retailers). The framework should be debated and agreed by consensus, be generalisable and pragmatic, and evolve over time.

## Global nutrition and health research

### Background

Historically, the UK has exploited its strengths in infectious research to tackle global challenges such as malaria, TB, HIV and other infectious diseases. The changing burden of disease across the world, however, has led to the emergence and rapid increase in prevalence of chronic non-communicable diseases (NCDs), for example heart disease, obesity and diabetes, in developing countries. Nutrition, and its influence at all life stages, is likely to play a pivotal role in understanding NCDs and their prevention and treatment. Malnutrition, including the excessive intake of energy-dense food, together with reduced physical activity is a global concern. Malnutrition and poor diets are key drivers of the global burden of disease and result in economic deficit. Annual gross domestic product (GDP) losses from low weight, poor child growth, and micronutrient deficiencies average 11% in Asia and Africa<sup>68</sup>.

Both developed and developing countries are experiencing urbanisation which, without appropriate planning and control, rapidly results in poor health and social conditions and increased inequalities. For example, in Africa, economic development is increasing resulting in rapid urban expansion.

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68. International Food Policy Research Institute. 2016. Global Nutrition Report 2016: From Promise to Impact: Ending Malnutrition by 2030. Washington, DC. <http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/130354/filename/130565.pdf>



By the mid-2030s, more than half of all Africans are expected to live in cities and towns<sup>69</sup>, with predictable consequences for diet and living conditions. Overall, deaths from NCDs are expected to exceed those from communicable, maternal, perinatal, and nutritional diseases by 2030<sup>70</sup>. Yet, as in the UK, diseases of sedentary lives, over-consumption and increased lifespan coexist with those of poverty, deprivation and suboptimal nutritional intake. Looking forward, there is a need for researchers both in the UK and in the developing world to continue to forecast and address these demographic and epidemiological transitions.

### Opportunities for research

Micronutrient malnutrition is widespread in the developing world and linked to infections, poor hygiene, inadequate diet and socioeconomic status/poverty. There is a need for a deeper understanding of nutrition in the presence of infectious disease, nutrient absorption and gut health and the role of the gut microbiome. Also important is nutrient metabolism and the requirement for specific vitamins and minerals for specific population groups and genetic dispositions, and interventions such as biofortification (improving the nutritional quality of crops) and food fortification. More work is needed to better understand the common determinants of poor nutritional status in LMIC settings and the associated risk factors for the development of NCDs. In addition, the development of more effective context-specific and acceptable interventions will be required for successful translation into policy and practice by local governments and health agencies.

It will be important to take a holistic view of nutrition research across the entire food chain from the growth of nutrient rich crops through to policy development. Local context will be key and the research effort required will depend on the particular nutritional challenge, the location (urban or rural) and the food system(s).

As child mortality declines, policies and interventions that have traditionally been applied on a population basis will need to be targeted at groups and individuals. This will require improved phenotyping in order that interventions are cost effective.

### Requirements for strengthening global nutrition research

Every effort should be made to ensure a wide base of UK researchers are well-placed to work collaboratively, crossing disciplinary as well as geographical boundaries, to undertake high quality multidisciplinary global health nutrition research with the greatest possible impact. Equitable international partnerships between universities and other academic institutions in the Northern and Southern Hemispheres offer an important way to tackle the global health challenges of the 21st century, including those outlined in the Sustainable Development Goals. Such collaborations play an important role in building capacity in research (including the development of cutting-edge infrastructure and the collection of high quality data at the local level) and health services in Low and Middle Income Countries (LMIC) countries. They also provide high level training and leadership development both for nationals of those countries, and for UK scientists.

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69. African economic Outlook 2016

70. The Global Economic burden of Non-Communicable Diseases A report by the World Economic Forum and the Harvard School of Public Health September 2011 [http://www3.weforum.org/docs/WEF\\_Harvard\\_HE\\_GlobalEconomicBurdenNonCommunicableDiseases\\_2011.pdf](http://www3.weforum.org/docs/WEF_Harvard_HE_GlobalEconomicBurdenNonCommunicableDiseases_2011.pdf)

## Translation

Effective translation requires the pull-through of findings from both basic biological and population-based nutrition research, via an implementation stage, into cost-effective public health or healthcare interventions, or the development by industry of new healthier, attractive and acceptable products.

### Barriers to progress

In the UK there are gaps in the research evidence required to underpin public health policy and interventions including a lack of high quality studies, particularly on the broader determinants which influence health status. The lack of good translational nutrition research and suboptimal translation of findings/pull-through is an issue across Europe. In relation to diet and health, this reflects the lack of linkage between nutrition and disease-related disciplines. There is a perception that the focus on disease areas, often without examining the role of nutrition in the aetiology of the condition, has led to slow progress in translating basic research findings into effective interventions. Translational research can be slow and expensive, particularly in nutrition research where large complex studies may be required and there is a lack of intermediate markers of outcome.

### Requirements to improve translation

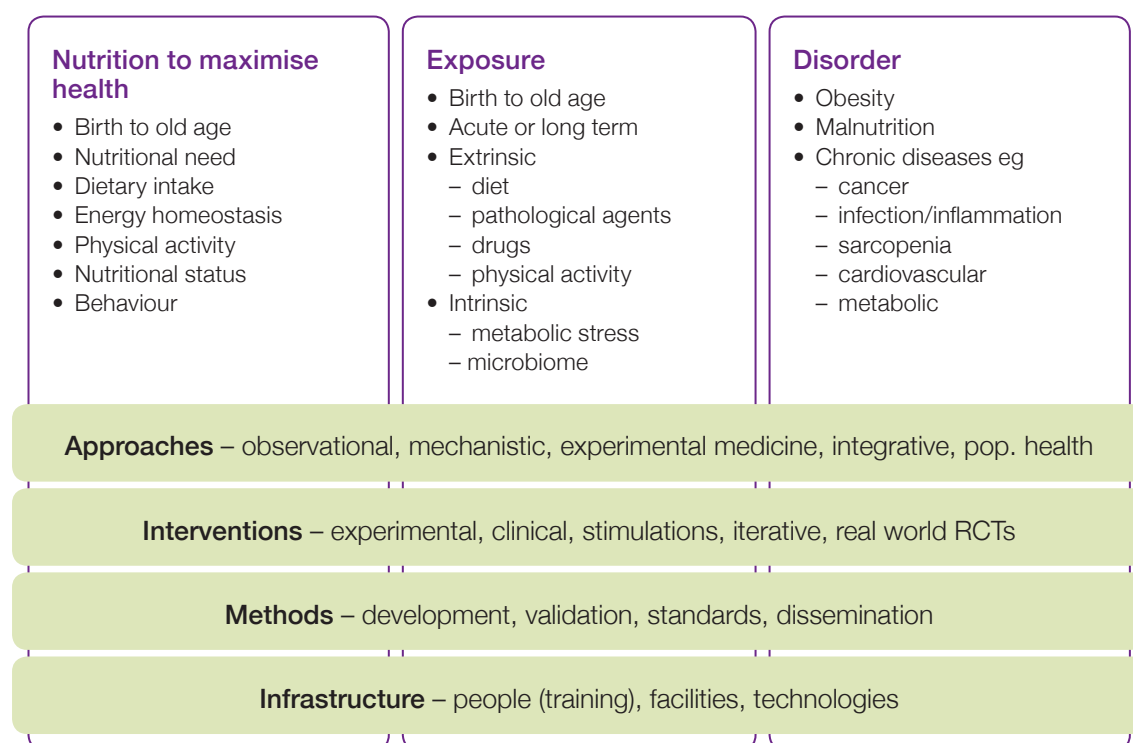
The following approaches have been identified to facilitate the pull through of biological/physiological understanding into both public health for disease prevention and clinical practice for disease management:

- A strong recommendation that all health professionals make nutrition a key consideration as they develop approaches to optimise health outcomes, in the UK and/or internationally.
- The uniting of the UK's leading academic nutrition research centres with clinical centres (both within and beyond the BRC family) with expertise in experimental medicine and translational nutrition research. The aim would be to provide an effective platform to undertake high quality studies in integrative physiology and experimental medicine to enhance basic understanding and the development of effective nutritional interventions.
- Improved understanding of how to move beyond the individual to group behaviours. Better integration with social science to understand diet patterning, dietary exposures, bioecology and social context and programming.
- A thorough evaluation of the implementation and impact of interventions/policies to better understand why these succeed or fail.

