JPI
a healthy diet
for a healthy life

Strategic Research Agenda
2012-2020 and beyond

Joint Programming Initiative
A healthy diet for a healthy life

2nd edition — June 2015

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Foreword

Since the launch of the Joint Programming Initiative A healthy diet for a healthy life (JPI HDHL) in 2010, 25 countries have been working together to achieve a common vision that by 2030 all citizens will have the motivation, ability and opportunity to consume a healthy diet from a variety of foods, have healthy levels of physical activity and that the incidence of diet-related diseases will have decreased significantly. The core principle of the JPI HDHL is to facilitate co-ordination between policy makers within the countries involved with a view to support collaboration between scientists to generate new scientific knowledge, share existing knowledge and expertise, and bring together important datasets in the areas of food, nutrition and health.

In Europe as well as other countries, such as Canada and New Zealand, governments are struggling with the growing social and economic burden of diet- and lifestyle-related diseases such as type 2 diabetes, cardiovascular diseases and certain cancers but also of malnutrition and micronutrient deficiencies as for example in elderly and diverse minority groups. In the JPI HDHL Member States, through the Management Board and on the advice of the Scientific and Stakeholder Advisory Boards, engage in defining, developing and implementing a common Strategic Research Agenda (SRA) to tackle major societal challenges that no country is capable of tackling on its own.

To address this societal challenge, the JPI HDHL SRA defined three research pillars that cover the determinants of diet and physical activity, diet and food production and finally diet in the context of diet-related chronic diseases. In each of these three pillars the JPI has defined research priorities thereby providing a roadmap for harmonized, co-ordinated and structured research efforts. The initial execution of these research priorities is described in the Implementation Plan 2014-2015. An Implementation Plan for the period 2016-2018 is currently being developed. To date, Joint Actions have been used by the JPI HDHL to support collaborative research efforts that are thematically organized with respect to the three research pillars. JPI HDHL Member States contribute to individual Joint Action on a variable geometry basis and their involvement is based on their national research priorities and the availability of funds. New instruments may be developed in the future to support the strategic objectives of the JPI HDHL.

Following web based and national consultations, and approval by the Management Board of the JPI, the SRA of the JPI HDHL covering the period 2012-2020 was published in 2012. The SRA was based on advice and guidance from the Scientific Advisory and the Stakeholder Advisory Boards. Since 2012, much progress has been made in implementing elements of the SRA. In research pillar 1, the SRA defines a holistic research approach on the determinants of food choices and physical activity behaviors as the basis of any attempt to change consumer´s attitudes and for promoting more healthy lifestyles. Approaches to this research challenge are described in the Implementation Plan 2014-2015 and a broad transnational Knowledge Hub on DEterminants of DIet and Physical ACtivity (DEDIPAC) was launched. In research pillar 2 on diet and food production, a Joint Action was launched on the validation of biomarkers and the investigation of intake/exposure and nutritional status biomarkers in the area of nutrition and health. The two research projects that

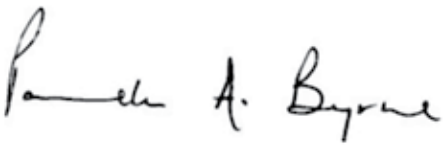
resulted from this Joint Action are addressing new food markers and the role of microRNA-species as new marker entities. In research pillar 3, the Joint Action European Nutrition Phenotype Assessment and DAta Sharing Initiative (ENPADASI) focuses on the development of an open access research infrastructure. With this infrastructure, researchers in ENPADASI are able to share, integrate and analyze data from a great variety of human studies on effects of diets and foods in a standardised and coordinated way.
These activities have translated the SRA into real transdisciplinary and pan-European research efforts, thus the JPI HDHL has been very successful in the first phase of implementation leading to improved coordination thereby significantly strengthening the base and competitiveness of the European Research Area.

Various themes and research subjects defined by the JPI HDHL in the SRA are closely linked to changes in global food production systems and thereby relate to critical policy issues, such as management of the food economy and on food security. Food systems are challenged by the need to sustainably increase production to support but at the same time may not consider the nutritional composition of those agricultural products. In addition, this increase in output has to be accomplished against a increasing competition for land for the production of biomass. Consumer expectations, for example regarding food quality, safety, price and convenience, are also changing. So in addition to the Joint Actions described above, the JPI HDHL has been working with the JPI Agriculture, food security and climate change (FACCE) to identify research challenges in the area of sustainable food and nutrition security. A similar requirement for co-ordinated efforts applies to other grand challenges such as the aging societies and the rapidly growing number of elderly with neurodegenerative diseases. Therefore, in research pillar 3, the role of the diet for brain function and neurodegenerative diseases has been identified as a priority and collaboration opportunities with the JPI's on Neurodegenerative Diseases and More Years Better Lives will be explored. In addition, there are also horizontal Issues defined within the SRA in which the JPI HDHL will need to support coordination.

This second edition of the JPI HDHL SRA builds on the first edition which was published in 2012, outlining additional strategic objectives that will be considered by JPI HDHL member countries over the coming years. The strategic objectives outlined in this SRA will be executed through a series of Implementation Plans which will be developed by the Management Board and guided by the advice of the Scientific and Stakeholder Advisory Boards over the coming years.

Taking this all into account, the prime aim of the JPI A healthy diet for a healthy life is to better understand the food-health relationship and subsequently translate this knowledge into programs, products, tools and services that enable consumers from Europe and beyond to live a healthy life. In the JPI HDHL we are all committed to bring collaborative efforts forward and for establishing a fully operational and vital European Research Area.

June 2015,



Pamela Byrne

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Executive summary

To address major societal challenges, the European Commission has suggested an enhanced cooperation in European research and development (R&D). This joint programming is a process by which participating countries engage in defining, developing and implementing a common Strategic Research Agenda (SRA), based on a common vision of major societal challenges that no country is capable of resolving on its own.

In September 2010 the Vision Document of the Joint Programming Initiative (JPI) A healthy diet for a healthy life (HDHL) was approved by the Management Board. Since its inauguration, the JPI has increased in size with the inclusion of new EU Member States, and also Third Countries, such as Canada and New Zealand. The partnership and collaboration with Canada and New Zealand show that the societal challenge that JPI HDHL is addressing is relevant for countries beyond the EU and its associated members. In recognition of this fact the Management Board of JPI HDHL updated its vision in 2015 as follows:

The vision of the JPI on A healthy diet for a healthy life is that by 2030 all citizens will have the motivation, ability and opportunity to consume a healthy diet from a variety of foods and to have healthy levels of physical activity, and that the incidence of diet-related diseases will have decreased significantly.

The following three key interacting Research Areas were identified and are described in this document:

Determinants of diet and physical activity: ensuring the healthy choice is the easy choice for all consumers. The challenge is to understand the most effective ways for improving public health through interventions targeting motivation, ability and opportunity to adopt and maintain healthy dietary and physical activity behaviours.

Diet and food production: developing healthy, high-quality, safe and sustainable foods. The challenge is to encourage farmers and the food industry to produce and to market foods with a healthier improved nutritional content, and to stimulate consumers to select foods that fit into a healthy diet and which are also safe, sustainable and affordable.

Diet-related chronic diseases: preventing diet-related, chronic diseases and increasing the quality of life. The challenge is to prevent or delay the onset of diet-related chronic diseases by gaining a better understanding of the impact of nutrition and lifestyle on human health and diseases.

For each of these Research Areas, primary initiatives and research challenges are described for the periods 2012-2014 and 2015-2019. Horizontal issues to achieve the primary goal for 2020 and beyond of a full integration of the Research Areas and the establishment of a European Nutrition and Food Research Institute, are formulated in the last chapter.

The SRA is structured along the lines of establishing networks and standardising new and existing data in Europe and beyond and making these databases accessible, followed by joint research programmes. Future joint programming agendas are envisaged to be

developed within a (virtual) European Nutrition and Food Research Institute. The research needs to be framed by effective strategies for joined-up research including new infrastructures but also by development and innovation activities. Clear communication within the JPI HDHL, as well as effective dissemination to all stakeholders is crucial for success.

The SRA of the JPI HDHL was launched in 2012. This current second edition of the SRA is published in June 2015 and provides an update on the development of foods and lifestyles in Europe and beyond, as well as a greater perspective on the context of the JPI HDHL and horizontal issues. Furthermore, the document contains some additional research themes that were identified by the Foresight Activities, Scientific Advisory Board and Stakeholder Advisory Board. In the forthcoming years, the JPI will work on an extensive update of the SRA in which the goals for 2020 and beyond will be updated and specified in greater detail by taking into account results of the first Joint Actions of the JPI HDHL and other transnational projects related to healthy diets and healthy lives.

Introduction

A healthy diet for a healthy life

Diet, health and physical activity

According to the Kondratieff Cycle Theory, health is the key driver for Europe's growth and prosperity[1]. Governments of European countries and across the world are struggling with the growing social and economic consequences of an alarming increase in diet-related diseases, including obesity, type 2 diabetes, cardiovascular disease, malnutrition[2], micronutrient deficiencies and food intolerances and allergies[3] in subgroups of the population. Lack of sufficient physical activity and excessive energy intakes are the prime factors determining overweight and obesity development, and the growing incidence of diseases directly or indirectly linked to these lifestyle factors. Increased affluence and urbanisation are contributary factors that result in lifestyles and daily routines which require less physical activity. At the same time, access to foods with high energy density is becoming more prevalent. It can be foreseen that without effective prevention of diet-related diseases and with an ageing population, health systems will be stretched to their breaking point. Consequently, improving health by providing more healthy diets, changing food choice patterns and increasing energy expenditure are key priorities for most countries involved with the joint programming initiative A healthy diet for a healthy life (JPI HDHL) in fighting obesity and diet-related chronic diseases amongst their populations.

The 2014 WHO Global status report on noncommunicable diseases showed that these diseases are the most commen cause of death worldwide. They were responsible for 68% of all deaths globally in 2012, up from 60% in 2000. The four main groups of noncommunicable diseases are cardiovascular diseases, cancers, diabetes and chronic lung diseases. Noncommunicable disease are mainly caused by preventable risk factors[4]. In addition, the Global Burden of Disease (GBD) 2010 identified that the burden of non-communicable diseases (i.e., the absolute number of years of life lost and the years lived with disability) has been increasing in the past decades. The largest increases were associated with diabetes. Using exposure data and the causal associations of risk exposure to disease and injury outcomes, the WHO identified the five leading risks for worldwide mortality as: high blood pressure (responsible for 12.8% of deaths globally), tobacco use (8.7%), high blood glucose (5.8%), physical inactivity (5.5%), overweight and obesity (4.8%). These risks are strongly associated with the development of chronic diseases, such as cardiovascular disease, type 2 diabetes and certain cancers. The burden of disease attributable to risk factors is measured in terms of lost years of healthy life using the metric of the disability-adjusted life year (DALY), which combines years of life lost due to premature death with years of healthy life lost due to illness and disability (see Table 1). According to the GBD[5] all leading risk factors associated with diet and physical inactivity accounted for 10.2% of global DALYs in 2010.

1 www.kondratieffzyklen.de
2 Stratton RJ. Malnutrition: another health inequality? Pennington Lecture. Proc Nutr Soc 2007;66:522-529.
3 McBride D, Keil T, Grabenhenrich L, et al. The EuroPrevall birth cohort study on food allergy: baseline characteristics of 12,000 newborns and their families from nine European countries. Pediatric Allergy Immunology 2012: 23: 230-239.
4 World Health Organization (WHO). Global status report on noncommunicable diseases 2014. Geneva: WHO, 2014.
5 Murray CJL, Lopez AD. Measuring the Global Burden of Disease. New England Journal of Medicine 2013; 369 (5):448-57.

Table 1
Ranking of selected risk factors: ten leading risk factor causes of death worldwide, 2004[6] (in millions)

	Risk factor	Deaths	DALYs
1	High blood pressure	7.5	57
2	Tobacco use	5.1	57
3	High blood glucose	3.4	41
4	Physical inactivity	3.2	41
5	Overweight and obesity	2.8	36

Eight diet-related risk factors, including high blood pressure, high body mass index, high cholesterol, high blood glucose, low fruit and vegetable intake and physical inactivity together account for 61% of cardiovascular deaths, the leading cause of death worldwide[6].

If no positive action is taken, it is expected that the prevalence of diet- and lifestyle-related diseases will increase rapidly in the next decade and have a negative social and economic impact in many EU Member States. For this reason, the European Parliament adopted in September 2011 a resolution (P7_TA(2011)0390) on the European Union position and commitment in advance of the UN high-level meeting on the prevention and control of non-communicable diseases. Cardiovascular diseases and cancer are the leading causes of death in economically developed countries and obesity is the second main cause, after smoking, of developing cancer. Cardiovascular diseases represent a major economic cost. For example, overall cardiovascular diseases are estimated to cost the European economy almost €196 billion a year[7]. Of the total cost of cardiovascular diseases in Europe, around 54% is due to direct health care costs, 24% to productivity losses and 22% to the informal care of people with cardiovascular disease[8]. There is evidence that improved lifestyles can reduce the risk of type 2 diabetes by 58% over four years. Population studies have shown that up to 80% of cases of coronary heart disease and up to 90% of cases of type 2 diabetes could potentially be avoided through changing lifestyle factors[9]. Similarly about one-third of cancers could be avoided by eating healthily, maintaining normal weight and regularly exercising. Physical inactivity is seen as another key modifiable factor contributing to risk of obesity and associated diseases. Furthermore, sedentary behaviour is beginning to be seen as a separate important risk factor; it appears that being sedentary for large periods of the day may carry a separate risk that is not prevented by short periods of activity[10]. There is thus a pressing need to quantify physical activity and sedentary behaviour in addition to research on improved nutritional food choice and dietary intake to gain full insight into energy balance and obesity in European populations[11].

6 World Health Organization (WHO). Global health risks. Mortality and burden of disease attributable to selected major risks. Geneva: WHO, 2009.
7 Allender S, Scarborough P, Veto V et al. European Cardiovascular Disease Statistics 2008 edition. Brussels: European Heart Network, 2008.
8 Nichols M, Townsend N, Luengo-Fernandez R, Leal J, Gray A, Scarborough P, Rayner M (2012). European Cardiovascular
9 Disease Statistics 2012. European Heart Network, Brussels, European Society of Cardiology, Sophia Antipolis
10 WHO/FAO. WHO/FAO Expert Consultation on Diet, nutrition and the prevention of chronic diseases. WHO Technical Report Series, No. 916. Geneva: WHO, 2003.
11 Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. Exerc Sport Sci Rev 2010;38:105-113.

Successful strategies for reducing obesity rates must target all age groups and use a life-course approach underpinned by natural experiments[12]. Prevention should start in early life phases as there is increasing evidence that prenatal and infant nutrition can condition for health problems later in life. Advances in these areas require a better understanding of the underlying mechanisms and effective translation into the public health domain. Cost-effective measures to improve citizens' health status will deliver very significant social and economic benefits and improve future productivity and competitiveness.

In the recommendations published in The Lancet[12] five messages for a concerted response were formulated:

1 The obesity epidemic will not be reversed without government leadership.
2 'Business as usual' would be costly in terms of population health, health care expenses and loss of productivity.
3 Speed and sustainability of weight loss are usually overestimated and need to be readjusted.
4 Basic population weight data and intervention outcomes need to be accurately monitored and evaluated.
5 A systems approach is needed which operates across multiple sectors.

These recommendations also set a firm basis for projects and programmes developed within this JPI.

Key message[13]
Governments have largely abdicated the responsibility for addressing obesity to individuals, the private sector, and non-governmental organisations. However, the obesity epidemic will not be reversed without government leadership, regulation and investment in programmes, monitoring, and research.

As a direct response to an ageing population, there is a particular demand of research in Europe, and elsewhere, to define the dietary needs of the elderly and geriatric groups, examine their lifestyles and develop foods that can promote healthy ageing. Proper health maintenance and vitality throughout all the stages of life has to be assured by all means, including education, adequate physical environments and diets, and with a high level of commitment by commercial and public entities.

12 The EU Platform on Diet, Physical Activity and Health was set up in March 2005 to provide a forum for stakeholders at European level; the High-Level Group on Nutrition and Physical Activity strengthens the role of governments in counteracting overweight and obesity.
13 Swinburn BA, Sacks G, Hall KD, et al. The global obesity pandemic: shaped by global drivers and local environments. The Lancet 2011;378:804-815.

The European population and their food

Attempts to increase public awareness of the best way to eat more healthily, despite being very numerous, have not led to major changes in patterns of food purchase and consumption. More attention must be given to finding ways to increase people's motivation, abilities and opportunities to make healthy choices[14]. To do this effectively, research is needed to discover why consumers make certain choices; what they understand about food; what type of information is lacking; how this information can best be presented; what factors prevent individuals and populations from exercising a healthy lifestyle and what changes in the food and nutrition environment can 'nudge'[15] people towards more healthy choices. Research has shown that knowledge is often not a direct determinant of eating behaviour.
A UK House of Lords Science and Technology Select Committee[16] examined the evidence base for the effectiveness of nudges in the context of alcohol, food, and physical activity. They concluded that while businesses and industry, with their enormous, expensive and clever advertisements, are very effective at nudging people to buy and consume their products, non-regulatory measures to increase consumption of healthy food in isolation are unlikely to be effective.

Increased differentiation of (European) populations on socio-economic and age grounds may increase vulnerabilities in some target populations and this might be exacerbated by genetic population differences. Some population subgroups appear more vulnerable to diet-related diseases (for example, population groups with a lower socio-economic status, socially-excluded groups, some immigrant communities and ethnic minorities), particularly during critical life periods such as pregnancy, lactation, infancy, childhood and old age. Any delay in the onset of chronic diseases, such as cardiovascular diseases, type 2 diabetes and some cancers, or in their reduction, are important from the perspectives of improving quality of life and improving European competitiveness through reduced absenteeism, impact on household economic functioning and health services costs.

The world population is expected to increase to over nine billion by 2050. There is a requirement to guarantee this growing population access to and control of safe, sustainably-produced, nutritious and culturally-acceptable food, and to manage the necessary balance between food demand, health and nutrition requirements and natural resources. Global food scarcity and food poverty could become a major threat to the world's population within a decade. At present, a large proportion of foods, from raw materials to finished products, is wasted because of spoilage; a situation that is particularly evident in rural communities in Africa and Asia. Alternatives to animal-based food proteins are needed to guarantee a future protein supply. The need for more sustainable food production and associated supply systems must also be addressed.

14 Brug J. Determinants of healthy eating: motivation, abilities and environmental opportunities. Family Practice 2008;25:i50-i55.
15 To nudge is to push into action gently.
16 House of Lords. Science and Technology Select Committee. Behavioural Change. 2nd report of Session 2010-12. London: The Stationery Office Limited, 19 July 2011.

The food and drink industry

The food and drink industry[17] is an important economic sector in Europe and other countries participating in JPI HDHL, such as Canada and New Zealand. In Europe it is the largest manufactoring sector in terms of turnover (14.9%) and added value (12.9%). In addition, the EU food and drink industry is a key job provider and a direct employer of 4.24 million people with jobs spread across all European Member States, mostly in rural areas. The EU is the number one exporter and the number two importer of food and drink products worldwide, bringing the EU positive trade balance for food and drink to a record level of €28 billion in 2012. The EU food and drink industry is diverse, with a variety of sectors ranging from meat processing to diary production and drinks. The top-5 sub-sectors include bakery and farinaceous products (made from, rich in or consisting of starch), meat and meat products, dairy products, drinks and the 'various food products' category. These sectors represent 75% of the total turnover and more than four fifts of the total number of employees and companies[18].

When taking a look at the JPI HDHL Third Countries Canada and New Zealand, the Canadian food and drink industry is a large manufacturing sector. The Canadian food supply industry accounts for 2% of the national Gross Domestic Product (GDP) and is the largest manufacturing employer. The largest food processing industry in Canada is meat production. Dairy product manufacturing is the second largest industry followed by beverage manufacturing. Canadian processed food and beverage products are exported to around 190 countries with a significant proportion exported to the USA[19]. The food and drink industry is also important for New Zealand as a major exporter. New Zealand's food and drink exports are growing strongly and the country's export performance is strong and improving relative to peers. New Zealand is the largest exporter in the world of dairy products and lamb, and a major exporter of beef, kiwifruit, apples, seafood and wine[20].

A clear trend towards a stronger segmentation of the food and drink sector will drive a need for innovation in all stages of the value chain. Innovative technologies will, in the first place, strive to increase agricultural production as well as to produce and process food meeting different demands in the context of changing lifestyles and increasing health awareness[21]. On the other hand, consumer acceptance for technologies (e.g., genetic modification of living organisms) is of a crucial importance. In addition, technological advances and innovations in the food sector can also lead to negative consequences regarding the prevalence of diet-related diseases, for example when driven by efficiency and productivity.

17 In this document reference to the 'food industry' refers to the food and drink industry, including plant-, animal- and marine production.

18 FoodDrinkEurope. Data & Trends of the European Food and Drink Industry 2013-2014.

19 Government of Canada. Agriculture of and Agr-food Canada. http://www.agr.gc.ca/eng/industry-markets-and- trade/statistics-and-market-information/by-product-sector/processed-food-and-beverages/significance-of-the-food-and-beverage-processing-industry-in-canada/?id=1174563085690

20 iFAB (2014). 2013 F&B industry overview. http://www.med.govt.nz/sectors-industries/food-beverage/pdf-docs-library/information-project/2013-OverviewReport.pdf

21 The complex interrelation between food production, innovation, consumer demand and broader environment is examined e.g. in the 3rd SCAR Foresight exercise Sustainable food consumption and production in a resource-constrained world (2011), or UK Government Foresight report The Future of Food and Farming: Challenges and Choices for GlobalSustainability (2011)

Consumers are demanding assurance from food producers that ethical and environmental concerns are reflected in the foods they purchase and that they and their families consume. Transparency, traceability as well as consumer information and communication, thus, become increasingly important for food, nutritional and health choices. Consumers trust that their foods and drinks are safe and have become much more demanding in their requirements of food quality, which requires longer shelf-life, food reformulation, use of a limited number of additives and consideration of environmental aspects. The trend towards safe foods of high quality and 'fair' products is accompanied by growing preferences for local or regional food products as this is seen as one of the important means to preserve cultural landscapes as well as cultural heritage and regional identity[22]. In addition, the health effects and promotion of key natural foods such as fruit and vegetables, whole grains, meat, dairy and marine products should also receive proper attention. Consumers also expect unlimited access to high-quality drinking water that needs to be assured by the public and commercial sectors.

Neither the primary production sectors nor the Small and Medium Enterprises (SME) that dominate this sector in the EU (99.1% of the 286,000 companies were SMEs in 2011[23]) can invest in long-term or large-scale research and development (R&D). Small food companies, in particular, are unable to take on the innovation challenge and so a joint and coordinated initiative is required. Effective partnerships built on public and private collaborations, and funding, are necessary to identify the most important research needs and to pool resources. Consideration must also be given to laws and regulations and the protection of intellectual properties (IP) arising from this research to ensure that SMEs can derive benefits from their outputs. This will foster a strong culture of investment in R&D in this sector. This has been addressed in the European Technology Platform Food for Life[24].

22 A comprehensive outlook and scenarios encompassing also trends and changes in consumer demand in Europe is provided by e.g. Colin Blackman, (2005),"A healthy future for Europe's food and drink sector?", Foresight, 7 (6), pp. 8-23.

23 FoodDrinkEurope. Data & Trends of the Food and Drink Industry 2013-2014.

24 www.etp.ciaa.eu.

The (European) Food Systems: a whole system approach

Health aspects related to food supply and dietary choices are closely linked to economic, social and environmental determinants of consumer behaviour. Specifically, challenges within food systems, such as ecosystem degradation, resource scarcity and social inequalities play an important role in the dietary behaviour and health of consumers. The current food systems are inadequate, which is illustrated by the high levels of food waste and the provision and promotion of foods high in fat, sugar and salt, while obesity and diet-related diseases are increasing. This indicates the need for an urgent change in the food systems, aligned with values such as environmental sustainability, public health and social justice. This change may include the introduction of new foods to cover shortages of certain nutrients or to provide more nutritious foods that are affordable and appealing, and enable consumers to follow a healthy diet. Furthermore, attention should be drawn to the consequences of introducing highly customised diets and new foods and food replacements, and the potential loss of the social aspects implicated in sharing meals. Realisation of sustainable diets, (i.e., covering environmental, social, economic and health aspects) will require a holistic food-chain perspective, aiming at an economically viable system for all actors within the food chain[25].

The interest in the role of agriculture in improving nutrition and specifically the nutritional quality of food has increased in the past years. Agriculture is a source of improving the nutritional quality of foods necessary for a healthy life, but agricultural policies and technologies foremost focus on improving profitability instead of improving nutrition[26]. Collaboration with other JPIs, especially the JPI Agriculture, Food Security and Climate Change (FACCE-JPI) is crucial to bring together researchers in the fields of agriculture and public health nutrition. As JPI FACCE foremost focuses on food security, the JPI does not include human nutrition aspects. Besides JPI FACCE some other JPIs, in particular JPI Climate and JPI Oceans, have a common interest in sustainability, food systems and health.

25 Bock A-K, Maragkoudakis P, Wollgast J (2014). JRC Foresight Study: Tomorrow's Healthy Society — Research Priorities for Foods and Diets (Final report). European Commission.

26 Bouis HE, Welch, RM (2010). Bioforticication — A sustainable Agricultural Strategy for Reducing Micronutrient Malnutrition in the Global South. Crop Science, 50 (2): S1-S13.

The way forward: A Joint Programming Initiative for well-coordinated and harmonised research activities

Joint Programming is the process by which Member States engage on a variable-geometry basis in defining, developing and implementing a common Strategic Research Agenda (SRA) based on an agreed vision of how to address major societal challenges that no individual country is capable of handling on their own. For research on the relationship between diet, exercise and health in particular, large population studies and controlled trials with a long-term follow-up are needed that have sufficient power to demonstrate the influence of factors such as individual differences in genotypes and variable dietary patterns on health parameters. Joint Programming entails a voluntary partnership between Member States (and Associated Countries) of the European Union and aims to tackle major European societal challenges by combining and coordinating national research programmes and, thereby, making better use of Europe's public R&D resources. Furthermore, non-European countries have expressed their interest in joining these European initiatives enabling them to address societal challenges on a global level. The Joint Programming process has the potential to bring major benefits by:

- Helping to coordinate the scope of research programmes across Europe and beyond and diminishing duplication in effort.
- Making it easier to address common challenges, to develop common solutions and to speak with one voice on food and nutrition policy in the international arena.
- Promoting scientific excellence through joint calls with common funding, bringing together expertise and minimising duplication of research activities.
- Supporting cross-border collaboration and facilitating data pooling (preferably collected in a uniform and standardised way).
- Sharing fragmentary expertise scattered across countries or throughout Europe as a whole so as to facilitate rapid dissemination of research results, promoting cross-border mobility, education and training.
- Increasing the scientific, technological and innovative impacts of the investments in public research.
- Increasing programme depth by strengthening the coordination with other related policies through greater programme visibility and promotion of cross-border policy learning.
- Using public resources more efficiently and effectively through reducing programme management costs and improving the accountability and transparency of public research programmes.

Europe's research landscape is still highly fragmented. As estimated based on data from European surveys, around 85% of public R&D spending is programmed, financed, monitored and evaluated at the national level, with little trans-national collaboration or coordination. Less than 6% of total R&D investment and only 15% of European publicly-funded civil R&D (of which 10% is accounted for by intergovernmental organisations and

schemes, and 5% by the Framework Programme of the European Commission) is financed through cross-border collaboration[27]. Thus, one of the most obvious causes of sub-optimal returns from R&D has been insufficiently addressed, namely the lack of collaboration and coordination between national public R&D programmes. This requires proper information, transparency and the willingness of national funding agencies to join and commit resources to multidisciplinary and multinational efforts. By enhancing cooperation among those that develop and manage research programmes, Joint Programming will:

- Reinforce the capacity to transform research results into societal and economic benefits, notably through the innovative capacity of industry as well as through educating consumers to better understand the importance of diet and exercise and to choose healthier foods.
- Contribute to the creation of the 'fifth freedom' by removing barriers to the free movement of knowledge.
- Develop suitable methodologies, research protocols and standards.
- Help overcome barriers to entry, such as high start-up and operating costs in certain science and technology fields.
- Lead to improved and standardised nutrition- and health-related statistics, terminology and evidence for policy-makers to base their decisions on.

Joint Programming may involve strategic collaboration between existing national programmes or jointly planning and setting up new initiatives. In both cases, it requires the significant commitment of participating countries in putting resources together, selecting or developing the most appropriate instrument(s), implementing collectively monitoring and reviewing progress. There is no need for all countries involved in JPI HDHL to be involved in a specific initiative but between them, the partners must be able to provide the required critical mass of resources. Close cooperation is needed to ensure that resources are targeted effectively, efficiently and with sufficient power to address societal and scientific challenges, without duplication of effort or leaving gaps that will reduce opportunities for innovation. Where necessary, experience and best practices from outside Europe must be captured and, if necessary, adapted before being exploited across the continent.

As well as having implications for quality of life, additional ramifications for an innovation trajectory can be identified. For example, there is an urgent need to translate results of scientific research more effectively into concrete and actionable policy initiatives. Closer interaction between policy actors, health professionals and scientists will ensure that policy questions can be translated into scientific activities, and vice versa. More effective interdisciplinary collaboration between the natural and social sciences is required, as many of the issues and emerging problems are caused by both biological and socio-economic factors and their interaction.

27 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the committee of the Regions. Towards Joint Programming in research: Working together to tackle common challenges more effectively. Brussels, COM(2008) 468.

The vision

The vision of the JPI *A healthy diet for a healthy life* is that by 2030 all citizens will have the motivation, ability and opportunity to consume a healthy diet from a variety of foods, have healthy levels of physical activity and that the incidence of diet-related diseases will have decreased significantly.