# Summary of key components and requirements in nutrition and health research

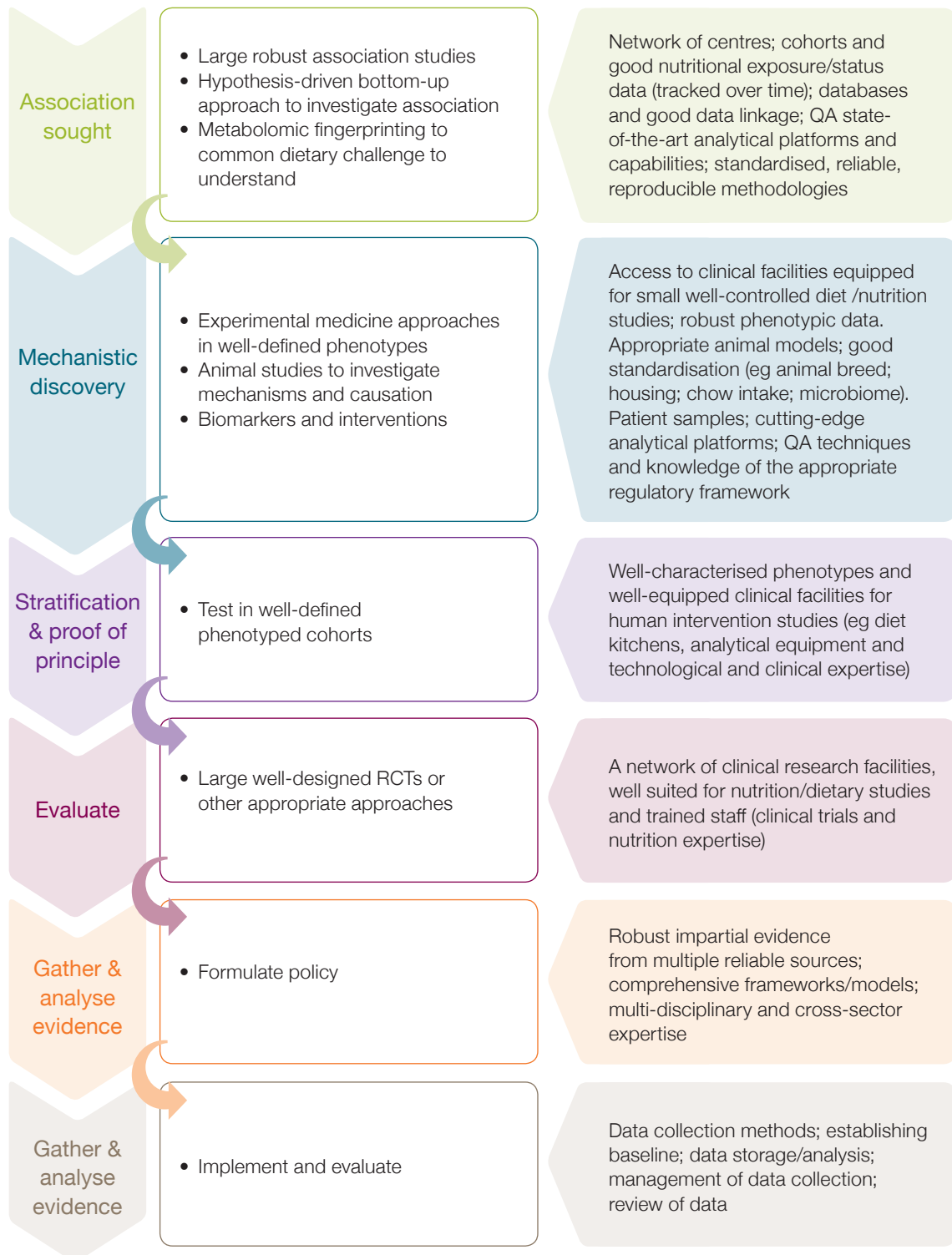
The following figures (figures 3 and 4) provide an overarching and high level visual representation of the key components and requirements as set out in the preceding sections:

**Figure 3: Summary of key components in nutrition and health research**



**Figure 4: Nutrition research framework**

The following is a conceptual nutrition research framework which attempts to unify some of the findings and key requirements set out in the report:



# Summary of recommendations

Whilst there are many recommendations which could be made and justified on the basis of the evidence gathered, the following have been identified and selected as those likely to have the greatest and broadest impact for the nutrition research field. The recommendations aim to reinvigorate and strengthen the field by fully capitalising on existing strengths whilst providing new momentum through increased coordination and targeted strategic investment.

## Reinvigorating and strengthening the field

### **Recommendation:**

The establishment of internationally leading cross-disciplinary Centres of Excellence (CoE) in integrative nutrition to strengthen both research and training in key challenge areas, and to enhance scientific networking and cooperation across institutions. Alignment with global initiatives and partnership with research organisations in Low and Middle Income Countries (LMICs) should be strongly encouraged. The CoE should form an integral part of the host institutes' strategic vision and long-term commitment to developing capacity in the field. The CoE should also increase the attractiveness of the UK as a research location in the long term, improving its international competitiveness and ability to attract inward investment.

Phased support, beginning with flexible pump-priming awards, may be necessary to build solid foundations for the CoE. Such support may also be required to enable the development of networks in high priority/specialist areas and their integration into the new centres.

## Integrative approach to nutrition research

### **Recommendation:**

Nutrition research should be fully integrated within studies of health and disease to optimise health outcomes. Research environments should fully support integrative research and a whole system approach. Cognate disciplines should work together effectively to firmly embed nutritional and metabolic science into the biological sciences related to human health, as well as disease-based disciplines.

## Improving standards and research methodology

### **Recommendation:**

The development of standardised and validated objective measures of human dietary intake and human nutritional phenotyping with the aim of generating reliable data on patterns of diet and physical activity, nutrient status, and individual variation in response.

### **Recommendation:**

Improvement of the reproducibility and robustness of animal and human nutrition research. A formal initiative, led by an appropriate professional body, to develop internationally accepted standards (ISO) and quality assurance for nutrition studies in animal models and humans.

## Connecting expertise and resources

### **Recommendation:**

The development of a detailed understanding of the UK's nutrition research landscape to facilitate greater linkage of expertise and capability (eg analytical platforms and human experimental medicine facilities) within the academic and the food/nutrition science industry sectors, thereby maximising the benefits of public and industrial/commercial investment.

## Accelerating translation

### **Recommendation:**

The establishment of a nutrition network to unite the UK's leading academic nutrition research centres with clinical centres (both within and beyond the BRC family) with expertise in experimental medicine and translational nutrition research. The aim would be to provide an effective platform to undertake high quality studies in integrative physiology and experimental medicine to enhance basic understanding and the development of effective nutritional interventions. In the longer term this might include the establishment of a Translational Research Partnership in nutrition.

## Strengthening partnership working and the interface with industry

### **Recommendation:**

There is a need to build strong pre-competitive research collaborations with the food and nutrition science industry to address key challenge areas in a rigorous manner, enhance sharing of expertise and resources, and to build capacity in the field. Whilst the nature of the collaborations might vary according to specific research needs, they should always adhere to the principles of fairness, equal partnership, openness and transparency.

### **Recommendation:**

There is an urgent need for an independent organisation to develop a set of shared guidelines and/or principles to be used as a trusted framework for engagement between academic researchers and the food/nutrition science industry (including manufacturers and retailers). The framework should be debated and agreed by consensus, be generalisable and pragmatic, and evolve over time.

## Improved platforms and infrastructure

### **Recommendation:**

Steps should be taken to ensure that large national surveys and cohorts (for example, the National Diet and Nutrition Survey) are fully utilised by the research community, embedded in a stable and strong research environment and use the most appropriate methodology. Linkage between large national resources and platforms would be beneficial to optimise their contribution to the evidence base of UK public health policy.

## Improved platforms and infrastructure (continued)

### **Recommendation:**

Improved 'omics, including metagenomics, and deep phenotyping facilities: the field would benefit from validated, quality-assured open access platforms for food composition and nutritional data ('Dietome') and the determination and surveillance of phenotypic and nutrient biomarkers ('Nutriome'), physical activity and stress (the 'Exposome'). The model, whether centralised or a 'hub and spoke' arrangement, should be that which best fits the science.

### **Recommendation:**

Improved facilitation of research on the role of nutrition in brain development and functional decline during ageing. There is scope for greater specialisation of some brain banks (eg via the UK Brain Banks Network) to address particular nutrition research needs (eg the neuroscience of appetite, satiety and obesity) by linking samples to appropriate clinical data (eg Body Mass Index (BMI), body composition and blood metabolites).

## Capacity building and training – a more explicit role for nutrition education across health research

### **Recommendation:**

Increased leadership and a more explicit role for nutrition education across health research (basic and clinical). Within the clinical context, this might include the establishment of a single professional medical body concerned with nutrition to foster the coherent development of systematic training and education, research and practice, and to interact with regulators, other professions and Government.

# Annex 1

## Membership and Terms of Reference for the Review Group

### Terms of reference:

- To provide a balanced view of the of strengths and weaknesses of nutrition research relevant to human health in the UK
- Assess whether the research base is well-placed to meet the current and envisaged needs of policy makers
- Identify opportunities for further interaction with the food/nutrition science industry both in the UK and globally
- Consider whether research capacity issues are being sufficiently well-addressed to provide a sustainable future for nutrition research in the UK
- Formulate recommendations in a report to the OSCHR Board

### Review Group membership:

Chair: Professor Chris Day – Newcastle University, UK

Deputy Chair: Professor Alan Jackson – University of Southampton, UK

Professor David Adams – University of Birmingham, UK

Professor Ian Charles – Institute of Food Research/Quadram Institute, Norwich, UK

Professor Hannelore Daniel – Technische Universität München (TUM), Germany

Professor Sadaf Farooqi – MRC Metabolic Diseases Unit, Cambridge, UK

Professor Graham Lord – King's College London, UK

Professor Malcolm Jackson – University of Liverpool, UK

Professor John Mathers – Newcastle University, UK

Professor Peter Morgan – Rowett Institute, Aberdeen, Scotland, UK

Professor Yolanda Sanz – Institute of Agrochemistry and Food Technology (IATA), Spain

Professor Wim Saris – Maastricht University, The Netherlands

Professor Christine Williams – University of Reading, UK

Professor Ian Young – Queens University Belfast, Northern Ireland, UK

### Invited guests (second meeting of the Review Group):

Dr Alison Tedstone – Deputy Director of Diet and Obesity/Chief Nutritionist, Public Health England (PHE), London, UK

Professor Neena Modi – Professor of Neonatal Medicine at Imperial College London and President of the Royal College of Paediatrics and Child Health (RCPCH)



# Annex 2

## Funding for nutrition and human health research

### The UK landscape

Research and infrastructure relevant to nutrition and human health is supported by a range of UK funders including the UK Research Councils (MRC, BBSRC, and ESRC), government departments and agencies (Department of Health/National Institute for Health Research (NIHR) Food Standards Agency, Food Standards Scotland, Scottish Executive), charitable organisations (The Wellcome Trust, Cancer Research UK, British Heart Foundation, World Cancer Research Fund UK) and industry.

This funding analysis has been produced to coincide with the Nutrition and Human Health Research Workshop in July 2016. It is intended to provide a high level overview of the UK funding landscape with a view to informing and stimulate discussions at the workshop.

Whilst every effort has been made to ensure the accuracy of the data it should be emphasised that the report is designed to offer a quick visualisation of the portfolio, and not an in-depth analysis. In addition, it is often more helpful to focus on the patterns and trends rather than the absolute amounts captured in the analysis.

In general, it should be noted that the research analysed relates to a specific remit and the funding organisations may be supporting broader research portfolios.

### Approach

#### Data collection from UK funding organizations and agencies

The portfolio analysis draws on data provided by the following funders and agencies:

Arthritis Research UK (ARUK)  
Biotechnology and Biological Sciences Research Council (BBSRC)  
Economic and Social Research Council (ESRC)  
Food Standards Agency England  
Food Standards Scotland  
Health Care Research Wales (HCRW)  
Health and Social Care Research and Development (HSC R&D) Division (part of the Public Health Agency) Northern Ireland (HSC R&D NI)  
Innovate UK  
Public Health England (PHE)  
National Institute for Health Research (NIHR)  
Chief Scientist Office, Scottish Government Health Directorates (CSO Scotland)  
Scottish Government (Strategic Research programmes)  
The British Heart Foundation (BHF)  
The Medical Research Council (MRC)  
The Wellcome Trust (WT)  
World Cancer Research Fund UK (WCRF UK)

**Scope:**

Funding organisations were provided with guidance on the type of data required and what might be included in nutrition and health research: specifically research examining the impact of diet, dietary pattern or food components on normal biological function, health status or the development of disease.

Including:

- the effect of maternal diet/birth weight on life course events/early origins of disease
- gut function/health, the interface with nutrition and nutrition-related diseases; energy balance at the cellular and physiological level
- appetite control and factors influencing malnutrition and obesity
- obesity-related research – investigating genetic or molecular factors affecting obesity, appetite control, or energy balance; the effect of diet and exercise (but not exercise alone), lifestyle or environmental factors on obesity, strategies for prevention or treatment of obesity; and how obesity affects other diseases
- treatment or prevention strategies based on diet, dietary pattern or nutrients
- research into eating disorders where this is looking at health outcomes
- behaviour, consumer choice and food availability where this is looking directly at health and/or physiological outcomes
- research relating to food production or food safety only where the research is looking at nutritional content and/or health outcomes – eg food fortification or food allergy
- research undertaken in vitro or in animals having a relevance for human health;

Not in scope:

- behavioural research from a wholly social or cultural perspective
- research relating to nutrition and animal health
- agri-food research without health and/or physiological outcomes
- research on alcohol in the absence of diet

**Data capture:**

- A five-year funding summary of each organisation's nutrition and health research spend (research award, training award (fellowships), core unit or institute funding, research infrastructure funding)
- Live (on 1 January 2016) research awards and infrastructure awards eg core facility or platform, survey, major cohort – which serves to underpin nutrition research
- Where available – UK Clinical Research Collaboration (UKCRC) Health Research Classification<sup>71</sup> (Research Activity) for the live at 1 January 2016 awards (if this was not available from the funder then the MRC coded the awards)

**Data analysis**

All of the data received were manually checked using the working description above. It should be noted that not all funders were able to provide all categories of data requested. Some funders were not in a position to provide five-year spend data as this was not easily available; funders capture retrospective funding data in different ways – for example as yearly spend on awards made, or as whole life values<sup>72</sup> of the awards made that year<sup>73</sup>; many funders do not fund all four categories (research, training, units, infrastructure) or use UKCRC Health Research Classification categories. Specific funder notes are provided in the Annex.

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71. UK Clinical Research Collaboration (UKCRC) Health Research Classification System (HRCS)

72. The whole lifetime value of an award eg a 3-year project with an annual budget of £100k would have a whole life value of £300k

73. These are very different and cannot be collated together

With the exception of Public Health England funding for the National Diet and Nutrition Survey, this figure does not include support for significant national research infrastructure.

### **Data obtained from ÜberResearch *Dimensions* database**

Some data (where specifically indicated) was compiled using ÜberResearch's *Dimensions* platform, which has collated, cleansed and disambiguated a database of grants from more than 90 funders worldwide<sup>74</sup>. This includes a majority of funders from the UK. Details and a complete funder list can be found at [www.uberresearch.com](http://www.uberresearch.com)

### **Research data categorisation and classification**

The MRC, created a semantic nutrition and health 'category' in *Dimensions* based on tried and tested MRC diet, nutrition and human health portfolio search categories.

There were three key elements to this *Dimensions* category:

- 1) A Boolean expression – linked to algorithms utilising the Natural Language Processing that underpins *Dimensions*. Each term expression receives a score based on specific rules<sup>75</sup>:
- 2) An ability to 'Boost' terms or keywords
- 3) An ability to remove unspecific, unrelated and/or superficially relevant grants, which were not deemed fit to be part of this portfolio

All of the data for the 'live in 2015' analysis were manually checked using the working description above.

### **Important considerations**

*Dimensions* uses publically available data sources, such as; Gateway to Research, Euro PubMed Central, eReporter, as well as, some directly contributed data. Pooling data from multiple sources has many advantages but also some obvious limitations (for example, some relevant data – abstracts or funding amounts may be omitted from the public databases). In addition, all subject searches require a degree of subjective decision making: there is no perfect data set.

With this in mind, all of the data for the 'active in 2015' analysis were manually checked using the working description above.

## **Portfolio analysis – Results**

### **Five-year funding summary**

Notes: data is shown for those funding organisations able to make a return in this category. Some funders were not in a position to provide five-year spend data as this was not easily available. It is important to note that funding organisations capture retrospective funding data in different ways – either as yearly spend on awards made, or as whole life values of the awards made that year. For this reason the five-year data has been presented in two parts (see below) according to how each organisation's description of the five-year data provided.

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74. This includes funders in biomedical and non-biomedical fields

75. a. More specific terms receive a higher score than more common terms. This is calculated exactly by determining the total number of mentions a term has against the whole of the grants database. b. A term found in the title scores more than the same term found in the abstract. c. The same term found in a short abstract score more than the same term found in a longer abstract.