Strategy

Joint programming will contribute significantly to the construction of a fully operational European Research Area on the prevention of diet-related diseases and, by strengthening leadership and competitiveness of the food industry by effectively integrating research in the food-, nutritional-, social- and health sciences, will increase knowledge and deliver innovative, novel and improved concepts and products.

Strategic goal

To change dietary patterns based on developments in food-, nutritional-, social- and health sciences, and to develop evidence-based recommendations and innovative product formats that will, together with concomitant changes in physical activity, have a major impact on improving public health, increasing the quality of life and prolonging productive life.

A balanced, adequate diet and appropriate levels of physical activity are major requirements for optimal health, physical development and performance. This requires a good understanding of the health benefits of foods and drinks (and the combinations there of), food choices, production technologies and activity patterns. Joint programming in the field of nutrition, food, physical activity, sedentary behavior and health, with improved coordination of research should lead to a fully operational and coherent European Research Area on prevention of lifestyle and diet-related diseases with strengthened leadership and competitiveness of research[28]. An integrated multi-sector approach, embracing education, health care, agriculture, environment, food and drink industry, transport, advertising and commerce will be essential to position food, nutrition and related public health policy and evidence from research sufficiently high on the political agenda so that the combined effort can be translated into real health improvements.

28 Commission staff working document. Research Joint Programming Initiative on 'A healthy diet for a healthy life': motivations and state of play of research at European level. Brussels, 28.4.2010. SEC(2010)480 final.

Figure 1
Schematic presentation of the activities and Research Areas of the JPI A healthy diet for a healthy life

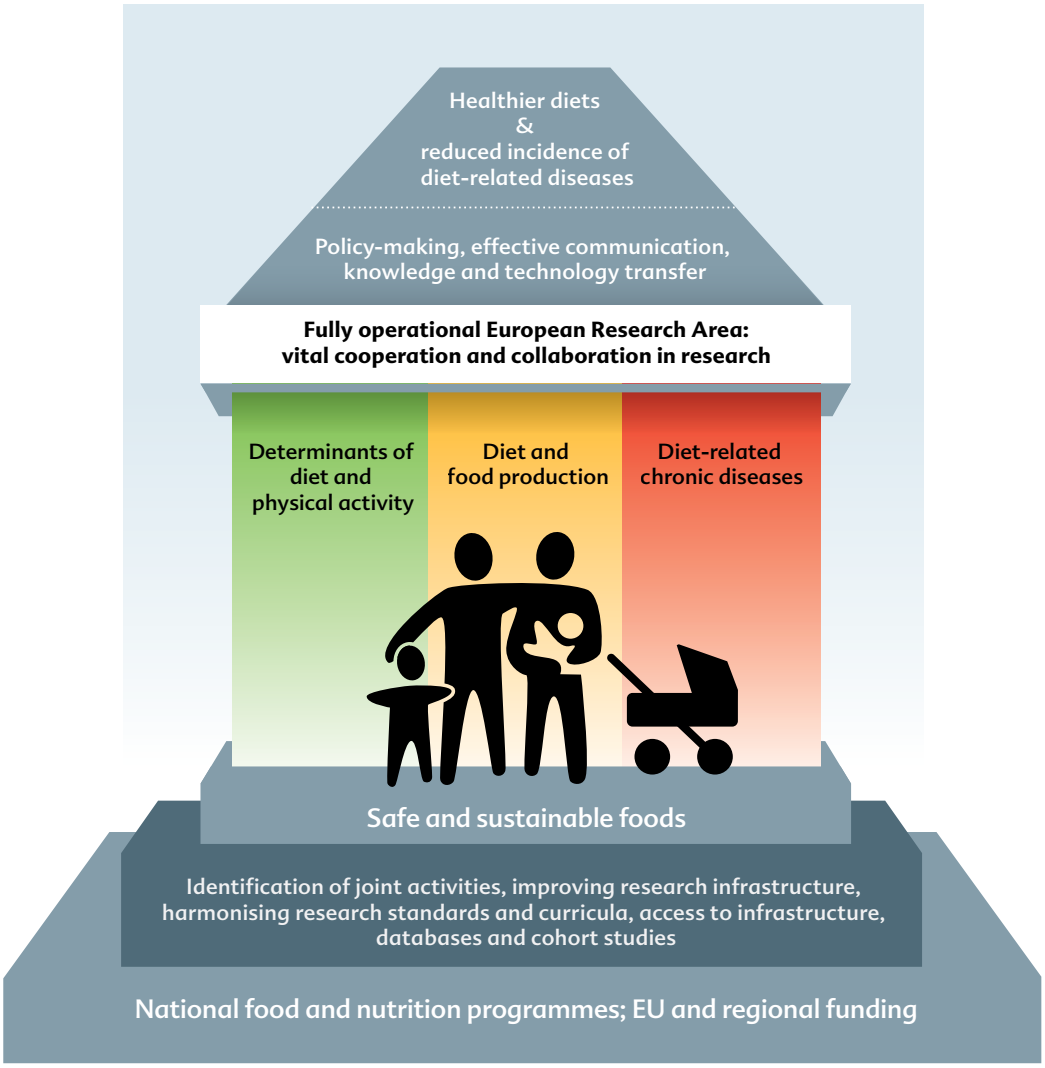


Figure 1 shows the identified activities and Research Areas that are necessary to attain the vision of the JPI A healthy diet for a healthy life. The following three key interacting Research Areas were adopted in the Vision Document.

Determinants of diet and physical activity: ensuring the healthy choice is the easy choice for consumers

This research aims to understand the most effective ways of improving public health through interventions targeting diet and physical activity and to understand the bottlenecks preventing consumers from choosing a healthy lifestyle. Research will include studies which aim to improve understanding of the different biological, psychological, motivational, environmental and socio-cultural factors that impact on health and the consumers' food and physical activity choices, and how they interact. The research will deliver information which will allow effective development and implementation of evidence-based interventions which will modify the impact of individual, social, economic, cultural, biological and other factors, affecting diet, physical activity and sedentary behaviour. Interactions with the other Research Areas are required to develop a full picture of potential determinants.

Diet and food production: developing healthy, high-quality, safe and sustainable foods

The agricultural and food industries are faced with the challenge of producing safe and tasty foods that are consistent with health status, lifestyle and culture, and that meet consumer preferences. This requires research to increase the understanding of food and diet compositions for optimal health, to develop new foods and to improve production, processing, packaging and proper food chain management. New foods have to comply with health, nutritional, energy and safety needs of consumers and also with legislation, and be affordable. An additional challenge is to develop innovative products and processes in a cost-effective and sustainable way and to provide insights into the barriers and facilitators for the agricultural and food industries to develop sustainable foods that will also benefit human nutrition. Foods must originate from systems that produce, process, store, package and supply foods in a fully sustainable way[29].

Diet-related chronic diseases: preventing diet-related chronic diseases and increasing the quality of life – delivering a healthier diet

Effective nutrition and lifestyle-based strategies are needed to optimise human health and reduce the risk, or delay the onset, of diet-related diseases. These strategies require, for example, research efforts on obesity and its causes (e.g., the availability of products rich in sugar and saturated fat and the effect of the environment on physical activity levels); research directed towards the association between neurological processes and metabolic disorders; on maternal and infant nutrition; on osteoporosis and malnutrition in the elderly; on micronutrient deficiencies and cognitive development and decline. The gastrointestinal tract is the key interface between food and the human body, and its role for human health (including immune functions) needs to be fully elucidated. This requires the incorporation of the gut indigenous microbiota as a metagenome with unique metabolic features.

29 An ERA-NET on Sustainable food production and consumption (Susfood) was launched in January 2012.

Strategic Research Agenda

This SRA further defines the three Research Areas above, and, based on the Vision Document, the knowledge base and structural framework that needs to be generated. It also proposes strategies on how to apply new and established knowledge to achieve the overall goal of the JPI A healthy diet for a healthy life. The following chapters describe the research priorities for each of the three defined Research Areas of the JPI. For each Research Area, the SRA identifies the knowledge gaps and defines research needs. The SRA is structured along the lines of establishing networks, strengthening the existing knowledge base, generating new data and standardising new and existing data, and making these databases accessible, followed by a description of joint research programmes. The primary initiatives and research challenges for each Research Area are described across three periods, 2012-2014, 2015-2019 and 2020 and beyond. Future joint programming agendas are envisaged to be developed within a (virtual) European Nutrition and Food Research Institute.

Implementation Plan

The SRA is a high level document which sets out the strategic areas JPI HDHL will act on to align and add value in the ERA landscape. To deliver on the vision and strategic goals of the JPI HDHL, JPI HDHL launches an Implementation Plan every 2 to 3 years in which the actions and activities that JPI HDHL will carry out in the next years are presented.

In the pre-implementation phase, JPI HDHL worked on the establishment of three Joint Action — one for each pillar. In this second edition of the SRA, current research activities resulting from these Joint Actions are described. The first Implementation Plan (2014-2015) of the JPI HDHL was launched in March 2014 and the Implementation Plan for 2016-2018, under development at date of publishment of this 2nd Edition of the SRA, will facilitate future planning for research investments at the level of the countries participating in JPI HDHL. Both Implementation Plans documents aim to translate the key research challenges into Joint Actions.

The implementation of the SRA, however, goes beyond the establishment of Joint Actions. Another crucial element of the Joint Programming Process is the alignment of national and European research programmes and strategies within a SRA, in order to achieve a European Research Area and to avoid fragmentation and duplication. JPIs play an important role in achieving alignment by bringing together programme owners, funding bodies and policy makers from both national and European level.

A significant amount of research activity relevant to nutrition and health is taking place within the participating countries of the JPI HDHL. Alignment of these activities with the goals of the JPI HDHL will increase the impact of the individual efforts of the involved countries to resolve the global societal challenge addressed by the JPI HDHL. At the national level often multiple funding bodies are involved in the area of nutrition and health, which may have different pay masters (e.g., ministries, private funds, charities) and mandates. Therefore, national tuning and collaboration within the participating countries of the JPI HDHL is of great importance for countries to be able to align with the JPI HDHL. Moreover, alignment and collaboration with the substantial number of European and global initiatives

with similar/related objectives of the JPI HDHL is crucial. Examples include European Technology Platforms (ETPs), European Innovation Platforms (EIPs), ERA-NETs and Knowledge and Innovation Communities (KIC) derived from the EC FP7 and Horizon 2020 programmes. Besides the JPI HDHL, nine other JPIs have been established, each addressing a different societal challenge. JPI HDHL can benefit from collaborating with these JPIs at a strategic level (e.g. sharing best practices) and at the level of Joint Actions (e.g., in areas of mutal interest). For example, the JPI FACCE is an important partner for collaboration, as together, the JPI HDHL and JPI FACCE cover the whole food and health system from farm to fork. In addition, other JPIs have interests in common with JPI HDHL, such as JP Neurodegenerative Diseases in research regarding nutrition and cognitive function. Finally, collaboration with the EC is essential for the implementation of the SRA to be able to differentiate between research topics that could profit from a place within the Framework Programmes of the EC and topics which could be more efficiently addressed by a Joint Action of the JPI. To conclude, the strategy and actions of JPI HDHL to encourage national and international alignment with the SRA will be an important part of the Implementation Plans of the JPI.

Stakeholders of the JPI HDHL

Stakeholders of the JPI HDHL are the scientific community, policy-makers, food producers, food and drink industry, workplaces, public health organisations, health care organisations, professionals, educational institutions, media and the civil society. Many of these stakeholders are represented in the Stakeholder Advisory Board (SHAB) of the JPI HDHL. The scientific community is represented in the Scientific Advisory Board (SAB). Both advisory boards are structured following the three Research Areas of the SRA and include members with expertise in at least one of the three areas. Both have played an advisory role in the development of the SRA and they provide the Management Board (MB) of the JPI HDHL with their advice when needed. In this way, the SHAB and SAB can make sure that all stakeholders of the JPI HDHL are addressed. Furthermore, they can provide a significant contribution to the achievement of the overall vision and goals of the JPI HDHL and its Research Areas.

RESEARCH AREA 1

Determinants of diet and physical activity

Ensuring the healthy choice is the easy choice for consumers

RESEARCH AREA 1
Determinants of diet and physical activity

The challenge is to understand and communicate the most effective ways of improving public health through interventions targeting dietary and physical activity behaviours. By 2030, all consumers will have the motivation, ability and opportunity to choose a healthy diet and physical activity pattern.

Overall goal

To understand the determinants, at both the individual and group levels, regarding diet, physical activity and sedentary behaviour using a broad multidisciplinary approach, including biological, ecological, psychological, sociological, economic and other socio-economic perspectives, and their interrelationships and to translate this knowledge into a more efficient promotion of a healthy diet and physical activity.

Scope

Diet and nutrition are of key importance for public and individual health and well-being. Specifically, unhealthy diets and nutrition are related to diet-related chronic diseases, such as obesity, cardiovascular disease and type 2 diabetes. The consumption of food is, however, also evidently associated with pleasure, culture and symbolism. In addition, economic factors and consumer preferences for sustainable production, etc. are also important to food choice. If foods and drinks with the right composition are consumed in the right amounts, they should make a major contribution to well-being and healthy ageing. Research is required to increase the understanding of health-impacting behaviour with respect to making diet and food choices. In addition, studies on the extent to which people from different ethnic populations engage in health promoting physical activity will create insights into how the social and physical environments influence these behaviours. This will lead to a rise in consumer understanding of healthy foods, healthy diets and healthy physical activity patterns and underpin consumer efforts to control their body weight. The main focus of this Research Area is on diet and food choice. However, because most diet-related chronic diseases are related to both diet and physical activity, this Research Area will also investigate physical activity, especially in relation to diet and food choice.

The European population is highly culturally and ethnically diverse and a wide variety of foods and drinks are consumed. Europeans also show substantial differences in levels of physical activity. Furthermore, the biological, ecological, psychological, sociological and socio-economic drivers of behaviour differ across Europe. This context and variation provides a unique opportunity to study the determinants of diet and food choices, and physical activity, all of which are related to health. Research in this area should ultimately be focussed on developing the most effective ways of improving public health through interventions designed to improve health environment by increasing the availability of cheaper and healthier choices, and through motivating and enabling consumers to adopt and maintain healthy diets and physical activity. Conceptually, this may include choosing for an architecture that can motivate, enable and nudge people to make better and more informed choices (as judged by themselves). The development of innovations in the area of Information and Communication Technology (ICT), including mobile devices, multimedia and web-based technologies (e.g., social media, online networks, e-health) may be an important part of this. ICT tools can provide consumers with tailored information about various health parameters, their physical activity and food intake and the origin and properties of their food. These developments have a potential to get closer to a more personalised advice regarding nutrition and physical activity, thus enabling consumers to consume a healthy diet and achieve a healthy lifestyle. Special attention needs to be placed on health issues associated with social inequality or minority groups' membership. Specifically, growing inequalities with regard to access to newly developed innovations should be taken into account.The research results generated will be of importance for policy-makers, professionals in the public health area, the food industry and citizens.