### Total combined per year spend

The following charts show the total combined per year funding for the funding organisations and agencies specified. The combined total spend for nutrition and health research over this five-year funding period was £411,243,538m; 73% of this was Research Council funding.

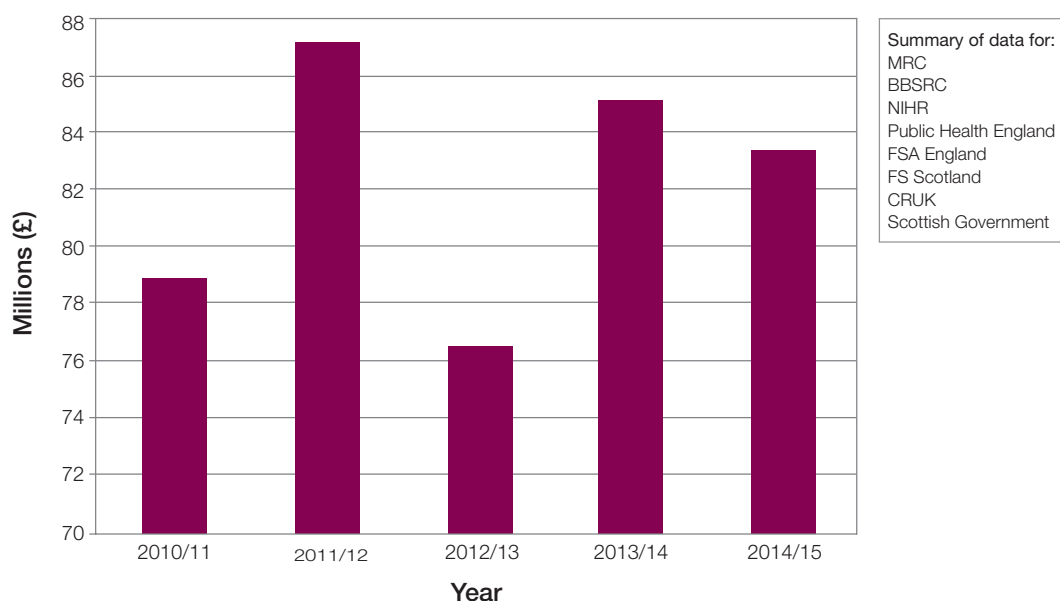


Chart shows spend per year

### Total combined per year spend by investment type

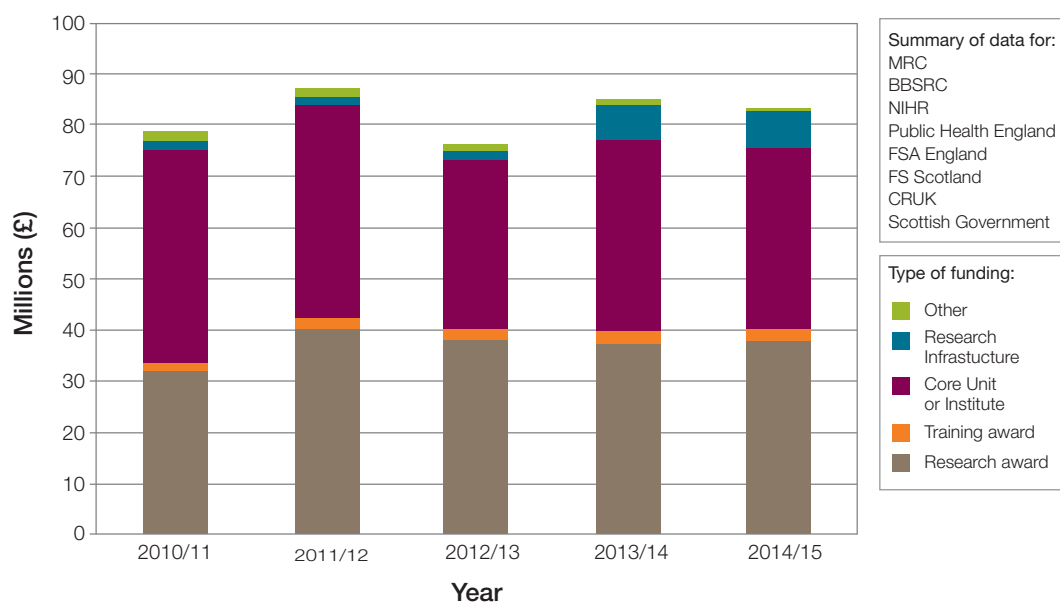


Chart shows spend per year

### Total combined whole life value of awards per year

The following charts show the total combined whole life value of awards per year for the funding organisations and agencies specified. The combined total spend for nutrition and health research over this five-year funding period was £80,540,618m; 93% of this was charity funding.

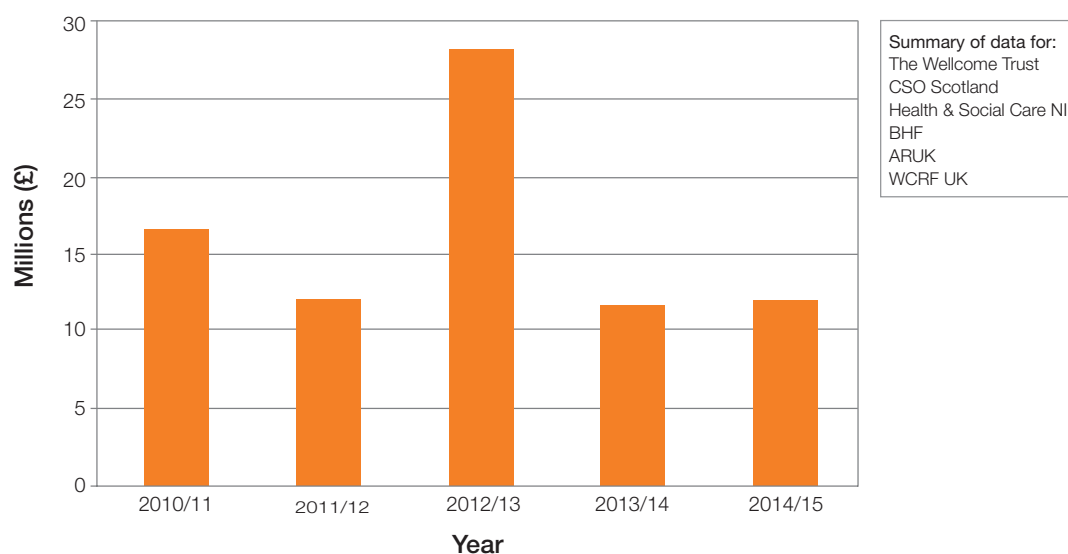


Chart shows whole life value of awards per year

### Total combined whole life value of awards per year and by investment type

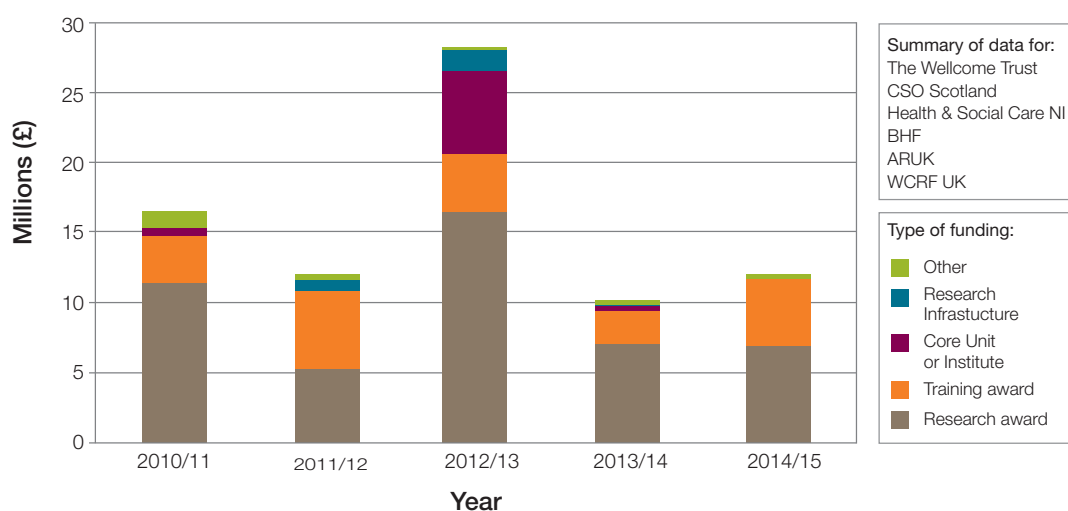


Chart shows whole life value of awards per year

**Funding to UK researchers for nutrition and human health research**

The ÜberResearch *Dimensions* database was used to enable a comparison of the level of funding provided to UK researchers by selected UK-based funding organisations and agencies and the European Commission and European Research Council. The chart captures the whole life value of awards active in the year 2015.