Research outcomes should lead to the development of integrated policy interventions that aim towards healthy diets and healthy lives, including their evaluation regarding the effect on consumers' health and lifestyles and their implementation in practice. One of the aims of these interventions is to develop healthier food environments, understanding the most effective ways for improving public health through interventions targeting food environments, specifically increasing the affordability, availability and acceptability of healthy food (and decreasing that of unhealthy food and drinks). Moreover, effective policies need to seek ways to motivate the various target groups or communities (depending on age, gender, religion or culture) by bottom-up incentives or schemes, pointing to indirect positive aspects of healthy diets and healthy lives. They should be able to respect various preferences in diets among different social groups.

Ensuring the healthy choice is the easy choice for consumers

RESEARCH AREA 1
Determinants of diet and physical activity

PRIMARY INITIATIVE FOR 2012–2014

To establish a European trans-disciplinary research network on determinants of dietary and physical activity behaviours, and their relation to best practice implementation strategies for long-term changes.

The objective is to improve the understanding of how biological, ecological, psychological, sociological, economic and socio-economic factors influence consumer decision-making in the context of diet and physical activity. An important element is to integrate the biological, behavioural and social sciences for a better understanding of how individual, social, and environmental parameters interact when considering the effects of food and physical activity choices on health.

Increased differentiation of (European) populations on cultural, socio-economic and environmental grounds increases disease vulnerabilities in some target populations and this may interact with biological differences across the European population. For example, groups with a lower socio-economic status, individuals living in disadvantaged neighbourhoods, socially-excluded groups, some immigrant communities and ethnic minorities frequently have higher obesity rates and a lower health status. People may also be differentially vulnerable during critical periods throughout life, for example during pregnancy, lactation, infancy, childhood, adolescence and in old age. Given that the behavioural determinants of diet and physical activity behaviour are associated with diet-related diseases and that these may be biological, ecological, psychological, sociological and socio-economic factors in origin, more effective collaboration across disciplines is required. Theoretical frameworks and models are needed, which integrate determinants of choices relating to food and physical activity; research is needed in all of these different domains to inform effective policy development regarding optimising the health of consumers.

Although there has been extensive research in different disciplinary areas focusing on this topic, their integration can be improved substantially. An effective approach to integrate activities might involve funding of science networks which will enable researchers from different disciplines to collaborate and create databases for further analysis. To facilitate prospective studies at a pan-European level, these analyses must be carried out with standardised and innovative measures on biological, ecological, psychological, sociological and socio-economic determinants of diet, food choice and physical activity. The great variability of diet and activity patterns observed across Europe and beyond, together with a broad diversity in cultural, social and environmental aspects as well as in health outcomes, provides a unique scientific opportunity to learn more about the determinants of diet, food choice and physical activity. The variability should also make it possible to group and classify consumer segments with respect to dietary patterns and responsiveness to health challenges so that efforts may be directed at the most vulnerable groups.

This research challenge requires the invention, integration and standardisation of monitoring systems, terminology, databases and measures regarding research on biological, ecological, psychological, sociological, economic and socio-economic determinants of diet, food choice and physical activity. This could be realised by trans-disciplinary research networks that bring the different relevant science disciplines together and promote their interactions. Key opinion leaders from the biological, behavioural, health and social sciences with experience on determinants of diet, food choice and physical activity should map the requirements of such a network, discuss the predefined research challenges and develop strategies on how to implement and optimise the impact of pan-European activities. Such activities should also lead to capacity building regarding studies on biological, ecological, psychological, sociological and socio-economic determinants of diet, food choice and physical activity across Europe. An important additional research challenge is establishing a framework for the translation of research outcomes to policy measures.

RESEARCH CHALLENGES

Collecting and using harmonised data

- Implement systematic foresight activities and initiate scenario studies, including and exploiting relevant expertise from trans-disciplinary research networks on determinants of diet, dietary behaviour and physical activity representing all JPI HDHL countries. The goal of such activities will be the generation of a common research agenda across disciplines, relevant to research needs in the area of determinants of diet, food choice and physical activity.
- Foster methodological- and data management procedures (extending from data collection to data retrieval) in all relevant disciplines for studying the determinants of diet, food choice and physical activity. The ultimate goal would be to obtain all relevant data in the most harmonised manner, so that cross-European comparisons, multi-centre studies and secondary data analyses are made possible.
- Establish a joint and standardised monitoring system of dietary intake and physical activity patterns and their multidisciplinary determinants across countries.
- Make better use of existing databases by pooling existing prospective cohort studies focussed on diet, food choice and physical activity, which include data from the natural, social, health or behavioural sciences. Establish and maintain an integrated multidisciplinary database of relevant studies that have used state-of-the-art methodologies.

Harmonising existing knowledge relevant to diet and health

- Carry out systematic reviews, meta-analyses and mediation and moderation analyses of existing data from evaluations of intervention and policy programmes across Europe and beyond in order to identify the policies and interventions having an effect and understand the mechanisms contributing to these effects. These results could be translated into best practice recommendations and large scale demonstration projects, including also targeting the most vulnerable consumer groups.
- Identify indicators to assess the costs and benefits of interventions and policies for health improvement.
- Link these research activities with those research challenges listed in the Research Areas Diet and food production and Diet-related chronic diseases (for example, the use of predictive biomarkers applied to chronic diseases addressed in Diet-related chronic diseases, or interactive psychological and neurobiological mechanisms involved in sensory responses to food).

CURRENT RESEARCH ACTIVITIES

The implementation of the research challenges with regard to the primary initiative 2012-2014 for Research Area 1 is described in the Implementation Plan 2014-2015. The DEDIPAC has resulted in the establishment of a Knowledge Hub with the aim of improving the understanding of determinants of dietary, physical activity and sedentary behaviours. In the DEDIPAC Knowledge Hub 46 participating research groups from 12 countries (i.e., Austria, Belgium, Finland, France, Germany, Italy, Ireland, Norway, Poland, Spain, the Netherlands and the United Kingdom) are working together on the following three thematic areas:

- Data assessment and harmonisation: assessment and harmonisation of methods for future research, monitoring and evaluation of interventions.
- Analysis of determinants: determinants of dietary behaviour, physical activity and sedentary behaviour across the life course and in vulnerable groups.
- Interventions and policies: evaluation and benchmarking of public health and policy interventions aimed at improving dietary, physical activity and sedentary behaviours across the life course.

The overall concept and work programme started in December 2013 and will be funded for 3 years with approximately €7.5M in cash and more than €10M in-kind contribution.

RESEARCH AREA 1
Determinants of diet and physical activity

PRIMARY INITIATIVE FOR 2015–2019

To create pan-European programmes utilising a prospective design and a comprehensive approach of biological, social, economic, health and behavioural determinants of diet, food choice and physical activity. These should relate to real-life conditions to better understand how these different categories mediate and interact to shape behaviours that promote the incidence of chronic diseases. Such research programmes should include pilot, feasibility, demonstration and real-life intervention studies, with different levels of intervention complexity (including natural experiments and policy interventions) to inform and determine the most effective ways of promoting a healthy diet, food choice and physical activity, and contributing to reducing social inequalities. Attention should be given to vulnerable population groups.

There is a lack of validated predictive models of interdisciplinary determinants of diet, food choice and physical activity and a healthy body weight. Current research is primarily observational and often cross-sectional and precludes any inference of causal relationships. Moreover, studies tend to focus on a limited range of such determinants and do not effectively integrate the interactions between biological, ecological, psychological, sociological, economic or socio-economic determinants. The variability of diet and activity patterns observed across Europe associated with the broad diversity in foods offered in different social, economic, cultural, built environments and settings offers a unique opportunity for pan-European longitudinal research with prospective multi-centre 'natural experiment' studies. The research will deliver a comprehensive understanding of the factors influencing dietary choice, physical activity and sedentary behaviour, and with different socio-cultural and physical environments.

An important challenge is to establish and assess the impact of 'real world' changes in policies or food or physical activity environments on people's behaviours in relation to diet, food choice and physical activity. Given the 'natural laboratory' of socio-cultural, economic and biological diversity within the (European) countries participating in JPI HDHL, various approaches to comparative analysis can be identified. Some examples include changes in taxation or pricing strategies (and could involve scenario building in different economic regions), the disposable income of consumers or the way in which food retail environments are developed, how foods are produced and marketed, how biological and socio-cultural factors may interact in determining sensory responses to foods, how changes in built environments may impact on physical activity, taking account of genetic differences in the population, and how changes in social environmental factors (such as social capital and social disparities) influence diet, food choice and physical activity behaviours. The societal trend towards 'electronic lifestyles' should also be considered. The research challenges should contribute to our understanding of how motivation, ability and opportunity to consume healhty diets and foods and being physically active impact on health and well-being. Validated, predictive models of consumer diet- and food-related and physical activity behaviour need to be developed and tested against health-related quality of life and economic outcomes including targeted interventions. This will include assessment of impact of global or targeted changes in food supply, their impact on European food security, and associated impacts on food choices. Moreover, the effectiveness and cost-effectiveness of policy interventions should be evaluated.

RESEARCH CHALLENGES

Understanding determinants of diet, food choice and physical activity

- Test different types of study designs, including large scale intervention studies, to assess changes in food and physical activity behaviour in real life conditions and define outcomes, including body weight, that will be relevant according to settings. In this context an integrative and comprehensive approach of diet and physical activity could rely on methodologies and networks established in the initiative for 2012-2014 and thus applies state-of-the-art measurement tools. Pilot studies conducted in regions with different living conditions could help to further identify the more pertinent methodologies and facilitate standardisation.
- Design new prospective, multi-site cohort studies involving different countries to better investigate different categories of determinants and their mediation and interaction across various population groups. These groups will be defined by life course (e.g., pregnancy and infancy, childhood and adolescence, elderly), socio-demographics (e.g., ethnicity, socio-economic position), and setting (e.g., neighbourhoods, schools, worksites). Such studies should incorporate better standardised and innovative measures of behaviours and of social/built environments. As part of this, it is important to extend existing cohort studies by including JPI HDHL countries not yet part of any of these programmes.
- Develop common methods to evaluate the effectiveness and cost-effectiveness of policy interventions (including in the area of food production) promoting healthy food environments, healthy eating and physical activity, both in the public and private (e.g., health insurances) sector.
- Promote epidemiological modelling inputs into the analysis of long-term health impacts and cost-effectiveness of policies and interventions, and evaluate these against quality of life indicators and measures of well-being. Validated predictive models of consumer food-related behaviour need to be developed and tested against health-related quality of life and economic outcomes including targeted interventions.
- Analyse, in a European-wide comparative manner, the health impact of social inequality and minority health challenges related to the needs of specific target groups (e.g, groups with low socio-economic status and minority groups) and, in particular, the impact and effects of policies and interventions on these various groups.
- Develop new approaches to assess socio-spatial influences on food and physical activity choices in different settings.
- Examine innovative individual potential determinants of food choice and physical activity such as brain functions in relation to (sensory) inputs, genetic predictors of food choice and physical activity.
- Develop and evaluate novel and valid instruments in the area of Information and Communication Technology (ICT), including mobile devices, multimedia and web-based technologies with the aim to (1) improve the measurement of dietary patterns or physical activity levels, (2) induce and maintain healthy behaviours and (3) facilitate the scientific evaluation of interventions (including feasibility, effectiveness and potential impact on public health systems).

RESEARCH AREA 2

Diet and food production

Developing healthy, high-quality, safe and sustainable foods

RESEARCH AREA 2
Diet and food production

The challenge is to stimulate consumers to select foods that fit into a healthy diet and to stimulate the farming and the food industries to produce healthier, high-quality foods in a sustainable and affordable way. By 2030, consumers should have a good choice of healthy foods to select from: the healthy choice should have become the easy choice.

Overall goal

To improve the quality of foods, food production systems, distribution and marketing to provide healthier, safe, sustainable and affordable foods that also contribute to market advantages for food producers and the food and drink industry. This will be achieved by sharing knowledge and data and carrying out harmonised research within the area of diet and food production.

Scope

The concept of food quality has changed over the years. Whereas in former days safety was strongly emphasised, food and drink are nowadays expected not only to be safe, but also to be of good quality, affordable, easy to prepare and to contribute to enjoyment, health and well-being. Changes in society and demographic trends, such as smaller household sizes, an ageing society, working parents and increases in proportion and integration of ethnic groups, occuringin many JPI HDHL countries, will impact on the choice of foods, the ways in which food will be prepared and the places in which it will be consumed.

Traditionally, nutrition goals have been set at the average population level. However, new research is increasingly showing that the risks, benefits and nutritional requirements may vary between different population groups, and even between individuals, on the basis of their genetics. Better understanding of these determinants and requirements is necessary so that dietary advice can be more focused on the needs of particular consumer groups and can even lead to development of specialised foods and services for specific groups of consumers (e.g., ‘personalised nutrition’, functional foods, food supplements). These needs, and also special nutritional requirements for different age groups, are strong drivers for the food and drink industry to produce innovative products that fulfil these expectations.
These innovations can also profit from technological support, e.g., for data collection, personalised messages, compliance encouragement and evaluation. With the increase

of the elderly population and the increased prevalence of lifestyle-related chronic diseases and metabolic diseases the need for efficacious approaches to risk reduction, possibly including personalised nutrition advice, will probably increase over the next coming years.

Foods optimised for their health impact are an important driver both for healthier food and functional food development. The impact of foods on health is, however, difficult to assess as seen from the many rejections of proposed health claims by the European Food Safety Authority. The two major bottlenecks are the characterization of the food intakes and the measurement of changes in health status. For the former, good intake biomarkers reflecting foods and food components, are largely lacking and must be developed to address the characterization of food intakes. For the latter, an operational definition of 'nutritional health' is of importance, possibly addressing the robustness or resilience of biological response to foods. Assessment could be achieved through identification or development of a much broader palette of validated biomarkers of such a health status at both individual and group levels.

The agriculture and food industries are faced with the challenge of producing tasty foods that are consistent with health status and lifestyle, and which meet consumer preferences and thus ensure repeated purchase. Health promotion via foods requires research to identify key bioactive components in foods, to understand how they are handled in the organism and their mode of action (including dose-response studies). Therefore, it is essential to obtain in-depth knowledge of the nutritional and functional characteristics of foods and diets, and validated measures of exposures. This knowledge is also important for improved risk-benefit assessments. Furthermore, ensuring a safe food supply requires research to identify biochemical and microbiological hazards in foods.

An additional challenge is to develop innovative products and processes in a cost-effective, sustainable and affordable way. Foods must originate from systems that produce, process, store, package and supply foods in an economic and sustainable way. Several JPI HDHL countries have or are implementing programmes for the production of more sustainable foods and for reducing food spoilage. It is a challenge to provide the consumer with the right type of food at the right time and in the right place. Innovative processes, value-added products, new marketing concepts, novel ways of selling products and improved production and supply chains are needed. Products must fulfil consumer expectations on safety, the required sensory characteristics and provide a maximum of convenience at an affordable price. Furthermore, research on new technologies is continually required. There is a need for improved methods, including rapid methods for field application, in-line methods for continuous safety management in food processing and precision and reference techniques for research and confirmatory purposes. New technologies are expected to lengthen shelf-life and reduce food spoilage. In addition, environmental issues related to sustainable food production, minimisation of waste production and use of non-renewable raw materials will become an increasing priority.

The agriculture and food industries will need to adapt and incorporate modern nutritional and production philosophies, such as lean and agile manufacturing of foods with lower content of saturated fat, sugar and salt, such as those which have proved to be successful in other market sectors and which allow producers to remain at the forefront of market innovation. Overall, attention must be paid to the entire process and production line so as to optimise each of the individual elements. In addition, further research is required on the collective impact of economic and environmental factors on the production levels and market prices of health-promoting foods including fruit, vegetables and seafood.

Developing healthy, high-quality, safe and sustainable foods

RESEARCH AREA 2
Diet and food production

PRIMARY INITIATIVE FOR 2012–2014

To set up a roadmap-initiative for biomarkers of nutrition and health; define research strategies and launch research activities addressing the needs of all consumers as well as of industry towards measures on health claims; and explore new methodologies or emerging biomarkers in consumer subgroups (target groups) or individuals at risk.

A first step should be to establish a roadmap-initiative and create a research stakeholder's network on biomarker research. This could be a concerted effort with ETP 'Food for Life' and an ongoing initiative of International Life Science Institute (ILSI) Europe. This network will be focused on the research needs addressing the consumer's health and the competitiveness of the European food and drink industries as these may be threatened with markets moving away. If industry is not developing and promoting healthy choices, the burden of diet-related diseases will further increase. This requires a critical reassessment and a new balancing of consumer expectations, consumer protection and the scientific requirements for claims. There is no doubt that insufficient scientific knowledge on the effects of individual food ingredients and technologies is hampering progress in this field; this applies to both academic research and industrial R&D and finally impinges on consumer interests in a wider range of healthy products. More human studies taking into account human diversity and phenotypic differences and in specific target groups (children, elderly people) or groups of increased disease risks are urgently required. There is also a need for better (surrogate) evidence-based markers that indicate health improvements or, at least, that address preventive measures in an organ-specific and target group specific manner. To date, biomarker research has often been based on the measurement of single entities.
The opportunity to use multiple gene, protein and/or metabolite analysis needs to be properly explored, but will also have to be interpreted within a framework that allows for distinction between normal and pathological variation, and identification of 'meaningful' effects. Novel biomarker discovery has been a core activity of the pharma, biotech and medicine realm, so it will be important to have them involved from the outset. However, the pharmacological approach is generally not applicable to complex foods with their smaller physiological activities and effect sizes.

RESEARCH CHALLENGES

Establishing a biomarker and health claim expert platform

— Establish a pan-European health claim and biomarker expert platform for defining validation and biological relevance criteria for (multiple) markers of health related to nutrition and physical activity (for whole organism and gut, including microbiota, brain, immune system, cardiovascular system, bone, muscle, skin, respiratory and endocrine systems) in the general population, as well as for defined subgroups. Make sure that the health claims systems are geared to evaluate whole foods with known health impact.
— Promote integration and harmonisation of large scale biomarker assessment programmes employing bio-bank samples (omics-based) and other disease register sample collections, in which clinical endpoints can be tested against the putative biomarkers of the effects of dietary components as an input variable. Investigate the importance of alterations in microbiota composition and function in affecting biomarkers for disease and health.

- Develop and validate biomarkers of health and food intake using novel approaches including functional genomics, food metabolomics, microbiomics and epigenetics and by exploring markers in human studies based on foods (and not solely their individual ingredients).
- Define and harmonise the methodology necessary to prove the nutritional effects in the development of foods. The pharmacological approach is generally not applicable to complex foods.
- Develop improved methodologies for the direct identification and quantification of compounds in complex multi-component foods or dietary ingredients and in the human body.

Establishing a platform on education and communication to heighten awareness among agricultural and food industries as well as consumers

- Implement better educational programmes on progress in the nutrition and food science areas and on needs for scientific proof of dietary interventions and the effects of ingredients.
- Define research activities and strategies that also address the needs of industry towards European Food Safety Authority (EFSA) measures on claims and for comparison along consumer subgroups (target groups) with individual risk. This needs to be done in consultation, or at least through dialogue, with EFSA.

CURRENT RESEARCH ACTIVITIES

The main objective of the Joint Action Biomarkers in Nutrition and Health is to support interdisciplinary research and innovative approaches for the validation of biomarkers and the investigation of intake/exposure and nutritional status of biomarkers in nutrition and health. It supports research consortia that aim to define and harmonise the methodology necessary to prove the nutritional effects in the development of foods. The Joint Action has resulted in two projects, i.e., FOODBALL and MIRDIET. FOODBALL includes a systematic exploration and validation of biomarkers to obtain a good coverage of the food intake in different population groups within Europe, by:

- Applying metabolomics to discover biomarkers.
- Exploring use of easier sampling techniques and body fluids.
- Revising the current dietary biomarker classification.
- Developing a biomarker validation and scoring system.
- Applying these on selected new biomarkers.
- Exploring biological effects using biomarkers of intake.

The consortium includes 20 research organisations from 9 European countries, Canada and New Zealand.

MIRDIET aims to identify differential responses of specific circulating microRNAs that occur during carefully assessed dietary interventions in individuals with various metabolic status. Studies will be based on adipose tissue miRNome studies by comparing hypo- and hyper caloric dietary interventions or intervention studies focused on dietary polyphenols, protein content or glycemic index. The biomarker potential of microRNA signature will be validated at the circulating level using blood samples from both same and unrelated dietary interventions. The consortium includes research institutes from France, Switzerland and the Netherlands.

The further implementation of the research challenges with regard to the primary initiative 2012-2014 for Research Area 2 is described in the Implementation Plan 2014-2015.

RESEARCH AREA 2
Diet and food production

PRIMARY INITIATIVE FOR 2015–2019

To initiate research programmes (including ERA-NETs) on comprehensive analyses of the metabolic fate of food constituents (nutrients and other bioactives, including microbiota effects) in human physiology with a strong emphasis on different population groups, including the elderly.

The ultimate goal is to define and catalogue the ADME (i.e., absorption, distribution, metabolism, excretion) of food constituents in humans. The bioavailability of food constituents is dependent on numerous factors, including the food matrix and meal composition but also on the biology of the host and its microbiota. Numerous studies have addressed putative health-promoting functions of a wide range of foods and ingredients, and in particular of plant bioactives. Yet in most cases, the nature of the compound(s) that carry the biological activity remains unknown. One of the reasons for this is that the compounds undergo substantial phase I, II and III metabolism in intestine, liver and other tissues to produce a wide spectrum of conjugates that appear in circulation. In addition, it has become clear that for some categories of plant bioactives the microbiota plays a crucial role in bioavailability and function in the host, thereby allowing responders and non-responders to be defined. Moreover, the bioavailability of dietary constituents (including both essential and non-essential constituents) appears to be reduced in the ageing organisms. This puts the elderly at risk for malnutrition not only through lower intake of nutrients (impairments in taste perception, satiety control, chewing, etc.) but also by impaired functioning of the gastrointestinal tract and the metabolic system.

To better understand the fate of food constituents in humans and their biology, including the heterogeneity in individuals (host and microbiome) in handling of the compounds, a concerted action of academic and industrial R&D is needed. New parallel methods for detection, identification and quantification of food compounds (nutrients and plant secondary components and metabolites), including stable isotope-labelled standards for quantification in metabolism, are needed. This should allow, for example, the classification of compounds undergoing similar biochemical reactions and could lead to a reference database on bioavailability and kinetic behaviour. A stable isotope-labelled food ingredient inventory for all studies in the food sciences and for analysing their properties in humans will be an invaluable tool.

In developing novel food ingredients on which to base functional foods, research on bioactives from the dairy, marine, horticulture, cereals and meat sectors requires active input from clinical practitioners and nutritional biochemistry, areas that extensively exploit modern molecular biology tools. Bioactives in foods use the same pathways of xenobiotic metabolism as drugs which means that food ingredients can alter drug bioavailability and drug efficacy. The most impressive example is that of the ingredients in grapefruit; one glass of grapefruit juice has been shown to drastically alter the plasma concentrations and functions of numerous drugs of different classes[30]. These possible side effects are highlighted in drug use leaflets (package inserts) but are not yet considered in the food area.
In an ageing population with multi-morbid individuals regularly using a large variety of drugs, food-drug interactions are a growing problem, in general, and with respect to bioactive food ingredients, in particular. However, also other food ingredients (fat, protein, etc.) can alter drug availability, action and elimination. It is also necessary for the food industry to address this issue (in particular, in relation to its liability) and heighten awareness. A research effort that addresses these

30 Paine MF, Widmer WM, Hart HL, et al. A furanocoumarin-free grapefruit juice establishes furanocoumarins as the mediators of the grapefruit juice - felodipine interaction. Am J Clin Nutr 2006;83(5):1097-1105.

food-drug interactions in proof of concept studies with partnerships from pharma and food (R&D and academia) is needed to provide a knowledge base and create awareness for this problem. An expert panel on food-drug interactions for safety assessment (for both drugs and foods) should be established as a matter of urgency. This project is of high societal importance and crosses the interface between pharma and food, with implications for the safety of every consumer. It can be foreseen that this issue will gain more public attention and could become important (and damaging to the industry) from the perspective of liability.

As consumers become more conscious of the impacts of their food consumption patterns on the environment, so the food industry will recognise its need to reduce the impacts of the food supply chain on the environment by using less energy and water, more sustainable raw materials and by exploiting — and thereby, reducing — waste.

Companies and regulatory agencies need to be able to model the impact of newly-developed functional products or reformulated foods in food composition and consumption patterns. Accessing up-to-date national food consumption databases and other relevant nutritional surveillance data sources are vital. In addition, such databases represent a key source that underpins public health policy.

Food safety and shelf life are both areas where novel technological interventions play a key role. They can be used to reduce and control microbial contamination of products throughout the entire production process, to control contamination on packaging and contact surfaces and even retain sensory and nutritional qualities. Research on the interaction between the main nutrient components in food, i.e., proteins, fats and carbohydrates, is key to unlocking new mechanisms for adding functionality and value to existing and new foods.

Since the structure-function relationship in food matrices is primarily influenced by the processing parameters used by the food industry, new knowledge is required on the effect of processing on functional characteristics in order to develop new and innovative foods. In order to respond to industry's requirements for novel processing technologies, it is essential that core research skills in more traditional processing techniques, such as separation and drying, chilling and freezing, pasteurisation, sterilisation, mixing and formulation technologies are retained. Whilst directing research towards new methods that offer faster and milder processing methods, it is important that the effect of these methods on the sensory and health attributes of food can be assessed or even predicted.

The research challenges are aimed at increasing the scientific knowledge needed to develop foods to improve health. Research and innovation in food processing should be both fundamental and consumer-oriented with the goal of improving product quality and promoting healthy eating. This may include reformulation of existing products to make them healthier without changing their characteristics or by designing new, innovative foods. Transnational research on the composition of foods, the effects of the food matrix and of food constituents in the human system will help product development and set the basis for approved health benefits. Important related issues include the communication on and presentation and marketing of foods and their association with various social and cultural environments. The development of healthy foods with scientifically validated health effects and, therefore, with clear added-value, is another challenge for both the food industry and society. Collaboration of scientists in academia (including the socio-economic sciences) and industry, partnered by various stakeholder groups will be essential for the development, validation and acceptance of these products.

The fast pace of modern lifestyles, including increased mobility, and the increase in single-person households, one-parent families and working women have all lead to changes in food preparation and consumption habits. Food technology, processing and packaging techniques have already adjusted to these changes but must ensure the safety and wholesomeness of the food supply in the convenience sector. In spite of major advances in the past, contamination in the food chain by either naturally-occurring or accidentally introduced contaminants or by malpractice does occur. Ultimately, the quality and safety of food depends on the efforts of everyone involved in the complex chain of agriculture and seafood production, processing, transport, food production and consumption. As the EU and the WHO put it succinctly — food safety is a shared responsibility from farm to fork. Maintaining the quality and safety of food throughout the food chain requires both operating procedures to ensure the wholesomeness of food and

monitoring procedures to ensure that all operations are carried out as intended. Based on global changes in the availability of food and growing competition for biomass (food and feed raw materials, fuels and fibres) and changing climate conditions, studies on diet and health should consider these factors and explore, for example, alternatives for meat proteins.

There is relatively little information on food spoilage on an international scale. If more information was available on (determinants of) food spoilage, rational strategies could be developed for reduction of food spoilage. On the consumer level this should be done by creating awareness through effective communication campaigns and, on the industrial level, this can be achieved by improving the interest of healthier nutrition, agricultural and food production systems and of food packaging. However, there must also be continual vigilance against emerging pathogens.

There are several target groups that could use products that meet their specific dietary needs. This is referred to as 'personalised nutrition'. Although specialised foods for consumers suffering from particular conditions are available (for example, for coeliac disease or lactose intolerance), foods that help to better manage health status may be developed. This demands a clear distinction between health maintenance and disease development. The development, improvement and validation of new and existing tools to better assess nutritional and physical health within the normal range is key to early prevention of any progress towards disease. Research in the area of early prevention has focused on nutritional and physical health as the ability to manage a challenge, i.e., the biological resilience of the individual. Early prevention and the tools and markers necessary to define and quantify nutritional and physical health within the normal range need more attention as a means to improve the health food sector and to advance the sciences of nutrition and physical activity. Foods to decrease the incidence of diet-related diseases may also be developed. This may cover all diet-dependent diseases (cardiovascular disease, type 2 diabetes, intestinal bowel diseases) and should be seen as an associated but clearly separated activity (see also the Research Area on Diet-related chronic diseases). Elderly people are a target group for whom more specific products should be developed. This also applies to pregnant women and children. The specific products for these target groups should match the dietary needs but in addition, attention needs to be paid to sensory aspects and to providing the individual population groups with relevant information.

RESEARCH CHALLENGES

Improving food quality: Agricultural production, food (bio)chemistry and technology research

- Ensure safe, nutritious and high-quality agricultural materials for food production at an affordable price. All stakeholders must engage in ensuring 'food first' with a sustainable food production form farm to fork. This activity requires close collaboration with other JPIs, in particular JPI FACCE.
- Investigate the collective impact of legal, economic and environmental factors on the production levels and market prices of health-promoting foods including fruit, vegetables and seafood.
- Enable redesign and optimisation of food processing, storing and packaging ensuring optimal food quality combined with microbiological safety and stability. Develop and/or improve the nutritional quality and functionality of foods
- Research on the supply side of the food economy, including research into the relationships between basic food production (e.g. farming), nutitional content and healthy diets.
- Explore the use and safety of novel technologies (including nanotechnologies and biotechnologies) in food systems or food ingredients/bioactives with improved stability, absorption and efficacy or improved sensory characteristics. Effective communication to consumers on such techniques and individual foods prepared using such techniques is crucial.
- Carry out research to reformulate food to improve their nutritional and health quality; develop the

concept of a measurable nutritional and physical activity related health of single foods and ingredients; model the resultant impact.
— Promote more efficient and better coordinated (trans-disciplinary) research on new and known bioactives (plant and animal raw materials).
— Promote sensory science (flavour and texture) related to satiety and food intake control; specifically, the role of cooking methods, culinary expertise and ingredients to enhance taste and promote the consumption of healthy foods such as fruit and vegetables.
— Define, evaluate and coordinate research on structure-function relationships (bioavailability and bioefficacy) of foods and ingredients for better design of food structure/properties in relation to nutrition and health.
— Harmonise databases on Life Cycle Assessment (LCA) and address their standards at a transnational level.Study alternative food sources of nutrients and animal proteins.