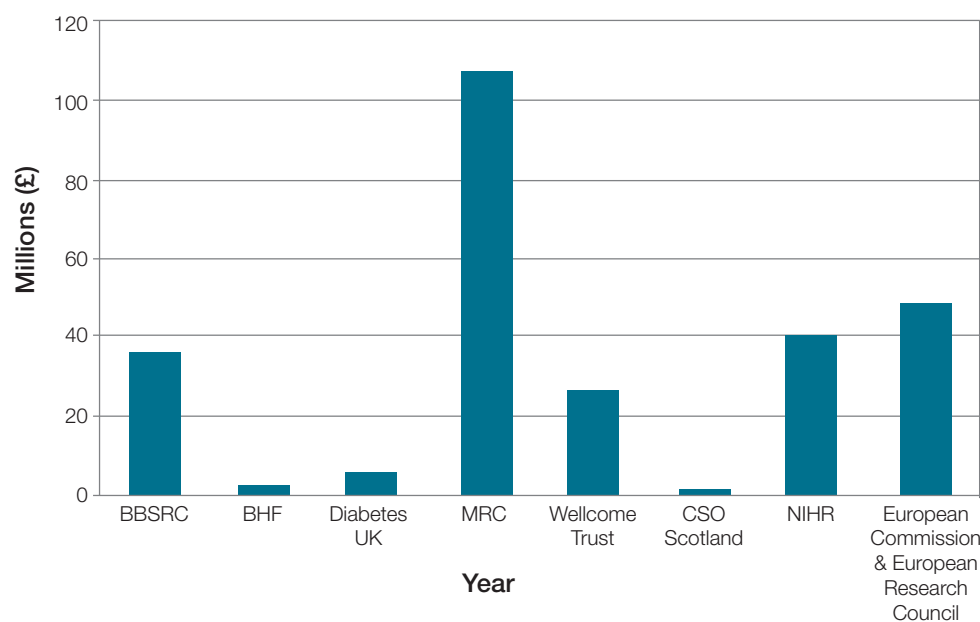


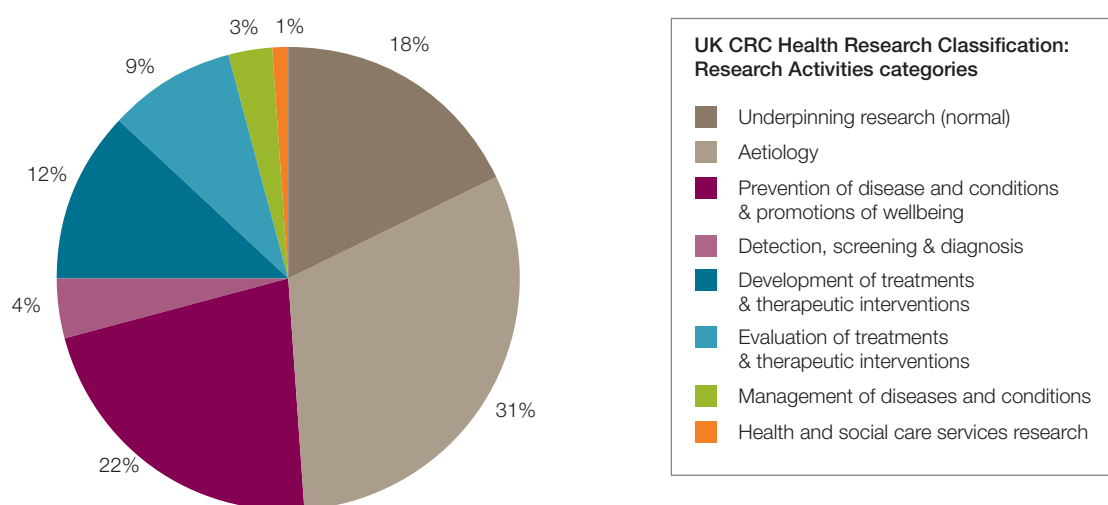
Chart shows whole life value of awards active in 2015  
Data obtained from the ÜberResearch Dimensions for Funders database <http://www.uberresearch.com>

It should be noted that according to the ÜberResearch *Dimensions* database the total amount of live nutrition awards (whole life values) in 2015 funded by the European Commission and European Research Council to researchers globally was £504m (264 awards). Of course, it has not been possible to check all 264 awards for exact fit to the remit of this portfolio review so it is possible that the total award value and number of awards is much less than this.

## Analysis of the portfolio of awards live on 1 January 2016 – combined data from the funding organisations

The total value of live awards (whole life values at 1 January 2016) across funders - £265,683,956m.

The combined data from the funding organisations and agencies has been classified against the UKCRC Health Research Classification: Research activity categories. The high-level set of research activity categories are shown below.

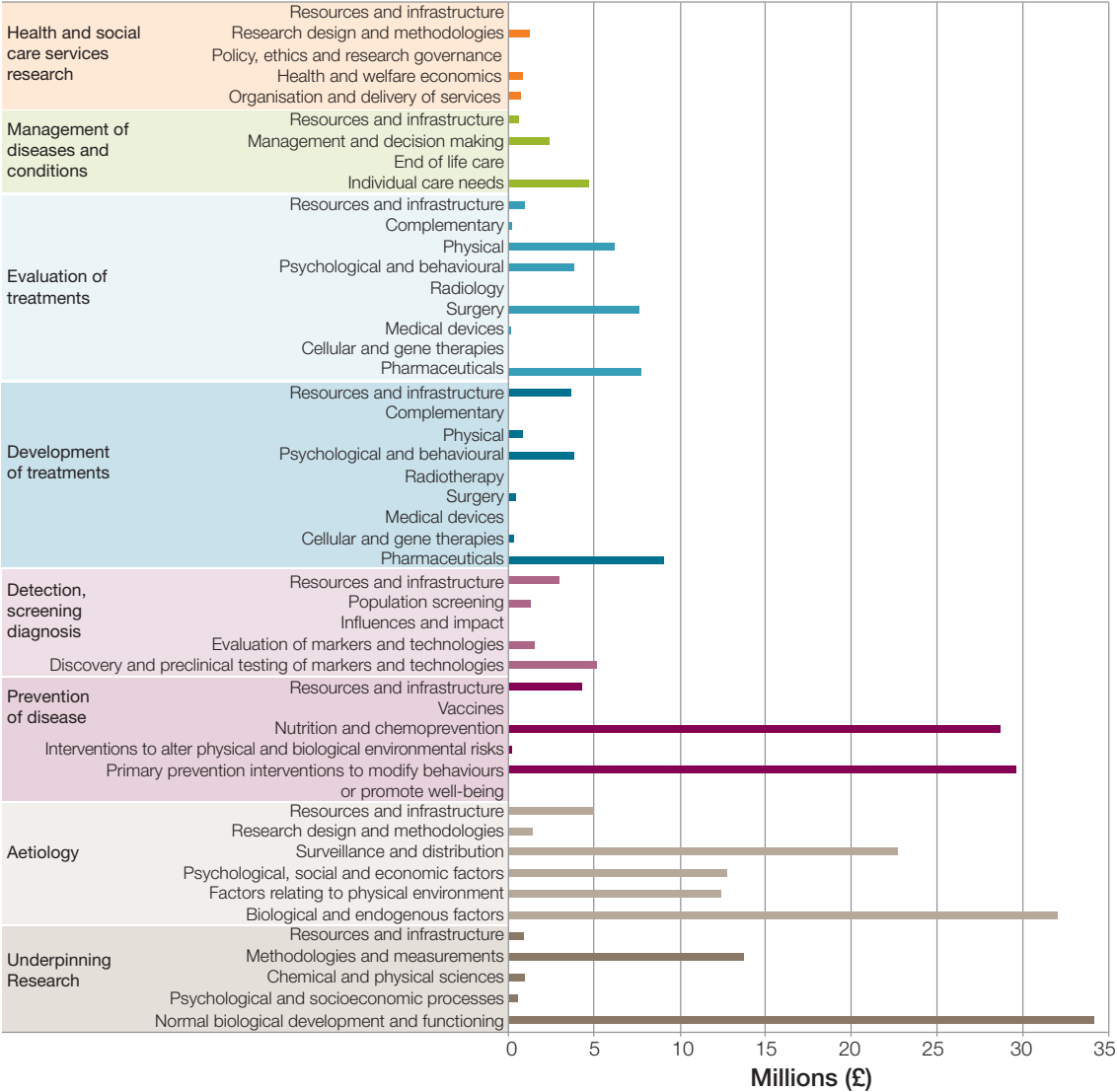


Live portfolio analysis: 1 January 2016

### Analysis of the portfolio of awards live on 1 January 2016 – combined data from the funding organisations

Combined data from the funding organisations and agencies classified against the UKCRC Health Research Classification: Research activity categories. The full set of categories are shown below although some may not be relevant to nutrition research.

### UK CRC Health Research Classification: Research Activity categories



Live portfolio analysis: 1 January 2016



**Funding organisation notes:**

In general, it should be noted that the research analysed relates to a specific remit and the funding organisations may be supporting broader research portfolios.

**BBSRC**

Analysis only includes relevant nutrition and human health research – it does not include: i) projects to develop healthier foods if there was no specific nutrition and health outcomes for the project ii) BBSRC's portfolio of research on microbial food safety which is approximately £8m per annum. BBSRC's five-year data does not include figures for training (not available) for 2010/11.

**Chief Scientist Office, Scotland**

CSO funds response mode research across all areas of applied health research. In addition to the grant – and fellowship-based funding relating to nutrition CSO also funds a number of research units with broad remits that include research relevant to the review. CSO has also contributed to strategic initiatives and schemes such as the multi-funder National Prevention Research Initiative led by the MRC, as well as NIHR award programmes.

**ESRC**

Five-year spend data not available at the time of data collection. Data included in the summary is very specific to nutrition and health. ESRC funds a much broader research portfolio.

**Food Standards Scotland**

The returned data includes some dietary survey work and food purchasing studies.

**Health Care Research Wales**

Five-year spend data not available. HCRW has funded relevant research but did not have any live research projects covering this area at present.

**Public Health England**

Public Health England was established on 1 April 2013 to bring together public health specialists from more than 70 organisations into a single public health service. PHE data includes work commissioned by the Diet & Obesity team. The five year summary covers time as PHE.

**National Institute for Health Research**

Data supplied by the NIHR Evaluation, Trials and Studies Coordinating Centre (NETSCC) and Central Commissioning Facility (CCF) teams and NIHR data cross checked using the ÜberResearch *Dimensions* for Funders database. A further analysis of nutrition-related funding was undertaken by NIHR in September 2016 and the findings are attached as an Annex to this report.

**Wellcome Trust**

The significant increase in funding seen in years 2012/13 was a result of a large Strategic Award made to the Institute of Metabolic Science, in collaboration with the MRC.

**World Cancer Research Fund UK**

World Cancer Research Fund UK (WCRF UK) is a member of the World Cancer Research Fund network of cancer charities with a global reach, dedicated to the prevention of cancer through diet, weight and physical activity. Please note that the data provided is not comprehensive of all research and activities funded by WCRF UK. World Cancer Research Fund International is a not-for-profit umbrella organisation that leads and unifies this network of cancer charities, providing strategic direction and administration of the Grant Programmes.

## **Nature and range of National Institute for Health Research (NIHR) support for nutrition-related translational research for the financial year (FY) 2015-16**

### **Additional data analysis undertaken in September 2016**

Alan Jackson, Kathryn Lewer, Steve Wootton – NIHR Office for Nutrition Research

### **The National Institute for Health Research (NIHR)**

NIHR supports research that will bring benefit to patients and the public through improved treatment and better care. It is charged with driving a program of translational research “from bench to bedside” for the benefit of patients, people and the economy, against the expectation that the effective translation of high quality research enables better structured approaches to standardised care through policies, protocols and guidelines for the benefit of all.

Supported by the Department of Health, the NIHR has created a health research system in which the National Health Service supports the best people working in the best facilities to carry out the research that best meets the needs of patients and the public.

By supporting leading-edge scientific research, NIHR drives speedier translation of basic scientific discovery to tangible benefits for patients and the public and creates the best possible conditions for inward investment by the life sciences sector. NIHR works in partnership with all sectors including other Government funders, academia, charities and industry. The NIHR manages its responsibilities through four organised components – the infrastructure, the faculty, the research and the systems.

### **Available information on nutrition-related research**

#### **The challenge**

There is an inherent challenge in determining the nature and extent of NIHR-supported nutrition related research because nutrition-related disease or malnutrition are not captured as specific Health Categories by UK Clinical Research Collaboration (UKCRC). To address this we sought the assistance of Business Intelligence Teams within the NIHR health research system in order to extract relevant nutrition-related studies from NIHR databases.

#### **Approach**

To be able to assess research effort in this area required that a bibliographic approach that met the purpose be developed. There are two obvious benefits from this approach: it helped to define the boundaries of the nutrition-related activity; the terms identified could be used in a consistent way across all NIHR databases. A number of sources were consolidated to identify 49 keywords that were considered to best capture nutrition-related activity and these were used in the search.

NIHR supports activities associated with specific aspects of nutritional-related research which can be captured in three separate but related areas: NIHR coordinating centres, NIHR Research Schools; Department of Health Policy Research Programme (further details in Annex). We contacted and received support from individuals with knowledge of relevant activity within each of the different areas:

### **NIHR coordinating centres**

There are four NIHR coordinating centres with the responsibility of managing awards on behalf of NIHR and we contacted and received support from the person in each coordinating centre with the technical expertise to access their data, interpret the request and supply results for the financial year (FY) 2015-16.

### **NIHR Research Schools**

The NIHR supports three “schools”: The School for Public Health Research, The School for Primary Health Research and The School for Social Care Research. The research conducted by the schools can be seen as being both directly relevant to nutrition and indirectly relevant to nutrition. The former addresses the biology and biological context within which nutrition might operate to either support health or increase the risk of ill-health. The latter may not necessarily identify or capture nutrition as a specific entity, but nevertheless has the potential to impact significantly on the wider environmental context for nutrition specific activities. The contribution of the indirect activities will tend to be underestimated.

### **Department of Health Policy Research Programme**

The Policy Research Programme (PRP) is a national research funding programme within the Department of Health’s (DH) Research and Development Directorate. The PRP commissions high quality, research-based evidence relevant to the full policy remit of the DH.

### **The Process**

A search was carried out of the titles and abstracts of each award to identify the use of the 49 pre-defined nutritionally sensitive terms. For those awards that were identified using the search terms, the title and abstract were reviewed by two individuals to ensure that the topic of the award was relevant to nutrition. Any differences of opinion were resolved by discussion. This generated a list of nutrition related research awards that had been supported by each coordinating centre. For each coordinating centre a summary statement could be made of the monetary value of the awards, the nature or scope of the awards and the geographical spread of the awards:

**SCALE** – The number of active projects that could be considered to be related to nutrition. The amount of funding committed and whether directly supported by NIHR, or NIHR-enabled;

**SCOPE** – Based on the UKCRC Health Categories, to determine with which recognised specialty or research theme the identified nutrition-related project was associated.

**SPREAD** – The geographical distribution of the supported research activities.

## Results

By using the 49 nutritionally sensitive terms it was possible to identify a wide range of nutrition-related research activity across a number of topic areas.

For the four NIHR coordinating centres, a total 1,106 projects were identified as being nutrition-related for FY 2015-16:

- 75 projects were funded by programmes running out of NIHR Evaluation, Trials and Studies Coordinating Centre (NETSCC)
- 500 projects were being prosecuted out of the NIHR Central Commissioning Facility (CCF) infrastructure
- 23 projects were supported by CCF programmes and
- 508 studies/projects were identified within the NIHR Clinical Research Network (CRN) portfolio.

There were 40 personal awards reported from the NIHR Trainees Coordinating Centre (TCC) for which there had been an active positive spend during FY 2015-16.

The estimated total NIHR investment (active spend) during FY 2015-16 was £41,596,519 across the TCC personal awards, NETSCC projects and CCF programme grants. It was not possible to derive an estimate of NIHR investment for the CCF infrastructure or CRN at this time.

### NIHR Trainees Coordinating Centre (TCC)

The TCC reports 40 personal awards, all but 3 of which were personal awards at the doctoral or post-doctoral levels. They had been awarded to a range of professionals with 25% going to dietitians. Geographically, 35% of awards were in London and a high proportion were in the south of England. TCC only reports on awards in England, hence the devolved nations are not included. The value of these awards for FY2015-2016 was around £17,136,144.