Improving health: Health-related research

— Develop and validate biomarkers of health related to nutrition and physical activity and to dietary exposures and health risks, using, where appropriate, novel approaches including functional genomics, food metabolomics, microbiomics and epigenetics. Explore markers in human studies based on foods (and not just individual ingredients).
— Launch a programme on bioavailability of plant secondary metabolites in the human system using validated methods and compound identification.
— Improve and harmonise food composition databases; including apparent bioavailability and bioaccessibility of ingredients (the FP6 project, EuroFIR[31], provides a strong basis for such development).
— Examine the short-term and long-term effects of diet and of its components, on the intestinal microbiota and the impact on health, with specific attention for various age groups. Such interdisciplinary research could exploit omics-approaches and could benefit from collaboration between food and medical sciences.
— Promote pan-European programmes that take advances in science (genotyping, phenotyping and enterotyping to stratify consumers) into account when planning human trials for assessing safety and functionality of food ingredients.
— Elucidation of the key components of energy balance as a key element in combating obesity.
— Personalised nutrition to study satiety markers in specific population groups (obese, elderly).
— Understand the underlying mechanisms of food intolerance and food allergies.
— Identifying biochemical and microbiological hazards in foods for the prevention of food intolerance and allergies. Furthermore, this knowledge should be applied in the development of foods.

Reducing food spoilage and increasing safety and sustainability of foods

— Compile data on food spoilage and waste with a transnational perspective (in production, commercial institutions and households) and develop strategies for reducing food spoilage by improving agricultural and food production systems and packaging.
— Develop smart sensor systems that allow safety and quality of foods to be monitored.
— Improve the sustainability of food production systems, including agronomic traits, transgenic technologies, optimisation of fermentation processes, separation and processing technologies.

Developing specific products for population groups

— Promote research on the development of ‘personalised nutrition’, i.e., soundly-based nutritional products for the elderly, pregnant women, children and other specific population groups that target dietary and sensory needs and assess routes of placement and target-group specific marketing.
— Develop packages for delivering healthy foods targeted at specific populations, including those that are ‘easy to open’ for the elderly or are appropriate for single person households, school children and commuters. The design should satisfy the need for information and motivation to use supported by ICT.

RESEARCH AREA 3

Diet-related chronic diseases

Preventing diet-related chronic diseases and increasing the quality of life — delivering a healthier diet

RESEARCH AREA 3
Diet-related chronic diseases

The challenge is to prevent or delay the onset of diet-related chronic diseases by gaining a better understanding of the impact of nutrition and lifestyle on human health and diseases across Europe and beyond. By 2030, the incidence of diet-related diseases will have decreased significantly and will continue to decline thereafter.

Overall goal

To pool existing national data and knowledge and define new research requirements to improve our capacity to understand the qualitative and quantitative links between diet, nutritional phenotype (e.g., obesity) and risk factors for diet-related chronic diseases (e.g., obesity, cardiovascular disease, type 2 diabetes). This includes the need for proper and predictive biomarkers (based on novel life science technologies) that characterise the trajectory from health to disease in the context of dietary intake and phenotypic changes. This may be achieved by the re-analysis of existing dietary intervention studies and the execution of newly-designed studies. The effects of dietary factors and lifestyle on health needs to be explored with respect to new treatment options or adjuvant approaches for health improvements. This research can be done by taking a systemic, whole-body, whole food approach and/or an organ-specific, nutrient specific approach.

Scope

Although epidemiological studies suggest an association of food categories (e.g., meat, fruit and vegetables) and individual dietary constituents (e.g., fibres, vitamins and trace elements) with human health, randomised controlled trials with, for example, vitamin supplements have in many cases failed to show beneficial effects. This may be due to the heterogeneity of the study populations (including genotypes) and, therefore, future studies should take this into account. Although genome-wide association studies have yielded a wealth of information on human genetic heterogeneity and risk alleles, it has become obvious that information on dietary exposure and phenotype is insufficient for defining causal relationships. Obtaining information on diet and other lifestyle factors and in particular on the human metabolic condition is much more difficult and demanding than

genotyping which is just based on technological advancements. A better understanding of how diet contributes to health and to the health disease trajectory on the basis of a given genetic makeup will require large scale cohort studies with a much better definition of the volunteer's phenotype and dietary exposures. For such studies, a greater focus should in future be placed on whole diets, whole foods and food patterns in assessing their contribution to the health status, as well as on their interactions with physical activity and other health behaviours. In addition, in vitro and animal studies can be useful to study the effects of dietary compounds on health. Much of the research below will be intimately linked with that of the other Research Areas.

Poor nutrition, imbalanced energy intake and insufficient physical activity can all lead to changes in gene expression and epigenetic alterations that cause sustained impairments, for example, in immune responses and increased susceptibility to disease. In this case, both protein energy malnutrition and malnutrition related to the excessive energy intake (i.e., obesity) is important. Malnutrition contributes to impaired physical and mental development, and reduced productivity. Advanced technologies allow the effects of diets to be studied on each level along the flow of biological information from the genome to the transcriptome, proteome and metabolome and, thus, the human phenotype. When embedded into the life stages this research can improve assessments of disease risk and, when applied to optimise human health, can help to reduce the risk, or delay the onset, of various diet-related diseases. These strategies require, for example, research efforts on how diets affect the conditioning to obesity and cause alterations in food choices and food intake control; this research should bridge to the neurosciences.

Almost all chronic diseases are negatively affected by low grade inflammation which derives from metabolic perturbations. Understanding how diet (and the composition of the diet) can interfere with these mechanisms is of key importance for effective food-derived strategies in prevention, such as 'personalised nutrition'. Access to these strategies for all population groups should be taken into account. Maternal diet and infant nutrition are important determinants that, by imprinting and epigenetic effects, can cause disease predisposition. However, current knowledge is insufficient to allow its translation into public health recommendations. Age-related impairments and diseases such as osteoporosis, sarcopenia, or cognitive decline, require better treatment options and prevention strategies, and also proof of concept studies. Micronutrient deficiencies in various population subgroups are emerging, sometimes despite high energy intakes. This is particularly evident in vulnerable groups, including people with a low socio-economic status and immigrants. Awareness of this problem needs to be heightened and proper prevention strategies developed.

Biology is not the only key factor in the diet-disease relationship. Determinants of diet and physical activity behaviour (Research Area 1) and diet and food production (Research Area 2) are also of major importance. The greater incidence of obesity in people with lower income or lower education or nutrient deficiencies in subgroups of the population must also be taken into account. It is important to improve education on the role of healthy diets and to ensure production of foods that contribute to a healthy diet at an affordable price, especially for those target groups. Furthermore, increased attention to nutrition in the (public) health sector, such as by prioritising dietary and nutritional advice above other demands on health services, is important.

Preventing diet-related chronic diseases and increasing the quality of life — delivering a healthier diet

RESEARCH AREA 3
Diet-related chronic diseases

PRIMARY INITIATIVE FOR 2012–2014

To establish a European Nutrition Phenotype Assessment and Data Sharing Initiative providing a standardised framework for human intervention studies on food and health, and their phenotypic outcomes with an open-access reference database.

Over several decades, dietary surveys have been conducted at national or large regional level, providing valuable data on patterns of food intake, the nutritional quality of nutrient intakes, an overview of anthropometric data (such as weight and height, data on physical activity) and, in a limited number of such surveys, data on standard nutrient-relevant biochemical variables. These data have helped policy-makers to develop and disseminate guidelines to improve dietary habits which have also been valuable to industry to understand the relevant contribution of different foods to given nutrient patterns.

In recent years there has been a move away from such limited databases to larger, more comprehensive information systems which embrace traditional food and nutrient intake data but which are extended to include ethnic foods, additional, much more comprehensive data on physiological function, physical activity and clinical data, as well as the collection of extensive data on genotype, on metabolomic profiles and to a limited extent data on proteomics or protein profiling and transcriptomics (gene expression). These new large comprehensive datasets are now referred to as Nutritional Phenotype Databases.

The challenge to create large national nutrition phenotype databases was first mooted by the Long Range Planning Committee of the American Society of Nutrition Sciences[32] and was taken up by the European Nutrigenomics Organisation (www.nugo.org) leading to a major initiative of the FP6 Network of Excellence (www.nugo.org/dbnp) with the publication of some key influential papers[33 34]. Several countries have moved toward the construction of nutritional phenotype databases[35]. The large amount of phenotypic data linked to genotypic and dietary data allows these Nutritional Phenotype Databases to search for nutrient-gene interactions, which drive phenotypic changes.

These different national dietary or phenotype databases need to be merged into large, harmonised mega-databases in a standardised manner to increase their statistical power and provide better cross-border comparisons for identifying dietary effects on health and disease outcomes. Only by operating at such a scale can understanding be optimised of the role of genes, nutrients and phenotypes in the initiation, development and progression of risk factors for diet-related chronic disease. This should remain a very high priority for food and health research.

It has been known for many years that bacteria in the intestinal microbiota affect the conversion and availability of dietary components. It is now becoming clear that variations in the microbiota are linked to diverse chronic diseases including irritable bowel syndrome, inflammatory bowel disease, coeliac disease, obesity, and metabolic disease. Recent studies

32 Zeisel SH, Freake HC, Bauman DE, et al. The nutritional phenotype in the age of metabolomics. J Nutr 2005;135(7):1613-1616.
33 Ommen B van, Bouwman J, Dragsted LO, et al. Challenges of molecular Nutrition research 6: the nutritional phenotype database to store, share and evaluate nutritional systems biology studies. Genes Nutr 2010;5(3):189-203.
34 Ommen B van, Keijer J, Kleemann R, et al. The challenges for molecular nutrition research 2: quantification of the nutritional phenotype. Genes Nutr 2008;3(2):51-59.
35 Examples include initiatives taken in Ireland (www.ucd.ie/jingo), the Nordic region (www.sysdiet.fi), the Netherlands Metabolomics Centre(www.metabolomicscentre.nl) and Germany (national cohort for epidemiological research including the most comprehensive phenotyping programme).

have shown that one of the principal determinants of microbiota composition is the long-term diet and that variations in the microbiota, caused by diet, can impact on health, especially in chronic diseases[36 37 38]. Thus a major re-evaluation of many chronic diseases is now called for, especially for diseases where a direct nutritional link was postulated, but microbiota-driven components in pathophysiology were ignored.
Such studies should include reference to the founder microbiota population in a given unhealthy individual and whether dietary modulation or dietary intervention can restore health-promoting microbiota. In recognition of the role played by the intestinal microbiota in determining health, the role of diet in sculpting the microbiota and the emerging evidence that the mammalian host genotype affects the microbiota composition, it will be necessary to integrate nutrigenomic databases with microbiota data.
In practice, this will have to be accomplished by phenotyping new individuals, measuring a broad spectrum of diet, metabolism, microbiota, health and genetic markers.

RESEARCH CHALLENGES

Providing valid measures of exposure and risk, and comprehensive phenotypying of humans for the assessment of diet-disease relationships.

- Foster methodological harmonisation and development of standard operating procedures (SOPs) for human studies and sample collection and coordinate and support ongoing nutrition- and health-related cohort activities by improving standardisation and access to data (open access).
- Launch a scoping exercise for existing databases and identify requirements for their merging, as well as appropriate study design and data analysis techniques that enable rigourous statistical hypothesis testing with such (large) datasets.
- Define minimal standards for data collection and phenotypic measures (SOPs), including study designs (power) and analyses.
- Develop an agreed methodology to incorporate data from different omic-technologies with standard phenotype data.
- Create an initiative for a pan-European genotype-phenotype database on food-health relationships.
- Provide a basis for assessing nutritional phenotype by integration of genetic, proteomic, metabolomic and other life science technologies, as well as identifying functional parameters and behavioural measures that better define the human nutritional status.
- Gain a thorough understanding of how nutrients and non-nutrients interact with the human genome, epigenome and downstream 'omes' at a molecular level throughout the life span. There is growing demand for more comprehensive phenotyping including challenge tests of human volunteers.
- Explore the interactions between foods or food ingredients, including the effects on the immune system and the composition and metabolic activity of the intestinal microbiota on the development of diet-related chronic diseases.
- Develop standardised approaches to assess the impact of chronic diet-related diseases on the quality of life including nutrition and physical activity, the economic condition of individuals and the health system and how health services impact on the quality of life.
- Including by drawing upon previous epidemiological studies, develop new epidemiological studies designed to clarify and to quantify causal relationships between components of diet and the aetiology and promotion of specific chronic diseases.

36 Greer JB, O'Keefe SJ. Microbial induction of immunity, inflammation, and cancer. Front Physiol 2011;1:168.
37 DuPont AW, DuPont HL. The intestinal microbiota and chronic disorders of the gut. Nat Rev Gastroenterol Hepatol 2011;8(9):523-531.
38 Sanz Y, Santacruz A, Gauffin P. Gut microbiota in obesity and metabolic disorders. Proc Nutr Soc. 2010;69(3):434-441.

CURRENT RESEARCH ACTIVITIES

The Joint Action ENPADASI has resulted in a Knowledge Hub with the aim to delivering an open access research infrastructure that will contain data from a wide variety of nutritional studies, ranging from mechanistic/ interventions to epidemiological studies including a multitude of phenotypic outcomes that will facilitate combined analyses in the future. In the ENPADASI Knowledge Hub 51 partners from 9 JPI HDHL countries (i.e., Belgium, Germany, Denmark, Estonia, Spain, France, Ireland, Italy and the Netherlands) are collaborating on the following 6 work packages:

- Management, coordination, governance and sustainability of ENPADASI.
- Preparation of the joint data analysis and sharing existing data.
- Development of the infrastructure.
- Ontologies and tools for integrated analysis,
- Guidelines for efficient and legal sharing of data, resolving ethical, data protection, intellectual property, and data sharing policy issues.
- Training of nutritional researchers in standards (SOPs and ontologies) and data upload using the infrastructure.

ENPADASI will be instrumental in improving the interpretation and validation of results of many different European studies. In this way it will underpin nutrition research and therefore our understanding of the role of food and nutrition in maintaining and improving human health, or in the development of disease.

The further implementation of the research challenges with regard to the primary initiative 2012-2014 for Research Area 3 is described in the Implementation Plan 2014-2015.