### NIHR Evaluation, Trials and Studies Coordinating Centre (NETSCC)

NETSCC fund 5 research programmes with different specialist remits and reported 75 projects of which 89% were entirely NIHR funded, totalling £13,137,805. Some projects were NIHR-enabled but received support from other bodies such as the MRC, totalling £931,454. Of the 5 research programmes, Health Technology Assessments (HTA) accounted for 38 projects. The most prominent HRCS health category was 'cancer' which accounted for 43% of the projects. It is the responsibility of NETSCC to manage the evaluation of research programmes across the entire UK and 24 cities were home to the 'lead centres' for the nutrition-related projects distributed across England, Wales, Scotland and Northern Ireland.

### NIHR Central Commissioning Facility (CCF)

The information obtained from the CCF database can be divided into two components:

- 500 projects out of the CCF infrastructure,
- 23 projects which were supported by a CCF programme.

Of the 500 projects operated out of CCF infrastructure, 32% were entirely NIHR funded. The five most frequent UKCRC Health Categories were metabolic and endocrine (n=106), generic health relevance (n=50), oral and gastrointestinal (n=47), cancer (n=47) and cardiovascular (n=45). There were 235 projects from the Biomedical Research Centres; 137 projects from the Clinical Research Facilities; 82 projects from Biomedical Research Units; 42 projects from Collaborations for Leadership in Applied Health Research and Care (CLAHRCs) and Healthcare Technology Co-operative (HTCs) projects. The CCF supports research projects in England, and of these 192 were located in London. The current awards were for a total of £11,322,570.

Of the 23 projects supported by a CCF programme, 16 were supported through the Research for Patient Benefit (RfPB) programme; 4 through Programme Grants for Applied Research (PGfAR); 2 through Programme Development Grants (PDG); and 1 through Invention for Innovation (I4I). The two most frequent UKCRC Health Categories were cancer (n=8) and cardiovascular (n=6).

### **NIHR Clinical Research Network (CRN)**

A total of 508 nutrition-related studies were identified within the CRN portfolio. They can be characterised in relation to the clinical specialty within which the work was carried out. The 5 most frequent were diabetes (n=61), children (n=42), primary care (n=40), cancer (n=33) and metabolic and endocrine disorders (n=33). Of these, 239 studies were observational, 225 studies were interventional and 44 were both. A total of 68,260 patients were recruited to these studies, with the greatest numbers being in the Thames Valley and South Midlands LCRN (26.8%).

### **NIHR Research Schools**

The Research Schools support work which has both a direct and an indirect impact upon aspects of nutritionally-relevant research. Of this work there are 10 programmes of direct relevance to nutrition which were active in FY2015-2016.

### **Policy Research Programme**

We were able to identify eight specific programme areas supported by PRP, six of which were active in FY2015-2016.

### **Comment**

This analysis has identified an extensive and wide pattern of relevant research being supported by NIHR in areas of activity that were identified as being nutritionally-related, based upon the 49 nutritionally sensitive terms developed for this purpose. The work was not necessarily seen as being nutrition related by the investigators themselves and they represent very wide variability in terms of focus and topic of interest, approach to investigation, purpose of the enquiry, outcomes of interest and subject group.

## Further background information on NIHR activities associated with specific aspects of nutrition-related research

### NIHR Coordinating Centres

The four NIHR Coordinating Centres are:

NIHR Trainees Coordinating Centre (TCC). The TCC provides training awards and career development awards (personal awards) to individuals. The awards are intended to better enable the development of a career as a clinical-academic, thereby enhancing the research careers of future leaders, which will in turn contribute directly to a stronger, more capable NHS Research Faculty.

The NIHR, Evaluation, Trials and Studies (NETS). NETS funds programmes of research for independent researchers, which inform evidence based decisions for policy in health and social care. They are managed by the NIHR Evaluation, Trials and Studies Coordinating Centre (NETSCC). Some of the research programmes share common themes and complement each other, but may have different specialist funding remits.

The NIHR Central Commissioning Facility (CCF). CCF supports the NIHR in providing information on recruitment to clinical trials, including commercial trials. They manage the Senior Investigator awards, competitions for the NIHR Faculty and for the NIHR Infrastructure, which comprise the following initiatives:

- Biomedical Research Centres (BRCs)
- Biomedical Research Units (BRUs)
- Clinical Research Facilities (CRFs) for Experimental Medicine
- Collaborations for Leadership in Applied Health Research and Care (CLAHRCs)
- Diagnostic Evidence Co-operative (DECs)
- Healthcare Technology Co-operative (HTCs)
- Patient Safety Translational Research Centre (PSTRCs).

The CCF also manage the following research funding programmes:

- Research for Patient Benefit (RfPB)
- Programme Grants for Applied Research (PGfAR)
- Programme Development Grants (PDG)
- Invention for Innovation (I4I)

The NIHR Clinical Research Network (CRN). The CRN comprises 15 Local Clinical Research Networks that deliver a portfolio of studies across 30 clinical specialties, for example: ageing, cancer, gastroenterology, respiratory disorders. This high quality clinical research activity generates recruitment data and the NIHR CRN Portfolio, which is used to inform the allocation of NHS infrastructure for research (including NHS Service Support Costs).

### **NIHR Research Schools**

The three schools are the School for Public Health Research, the School for Primary Health Research and the School for Social Care Research:

The School for Public Health Research is a partnership of eight academic centres with excellence in public health research. They have three major research themes: changing behaviour; changing the environment; and identifying cost-effective population health services.

The School for Primary Health Research is a partnership of nine academic centres with excellence in primary care research. They have five major research programmes: disease prevention and diagnosis; non-communicable disease, multi-morbidity and ageing; acute care; organisation and delivery of care; and research innovation and new technologies.

The School for Social Care Research is a partnership of five academic centres with excellence in research which covers a wide range of research in social care. They have five major programmes of activity: prevention and promotion; empowerment and safeguarding; care and work; service interventions, commissioning and change; and resources and interfaces.

### **Department of Health Policy Research Programme**

The Policy Research Programme commissions research by open competitive tender within the DH Research Governance Framework (2005). This research is managed by CC and PRP works alongside other national programmes within the National Institute for Health Research (NIHR), DH analysts and other government departments, as well as with policymakers in DH and system partners.

# Annex 3

## Key challenges and related questions

How can we ensure we are supporting the right research, infrastructure and expertise to develop an evidence base to support policy needs and improve the health of the public?

### SESSION 1: Research challenges and opportunities

Exploration of UK's nutrition and health research:

- Strengths and concerns
- International context and identification of the UK's niche
- How does MRC and NIHR contribute to the UK position? Other funders and stakeholders?
- What is known and what are the critical gaps?
- Emerging areas and opportunities
- How can we maximise the translation and impact of human nutrition research for the benefit of patients and the public?
- Are there any obstacles to research and/or its effective translation? If so, what is their nature?

### SESSION 2: Infrastructure – current landscape and future needs

Key elements of supporting infrastructure for nutrition and health research including: assay and analytical platforms; facilities for volunteer and patient studies; international facilities or global health; cohorts and biobanks; nutritional databases etc.

- Discussion of strengths and concerns
- What is the present state (capabilities and limitations) of human nutrition research (academia, clinical and industry) in the UK, as set in an international context?
- Coordination and join-up; UK and internationally
- How do MRC and NIHR contribute to the UK position? Other funders and stakeholders?
- Future requirements – improvements and/or new investment

### SESSION 3: Building capability and expertise

Capacity building for nutrition and health research:

- Strengths and concerns
- What are likely to be future demands and opportunities in the area?
- Are there specific strategic gaps in relation to particular skills and leadership in basic, clinical, translational research, including industry?
- How do MRC and NIHR contribute to the UK position? Other funders and stakeholders?
- Future requirements
- Are infrastructure and capability/expertise coordinated and well-matched?

### SESSION 5: Coordination and integration – partnering for success

- How well is nutrition and health research coordinated across i) disciplines ii) funders and stakeholders?
- How can we improve partnership with the food industry, particularly at the biomedical interface? What are the barriers?
- How can we maximise coordination and integration of effort across stakeholders – UK and internationally?
- Motivation and incentives/dis-incentives of those involved
- Can we strengthen our impact through new or improved partnerships?
- What can we learn from other disciplines? Other countries?



# Annex 4

## Workshop: Nutrition and Human Health Research 7 & 8 July 2016

Venue: BIS Conference Centre, 1 Victoria Street, London, SW1H 0ET

### Programme Day 1: Thursday 7 July

- 9.30 Registration and refreshments
- 10.00 – 10.10 Welcome – Professor Chris Day, Chair of the Nutrition Review  
Purpose of the meeting and what we wish to achieve (10')
- 10.10 – 11.10 The big issues – Key nutrition and health challenges (50'+10')**  
Chair: Professor Chris Day
- Opening Address: Professor Sir John Bell GBE (5')  
Chair, Office for Strategic Coordination of Health Research (OSCHR)
- Keynote Talk: Research to inform policy and public health decision making (15')  
Dr Alison Tedstone – Deputy Director of Diet and Obesity/Chief Nutritionist,  
Public Health England
- Keynote Talk: Nutrition – opportunities for greater health impact (15')  
Professor Alan Jackson – Professor of Human Nutrition, Southampton and NIHR  
Director for Nutrition Research
- Keynote Talk: We can do better (15')  
Professor Hannelore Daniel, Chair of Nutrition Physiology,  
Technische Universität München
- Open discussion: Q&A session with the panel of speakers (10')

### The health of human nutrition research – Are we fit for the future?

- 11.10 – 11.20 Introduction to the next sessions (10')  
Dr Des Walsh, Head, Population and Systems Medicine, MRC

### SESSION 1: Research – challenges and opportunities

Chair: Professor Alan Jackson

- 11.20 – 11.30 Key challenges: Professor John Mathers (10')
- 11.30 – 12.15 Roundtable discussion: (45')
- 12.15 – 13.00 LUNCH (45')

### SESSION 2: Infrastructure – current landscape and future needs

Chair: Professor John Mathers

- 13.00 – 13.10 Key challenges: Professor Peter Morgan (10')
- 13.10 – 13.55 Roundtable discussion: (45')

### **SESSION 3: Building capability and expertise**

Chair: Professor Ian Young

14.00 – 14.10 Key challenges: Professor Christine Williams (10')

14.10 – 14.55 Roundtable discussion: (45')

15.00 Afternoon Tea break (15')

### **SESSION 4: Food for thought – Feedback and discussion**

Chair: Professor Chris Day

15.15 – 16.10 Feedback from sessions 1, 2 and 3 (55')

Feedback from the group facilitators

16.10 – 17.10 Open discussion with Panel (Professors Mathers, Morgan and Williams) (60')

Discussion of grand challenges and potential solutions

Close of day 1

19.30 WORKSHOP DINNER

## **Programme Day 1: Friday 8 July**

9.30 Refreshments available

10.00 – 10.15 Welcome – Professor Chris Day (15')

Main messages from day 1 and context for day 2

### **10.15 – 10.35 The big issues – Key nutrition and health challenges Cont.**

Chair: Professor Chris Day

Keynote Talk: The importance of partnerships (15')

Dr Pamela Byrne - Chief Executive Officer, Food Safety Authority of Ireland

Questions (5')

### **The health of human nutrition research – Are we fit for the future? Cont.**

10.35 – 10.45 Re-cap instructions for the next sessions: Dr Des Walsh (10')

### **SESSION 5: Coordination and integration – Partnering for success**

Chair: Professor Yolanda Sanz

10.45 – 10.55 Key challenges: Professor Wim Saris (10')

10.55 – 11.40 Roundtable discussion: (45')

11.40 Morning coffee break (15')

## **SESSION 6: Food for thought – Feedback and discussion**

Chair: Professor Alan Jackson

11.55 – 12.15 **Feedback from sessions 5 (20')**

Feedback from the group facilitators

12.15 – 12.40 **Open discussion with Panel** (Professors Saris and Sanz and Dr Byrne) (25')

Coordination and integration – grand challenges and potential solutions

12.40 – 13.20 **LUNCH (40')**

### **13.20 – 14.30 Vision for the future**

How can we ensure we are supporting the right research, infrastructure and expertise to develop an evidence base to support policy needs and improve the health of the public?

Chairs: Professors Chris Day and Alan Jackson

13.20 – 13.30 **Key challenges:** Professor Sadaf Farooqi (10')

13.30 – 14.30 **Open discussion:** (60')

Building on discussions during the meeting, identify opportunities for future innovative research, the development or utilisation of new technologies, and further multidisciplinary and cross-sector engagement:

- How are we positioned to meet future research challenges and policy needs?
- Research and capabilities (expertise and infrastructure) – are we capitalising on game-changing opportunities and addressing important gaps?
- What should the landscape look like in 5 and 10 years' time?
- What do we need to do to reach our goals?
- What are the barriers to achieving this vision?

### **14.30 – 14.40 Where next?**

Summary of next steps – Dr Des Walsh (10')

Close of meeting

## Nutrition and Human Health Research Workshop

### List of speakers and workshop attendees

Professor Ashley Adamson	Newcastle University
Dr Lucy Allen	NIHR Office for Clinical Research Infrastructure
Professor Stephen Allen	Liverpool School of Tropical Medicine
Professor Sir John Bell	University of Oxford
Dr Jayne Brookman	Knowledge Transfer Network
Professor Judith Buttriss	British Nutrition Foundation
Dr Pamela Byrne	Food Safety Authority of Ireland
Professor Janet Cade	University of Leeds
Professor Aedin Cassidy	University of East Anglia
Dr Fraser Courts	Campden BRI
Professor Hannelore Daniel	Technical University of Munich
Dr Lucy Davies	Cancer Research UK
Professor Chris Day	Newcastle University
Dr Alison Daykin	Department of Health
Professor John Draper	Aberystwyth University
Dr Karla Duarte	NIHR Office for Clinical Research Infrastructure
Dr Susan Elden	Department for International Development
Professor Sadaf Farooqi	University of Cambridge
Dr Karen Finney	Medical Research Council
Dr Nita Forouhi	University of Cambridge
Professor Gary Frost	Imperial College London
Professor Keith Godfrey	University of Southampton
Dr Katy Gordon-Smith	Nutricia
Mrs Hazel Harper	Innovate UK
Professor Alan Jackson	University of Southampton
Dr Louisa Jenkin	Biotechnology and Biological Sciences Research Council
Dr Sarah Kehoe	University of Southampton
Dr Lindsay Keir	The Wellcome Trust
Professor Mike Kelly	University of Cambridge
Professor Tim Key	University of Oxford
Professor Michael Leitzmann	University of Regensburg
Mr Daniel Leverton-Vaughan	Medical Research Council
Miss Kathryn Lewer	National Institute for Health Research
Professor Graham Lord	King's College London
Professor Julie Lovegrove	University of Reading
Dr Joanne Lunn	Waitrose
Professor Ian Macdonald	University of Nottingham
Dr Joe McNamara	Medical Research Council
Professor John Mathers	Newcastle University
Dr Danielle McCarthy	Sainsbury's
Dr Christine McGuire	Department of Health
Professor Peter Morgan	Rowett Institute of Nutrition & Health, Aberdeen
Mrs Maura O'Donnell	VitaFlo International Limited
Ms Polly Page	MRC Human Nutrition Research, Cambridge
Dr Stella Peace	Unilever

Dr Ann Prentice	MRC Human Nutrition Research, Cambridge
Dr Belinda Quick	Mondelēz International – Europe
Professor Elio Riboli	Imperial College London
Professor Yolanda Sanz	Institute of Agrochemistry and Food Technology (IATA)
	National Council for Scientific Research (CSIC)
Professor Wim Saris	Maastricht University
Professor Naveed Sattar	University of Glasgow
Professor Avan Aihie Sayar	Newcastle University
Dr Nadia Slimani	International Agency for Research on Cancer
Professor Tim Spector	King's College London
Mrs Maggi St-Jon Vaughan	Medical Research Council
Professor Patrick Stover	Cornell University
Professor Sean Strain	Ulster University
Dr Alison Tedstone	Public Health England
Dr Joy Todd	Economic and Social Research Council
Dr Desmond Walsh	Medical Research Council
Professor Martin White	University of Cambridge
Professor Christine Williams	University of Reading
Professor Dominic Withers	Imperial College London
Professor Ian Young	Queen's University Belfast

# Annex 5

## Written Consultation – List of UK and international experts who responded and key questions posed

### Nutrition and Human Health Review – Key questions

1. Are there any important obstacles to nutrition research and/or its effective translation? If so, what is their nature and how might these be overcome?
2. Are there specific strategic gaps in the academic or industry sectors in relation to particular skills and leadership in basic, clinical, translational research?
3. How can we best foster interdisciplinary approaches and sustainable partnerships, including with industry, to improve impact?
4. How can we maximise impact of human nutrition research for the benefit of patients and the public?

*We would welcome your thinking on nutrition research framed in a broader international context. When answering these questions you may wish to consider likely future demands and opportunities in the area, nationally and internationally, including what might be learned from other countries.*

### List of experts who provided comments:

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Professor Neena Modi	Imperial College London, UK
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76. With contributions from Institute colleagues



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