RESEARCH AREA 3
Diet-related chronic diseases

PRIMARY INITIATIVE FOR 2015–2019

To expand and foster existing prospective diet-related cohort studies, merge them into open access nutritional databases and initiatate new pan-European prospective studies on diet-health relationships, including new markers of health derived from comparative phenotype analysis.

Whereas nutritional phenotype databases will provide deep insights into the associations between genotype, phenotype and diet, such associations must be validated by dietary intervention studies. In many cases, new intervention studies will need to be initiated but, in many more it should be possible to exploit already completed intervention studies, including those carried out with EU or other trans-national funding, e.g., Lipgene, Diogenes, Earnest, NuAge, PreventCD, EarlyNutrition Project, HELGA and EPIC.

There are two major limitations to maximising the exploitation of such dietary intervention studies. The first is the need for a clear policy on public accessibility of such data and, secondly, the merging of these databases to evaluate associations between genotype, phenotype, diet and health. This should be the main focus for 2015-2019. Determining optimal dietary intakes to maintain health requires a means of assessing the physiological effects of macro- and micronutrients, toxins and non-nutritional bioactives. Biomarkers to quantify health optimisation are needed since many if not all biomarkers are developed for disease endpoints (see also Research Area 2: diet and food production). Quantifying 'normal homeostasis' and developing validated biomarkers are difficult tasks because of the robustness of homeostasis and of inter-individual diversity. These ends might be achieved by focusing upon the functional significance of the variations within the range of data that will generally be considered 'normal' with the aim to identify successively earlier indicators of any deterioration. Even with such refinements, individual markers used in isolation will not be able to measure health reliably. Instead, integrated multi-component biomarkers are required. Ideally, these will examine a far broader concept of health than simply defining acceptable values for each parameter individually. In this respect, the 'omic' technologies that measure large numbers of parameters in parallel offer significant opportunities. However, even with such new approaches, it will be a major challenge to capture the functional status of a biological system with measurements at a single static point. Dynamic measures, taken under varying conditions, may provide a starting point. Therefore, there is a growing demand for more comprehensive phenotyping including challenge tests of human volunteers collected prospectively. This will require standardised methods (see also the ENPADASI).

Scientific progress in the field must be targeted at better defining chronic disease-preconditioning mechanisms against the background of human genetic heterogeneity and lifestyle factors. The new profiling and phenotyping technologies appear particularly well suited to obtain mechanistic insights. However, this will need an integrated and highly standardised effort that includes the identification of indicators which, as early biomarkers (including omics-based signatures), can predict disease onset and progression. These biomarkers or signatures will need, in the next step, to be validated in cohort studies, especially in groups with an increased (genetic) risk.
As early environmental exposures (during pregnancy), but also during infancy and early childhood, predispose to obesity and related diseases such as diabetes and other auto-immune disorders in later life phases, optimising foetal and early postnatal development is of high priority and needs adequate research efforts that allow sound knowledge to be transmitted into the public

health domain. Knowledge on how diet and physical activity affect cognitive function and performance in different life stages is currently a largely neglected area. In the elderly, cognitive functions and malnutrition, muscle wasting and metabolic abnormalities are observed together with increasing obesity prevalences. Chronic loss of organ performance is a critical condition and requires a better understanding of the underlying mechanisms and the identification and validation of predictive biomarkers. The impact of other lifestyle changes ('electronic life', computer games/other common new technologies) that may, for example, affect food intake and exercise behaviour is another poorly defined area and should be explored to understand its contributions to obesity development and associated diseases.

Chronic low grade inflammation underlies the initiation and progression of many diet-related chronic non-infectious diseases, including atherosclerosis, cancer, type 2 diabetes and chronic kidney disease[39]. The growing social and economic burden of such diseases is well established[40].

There is an urgent need to understand the underlying common and individual molecular mechanisms that drive such diseases in order to develop novel detection methodologies and therapeutic interventions. Current therapies are of only limited value in arresting or reversing many chronic illnesses. Earlier detection and a better understanding of the underlying pathologies will improve this situation. These ambitions are supported by quality inputs and outputs from many research groups throughout Europe and beyond and will be realised by integration of basic mechanistic, animal models and human epidemiological data.

There is an interaction of diet and physical activity across a range of disease states and physiological processes including vascular disease, diabetes, obesity, mental health and osteoporosis. Physiological and pathophysiological processes related to health and disease should not only be studied from a dietary perspective, but should also examine the effects of exercise. The possibilities that nutrition and exercise have an effect on disease processes and biomarkers, and that certain genotypes and phenotypes respond better to dietary or exercise interventions (personalised preventive medicine) should be studied using dose-response studies taking into account changes in both exercise and nutrition, and the combination of exercise and nutritional supplements. The interactions of nutrition, exercise and pharmacological treatments (medicines) should also be investigated.

RESEARCH CHALLENGES

Studying the incidence of diet- and lifestyle-related diseases in relation to genetic background

- Launch a scouting exercise for existing dietary intervention studies and explore the possibility of their merging.
- Collect samples (biobanks) and create sub-databases on human genetically-defined populations (either from population studies or from controlled trials with sufficient statistical power) to demonstrate where differences in genetic makeup and dietary patterns have meaningful effects on health parameters. Animal models with defined genetic backgrounds should support this research in a mechanistic manner.
- Launch new case control and cohort studies with optimal and harmonised designs and operating procedures.
- Perform studies investigating predictors of diet-related disease development and analyse the patterns from a systems biology approach that incorporates also lifestyle variables, such as diet and physical activity.

39 Hotamisligil G. Inflammation and metabolic disorders. Nature 2006;444:860-867.
40 Daar AS, Singer PA, Persad DL, et al. Grand challenges in chronic non-communicable diseases. Nature 2007;450:494-496.

Understanding the mechanisms and underlying factors in the development of diet-related chronic diseases

- Identify the mechanisms by which different diets and dietary components influence food-reward, appetite, body weight and metabolic homeostasis. These studies should be carried out in experimental animal models and in humans (using functional NMR or PET).
- Examine the organ-specific causes and consequences of sub-clinical chronic low-grade inflammation on predisposition to developing type 2 diabetes and other chronic diseases, explore the origin of the variability amongst individuals and assess how diet, food ingredients and physical activity can prevent organ-specific malfunction.
- Identify the basis of central nervous system nutrient-signalling and its implications for regulation of energy balance and metabolic homeostasis, and determine how dietary factors relate to brain, cognitive and metabolic function and performance in various life stages.
- Define the contribution of diets on the microbiota throughout the life stages and investigate how altered microbiota compositions affect host functions and its susceptibility to diseases.
- Identify the nutritional intakes and epigenetic modifications during pregnancy, infancy and early childhood that predispose or prevent chronic diseases and auto-immune disorders later in life.
- Understand the importance of early environmental exposure for development of obesity and diabetes (pregnant women) and for optimising foetal and early postnatal development. Of particular concern is the increasing incidence of childhood obesity and the role of lifestyle (e.g., 'electronic life', computer games, other common new technologies) on disease risks as well as on brain functions.

Managing chronic organ-specific diseases and malnutrition in a multimodal and integrative manner

- Better define the optimal nutritional needs and proper dietary intervention strategies according to the organ-specific metabolic abnormalities, and derive optimal organ-specific rehabilitation programmes, which may include 'personalised nutrition'. Important emerging inter-organ conditions such as sarcopenia and obesity need to be addressed.
- Investigate the effect of multimodal approaches to malnutrition related to a lack of energy intake in chronic organ diseases by taking into account the various determinants of impaired organ functions.
- Development of screening tools that detect the disorder in the early phases of malnutrition at primary care, medical or community settings to provide an advantage for early intervention.
- Analyse the health outcomes and economic costs of nutritional treatments to prevent and treat disease related malnutrition in a cost-effectve way: Malnutrition identification, Medical Nutrition Therapy interventions and effects on length of stay, mortality, morbidity and readmissions.
- Investigate malnutrition related to the intake of too much energy and relate this to the neurobiology of food choices and food intake control, food composition and obesity.
- Identification of tools that address the nutrition risk of patients with obesity.
- Study in an integrative way (including lifestyle, nutritional and environmental factor assessment) the mechanisms underlying malnutrition, energy unbalance, muscle wasting and other muscle metabolic abnormalities (brought about by inadequate physical activity, insulin resistance, hormone disturbances or micronutrient deficiencies) associated with chronic organ diseases, and identify predictive biomarkers.
- Develop scenario studies on the effect of dietary and/or physical activity changes on health, including their cost-effectiveness, in order to identify what can be achieved by changing the system (against the current treatment-based approaches).

Horizontal issues

Primary goal for 2020 and beyond: full integration of the Research Areas

HORIZONTAL ISSUES
Primary goal for 2020 and beyond

Full integration of the three Research Areas

The SRA of the JPI HDHL comprises three major Research Areas:

- Determinants of diet and physical activity
- Diet and food production
- Diet-related chronic diseases

For each Research Area, research priorities and challenges are defined, and these relate to the Joint Actions in the Implementation Plan. However, the three Research Areas of the SRA do not stand alone, but are related to each other. In order to achieve the overall vision and the goals of the JPI HDHL, it is therefore crucial that integration across the three Research Areas is achieved. The connection between the Research Areas is obvious for certain topics, such as the determinants of dietary behaviour, which are prominent in Research Area 1 and the production of food that is attractive to consumers (Research Area 2). Furthermore, 'personalised nutrition' can be discussed with regard to Research Area 2, but also relates to Research Area 3, when looking at personalised nutrition for people with a specific disease. Another example is the link between the research challenges in Research Area 1 and the research challenges listed in the Research Areas Diet and food production and Diet-related chronic diseases: the use of predictive biomarkers applied to chronic diseases addressed in Diet-related chronic diseases, or interactive psychological and neurobiological mechanisms involved in sensory responses to food. The implementation of the SRA through Joint Actions is instrumental in connecting the Research Areas. An example is the connection between the research projects funded in the Joint Action 'Biomarkers in Nutrition and Health' (Research Area 2) and the ENPADASI (Research Area 3). Within the projects, regular knowledge sharing will take place and the projects will utilise the same infrastructure to share their data. In addition to links between Joint Actions, a coherent inter-pillar approach for research and innovation in which the different Research Areas are connected may be described in the Implementation Plan 2016-2018. Inter-pillar research priorities and challenges should be explored and should be part of the future activities of the JPI.

To establish a European Nutrition and Food Research Institute to improve scientific collaboration and communication across national borders, and better integrate food, nutrition and health research throughout

The European Molecular Biology Laboratory (EMBL) with its sites in Hinxton (European Bioinformatics Institute — EBI), Grenoble, Heidelberg, Monterotondo and Hamburg has a flagship character. It has received international recognition as a leading science centre and attracts researchers from all over the world. EMBL is at the forefront of innovation and technology development and provides various services to the science community in its participating countries. It may, therefore, serve as a paradigm for the vision of a Nutrition and Food Research Institute with a flagship character and its ambition of becoming a world-leading centre of sciences addressing the food-diet-health relationship.

Research in nutrition, food and health is becoming increasingly complex. It has distinct and discipline specific requirements for analytical as well as physiological methods, including specific research procedures. Nutrition research is also driven by progress in genetics, epidemiology, biobanking, biomedicine, molecular biology, systems biology and material sciences. Food science similarly is driven by advanced analytical techniques, biotechnology and nanotechnology, material science, chemometrics and IT. Regulatory demands relating to health claims and novel foods regulations demand comprehensive safety assessment procedures and scientific evidence derived from human studies. Although the European research base and expertise in nutrition and food science is unique, it remains highly fragmented and, in some areas and countries, is below the critical mass needed for a sustained and competitive future. A European research base must also integrate into this research expertise into agriculture and food production. Such an integration means bringing togethers researchers in different domains.

In 2030, a European Nutrition and Food Research Institute (see Figure 2), which will address the aims and objectives of the European Research Area, should, therefore, be established to secure the present European skills for a productive development of food and nutrition research. The mandate of this institute should be to:

- Provide a platform for harmonisation and standardisation in nutrition and food research and technology, data storage and handling, and disclosure of nutrition and food research specific information as a basis for more sustained research conducted in a collaborative setting with experts from all over Europe and with inputs from leading scientists from third countries, if required.
- Establish, based on these standards, a sustainable European Nutrition and Health Cohort with sub-cohorts in all JPI HDHL countries, becoming a critical open access internet resource for research on health, food and prevention of related diseases from early development, including pregnancy, infancy and childhood, to adulthood and older populations.
- Provide a standardised infrastructure to support and perform large multi-centre nutritional interventions with long-term follow-up throughout Europe;
- Provide a vital research environment stimulating innovation in nutrition and food science.
- Provide a platform for continuing education for all stakeholders, including young researchers, experts in R&D from academia and industry with an emphasis on SMEs.

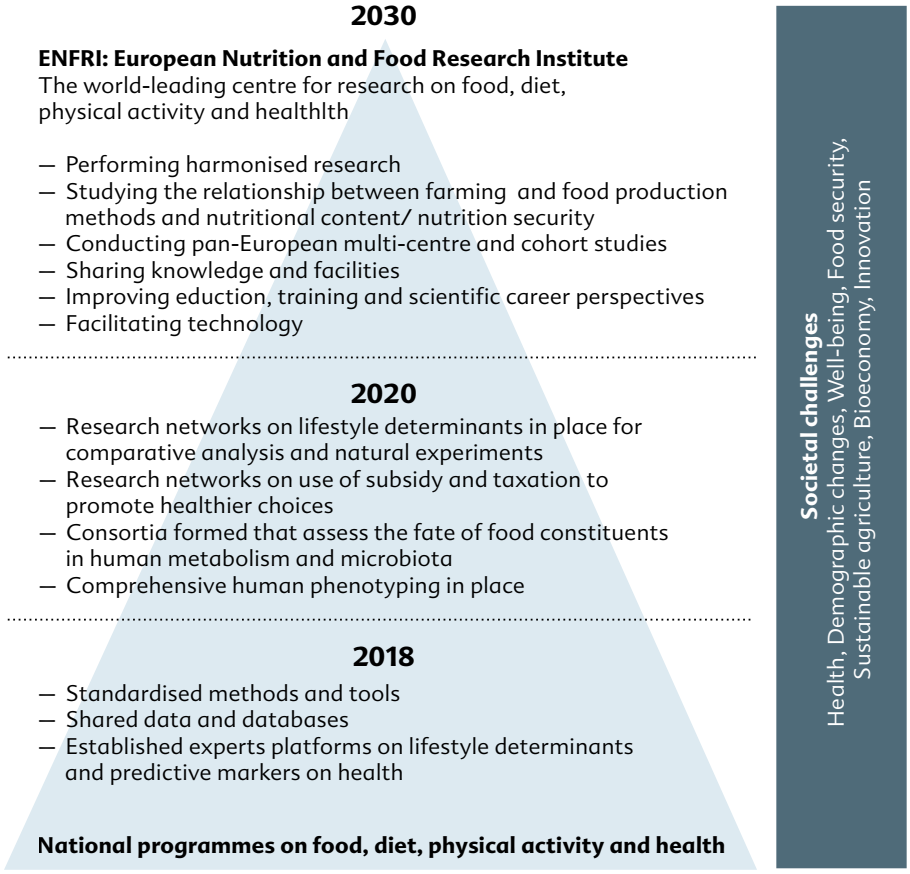
The European Nutrition and Food Research Institute will be organised as a virtual institute or network, with federated national hubs focusing on specific aspects. This hub structure links academic research institutes in JPI HDHL countries and creates a knowledge and education centre for transfer into various stakeholder groups (academia and industry) within the JPI HDHL countries and beyond (underdeveloped and developing countries). As such it would have close links and interactions with the European Institute of Innovation and Technology, in general, and with developing food and health KICs. The activities of the proposed Institute would complement initiatives developed through the European Technology Platform Food for Life and research, training, infrastructure and other activities funded through Horizon 2020 and its successors.

A description of different components needed to perform nutrition and food-related studies is presented, including genetics, transcriptomics, proteomics, metabolomics, systems biology, functional assays, imaging technologies, food composition and food intake quantification approaches will be elaborated, alongside epidemiology, physiology, food

technology, perception, sensory aspects, sociology, marketing, economics of food production, and ethics. Further studies in the clinical arena will be needed to test the data gathered by these research methods. In addition, they will be tailored to the specific research needs of society, agriculture and food industries and policy-makers and will be embedded in an environment of standardised protocols and procedures, annotations, modular databases, networking and integrated bioinformatics. The Institute should host these facilities as an integrated toolbox and should be committed to establish and maintain a nutritional phenotype repository and database as a publicly available data and knowledge depository that will underpin and enable integration and interegration of data from multiple studies. As part of the institute, a flexible IT-grid should be implemented allowing distributed networking and owner-controlled data sharing between all European nutrition research centres.

Highly trained and qualified researchers are a necessary condition to advance science and to sustain investments in research. Therefore, the Joint Programming Initiative aims to initiate and coordinate joint training activities to strengthen the transfer of knowledge from the joint research projects within the domains contributing to 'a healthy diet for a healthy life' among universities, public health research organisations, industrial health sector, clinical sector, agricultural research etc.

Figure 2
Towards a European Nutrition and Food Research Institute



Existing and new knowledge from the nutrition and health domain, such as research outputs, research methodologies, research tools, conceptual knowledge and practical experiences, will all be translated into high-quality educational materials suitable for distance learning (e.g., international courses and workshops). Attention will also be given to promoting the training of future generations of young people in science-, social science- and technology-based skills as well as in key complementary skills required of researchers in Europe in the twenty-first century. Joint collaboration on the translation of research output to training modules guarantees that new and existing knowledge is shared and will contribute to capacity building and enhancement of future transnational collaborative research activities. The proposed research infrastructure will require a joint e-learning platform functioning as an online repository of e-modules within the nutritional and health domain, education and training of future nutritional researchers (BSc/MSc), starting researchers (PhD students), young professionals (e.g., as in ENLP) and professional life-long learners.

The effectiveness and flexibility of training courses and curricula development will be enhanced by developing professional, evidence-based, distance learning modules of high educational quality, consisting of, for example, interactive exercises, tailored feedback, and (a)synchronous collaborative learning activities. The use of current technological and multimedia possibilities will contribute to sustainable dissemination of knowledge, advancing the innovation of learning and the translation of knowledge to practice. In addition to these, the network will ultimately set standards for European curricula and degrees in nutrition, balancing the scientific disciplinary specialisations relevant to scientific advancement (as represented in the JPI) including the knowledge translation from these domains to applications in nutritional practice and health policy.

The European Nutrition and Food Research Institute should be built on established and vital science networks derived from EU-funded FP7, Horizon 2020 and the succeeding programmes and should have the aim of extending into countries thus far not, or only partially, involved in pan-European activities. The JPI will allow a sustainable continuation of the initiatives, respecting national strengths and federating these into an institution that can harmonise nutrition, food and health research to benefit the European research landscape and the food industry as well as the public.

To establish an European Nutrition and Food Research Institute, the following actions are required:

- To formulate a Vision paper with goals, structure, content and governance for such an institute. Include issues on resources and membership.
- To establish a Promotion and Dissemination Group that takes the concept into all stakeholder circles and organisations for discussions (JPI, ETP, KIC, national funding agencies) and on to the political level of the European Parliament and the European Commission.
- To analyse critical infrastructure needed and develop strategies for research pooling.
- To standardise study procedures and study designs for a harmonised data collection in all relevant disciplines.
- To establish clear links between the different stages of research on nutrition and food.
- To establish processes for secondary analysis of open-access data.
- To monitor and distinguish one-off surveys (however large and complex) from ongoing nutrition surveillance. One-off research-orientated surveys should be replaced by ongoing surveillance with a public health basis as distinct from one which

has an academic/research underlying philosophy. This will facilitate the free (i.e. having no Intellectual Property issues) availability of a standard dataset on an ongoing basis for trend analyses and identification.

— To ensure that research outputs are managed appropriately to optimise their impact across a wide range of areas; for example, that they are used to underpin economic and industrial policy to ensure economic growth and development of the European agriculture, food and drink industries; and used to underpin improvements in nutrition, physical activity and public health policies where relevant. The outputs and impacts of the investments will require monitoring, benchmarking and assessment regarding value for money according to agreed metrics.
— To give particular attention to the transfer of knowledge into policy and application-oriented projects. The ongoing dissemination of evidence-based guidance to policy-makers and service providers from the Joint Programme will be very valuable. Options will be periodic reports or seminars (including those that are web-based) which will translate the knowledge garnered from the programme's work into initiatives and products that promote healthy food choices. There should be a clear tie-in with the Health and Food sectors in the JPI HDHL countries.
— To establish a working group that will discuss and implement the recommendations of the study on the need for food and health research infrastructures. The European Commission launched a call for such a study in 2011 (FP7-KBBE-2012-6) and the EuroDISH project is addressing this (www.eurodish.eu).

To create a European knowledge hub on research activities in the food, nutrition and physical activity areas that relate to human health

It is an essential prerequisite for Joint Programming and all research carried out within the three thematic areas highlighted in this SRA to be aware of programmes already implemented in the JPI HDHL countries and their non-confidential results. Although there are some national research activities with high international visibility, a much larger number of nationally-funded projects (with a broad diversity of underlying structures, organisational and financial frameworks, and evaluation criteria) is generally unknown to stakeholders (even at the national level). In addition to EU Framework and infrastructure programmes, it is essential to collect information and build an inventory on national funding programmes that target agricultural and upper food chain research as well as food/ingredient research in view of human health and identify areas in which coordinated programmes would add value. This inventory should go beyond the FAHRE project and requires a standardised assessment tool for defining the core and boundaries of the Research Areas assigned to the food, nutrition, lifestyle and health research. This inventory should combine the information provided by JPI HDHL countries as a 'top-down' approach and, that from scientists as a 'bottom up' approach, along the three Research Areas described. This would offer the most effective way of identifying ongoing activities that easily can be translated into joint programmes that cross national borders. As part of the knowledge hub activities, continuous analysis of critical infrastructure requirements is needed, alongside the development and execution of improved strategies for research pooling. Processes for secondary analysis of open-access data must also be established. The knowledge hub of the JPI HDHL should include data from foresight reports and activities, from the SRAs of relevant European Technology Platforms and joint reports of European Technology Platforms (e.g. BECOTEPS white paper), from relevant Knowledge and Innovation Communities of the the European Institute of Innovation and Technology (EIT), COST and European Social Fund (ESF) activities, and relevant information from third countries and regions outside Europe to ensure the highest level of transparency and knowledge transfer into the JPI and its participating countries, and to ensure that experience and best practice is effectively and efficiently captured, and disseminated for adaptation and use within Europe and beyond.

To improve education, training and scientific career perspectives in the food, nutrition, lifestyle and health areas

JPI activities go beyond the classical borders of scientific disciplines. Diversification and specialisation are intrinsic features of modern science. Yet, solving problems as in the area of human health, nutrition, food and lifestyles requires trans-disciplinary competence and a better understanding of the different science cultures (biosciences, social and cultural sciences). The success of the JPI across its three Research Areas will strongly depend on the proper education and training of experts and junior scientists in complementary skills (including communication, ethics, optimising the impact of research and having an awareness of the requirements of different stakeholder communities for research outputs). Moreover, science education is one of the thematic elements of responsible research and innovation and is described in Horizon 2020 of the EC (http://ec.europa.eu/programmes/horizon2020/en/h2020-section/science-and-society).

A particular concern is that highly specialised sciences with high impact publications have established ranking and incentive systems, whereas the multidisciplinary approaches and knowledge translation areas in most cases cannot measure up to these. To ensure that the Research Areas covered in this JPI are attractive for the best students and scientists, the reputation of the science disciplines needs to be improved. This means that a proper 'mind-set' is a prerequisite for successful joint programming crossing the classical borders of science disciplines. This also applies to science career perspectives and to the mobility of researchers from the participating countries. One of the most important goals of the JPI HDHL should be to foster, encourage and promote this new mind-set, and to enable the best education and training for future generations of scientists and technologists. Although the European Institute of Nutrition and Food Sciences will be the ideal setting to ensure this to happen, this JPI should meanwhile take all necessary measures to compile an inventory of necessary skills and knowledge, exploit the various programmes available in Europe and define a pan-European project for continuous education in the Research Areas targeted to scientists in academia and experts in industrial R&D. All people in the food chain area have a responsibility to promote and disseminate the challenge, excitement and societal importance of a career in these areas. This should extend to primary and secondary education so as to engage scientists and technologists of the future; provide examples of entrepreneurial activities that are crucial to underpin and drive Europe's global competitiveness, economic development, create new jobs and benefit society.

A KIC on food could help the food sector to turn global challenges into business opportunities by building upon six E's: education, excellence, entrepreneurship, end-users, exploration and Europe. A food KIC could become world-leading on science and a strong collaborative partner with high-quality universities and research centres, worldwide. Additionally, a food KIC could become instrumental in fostering best practice, becoming the frontrunner for the rest of the food sector.

To improve communication, knowledge and technology transfer

The impact of the JPI HDHL will, to a large degree, depend on the effectiveness of communication and the exploitation of the outcomes of research programmes. Best practices in communication and the exploitation of innovative communication techniques will be promoted and supported. Transfer of knowledge and technology is the driver for innovation and is a key focus for improvement. Within the overall context of this JPI, communication is important across all its areas; within the management and administration structures and with and between all stakeholder groups (e.g., the scientific community, policy-makers, research funding bodies, food producers, industry, public health organisations, health care

organisations and the civil society). Transfer of technology and knowledge to all stakeholders whilst ensuring IP protection, are necessary tools for establishing and promoting cross-disciplinary research and the transfer into various application areas. A relationship of trust and mutual confidence between individuals and organisations is a prerequisite for successful knowledge and technology transfer, and this is especially true when the pursuit of knowledge and its subsequent transfer and delivery crosses national borders.

In addition to being a key requirement of effective management and administration, communication is important to optimise interactions between themes, to enable the scientific community, policy-makers, research funding bodies, food producers, industry, public health organisations, health care organisations and the civil society to gain the maximum benefit from ongoing activities and to ensure that these stakeholders are regularly updated. Communicating research outcomes in such a way that they have an impact on stakeholders and target groups is challenging. For instance for the general public, having access to information on health and healthy lifestyle is crucial, but an overload of information and contradictory information should be avoided to prevent confusion. It is essential to understand that the effective communication of food-related issues depends on designing different patterns of communication aimed at capturing the diverse sensitivities and priorities of stakeholders involved in the knowledge process. Validated strategies will be adopted to ensure optimal impact across the members of the food chain and the general public. The heterogeneity of consumers from Europe and (with regard to age, eating habits, income, education, awareness and understanding of healthy eating campaigns, language, dietary patters, religious and ethnic cultures that impact of their diets, etc.) requires that communication be targeted effectively at each different sub-population and that a 'one size fits all' approach will be ineffectual and waste human, time and financial resources. The optimised effective information dissemination and, hence, to maximise its impact will require the active collaboration with journalists, use of electronic and social media, and communication and dissemination experts. In order to reach the desired level of communication, a holistic approach is needed, especially at the intersections of social or individual psychology, health communication and technology assessment. It is apparent that specific groups in the society (e.g., elderly people, people with lower socio-economic status, teenagers) have different attitudes towards new technologies, different access to information or different motivations. Therefore, effective communication needs to be understood as a dialogue between stakeholders and consumers. This interactive way of communication between all actors will raise effectiveness and securing delivery of the right and relevant messages tailored to the individual groups in societies so that their needs will be met. More details on the various stakeholders of the JPI HDHL and strategies to facilitate communication with and among them are provided in the Implementation Plans of the JPI HDHL.

With regard to the transfer of knowledge and technology within the JPI HDHL, it is important that ownership and transfer of newly developed IP, as well as existing IP, is managed according to national and/or European legislation. As sharing IP is a core part of a project success, participants should pay due attention to the management of IP and be aware of this from the very beginning. The Quick Guide for Dissemination of the JPI Research Projects Results defines the protection, management and sharing of intellectual property rights (IPR) and provides guidelines on how to set IPR rules. Furthermore, best practices for the dissemination and use of research findings are described in the document.

Open access policies

For the JPI HDHL knowledge sharing, including open access of research output of the various Joint Actions is of crucial importance to address the societal challenge of the JPI HDHL. The JPI HDHL expect its applicants to consider the exploitation and dissemination strategy already at the stage of drafting their proposal and the development of a data sharing plan and consortium agreement at the start of the project. On the website of the JPI HDHL a guideline is published on IPR, Open Access and Knowledge Sharing. The vision of the JPI HDHL is in line with the vision of the EC. The EC open access policy aims at making all publicly-funded research (i.e., scientific publications and research data) openly accessible. This contributes to better and more efficient science and to innovation in public and private sectors. Moreover, open science (including open access) is one of the thematic elements of responsible research and innovation and is described in Horizon 2020 of the EC (http://ec.europa.eu/programmes/horizon2020/en/h2020-section/open-science-open-access).

Other initiatives on food and health

The JPI HDHL has brought together experts from various scientific disciplines to develop a common vision, define the measures that need to be taken to reach the goal to improve the nutritional health of European citizens, create a coordinated and vital European Research Area and, thereby, improve the competitiveness of European industries and academia. Through its representatives on the Scientific Advisory Board and its management levels, the JPI represents a network spanning many (European) countries and all relevant scientific, technological and business areas. Yet, knowledge transfer into the JPI from national, European and global sources as well as knowledge transfer from the JPI to its stakeholders are crucial for the 'added value' intended and for minimising duplication efforts. The JPI is, therefore, committed to interacting as effectively as possible with all European initiatives and programmes for optimal information flow and transparency. Specifically, links with projects about the methodology of the development and evaluation of food to make health claims and the development of guidelines are relevant for the JPI HDHL.

Connection with other scientific and policy areas

In addition to links between the JPI HDHL and international initiatives on food and health, it is important to facilitate the connection between the JPI and different scientific and policy areas that are associated with the societal challenge of JPI HDHL (e.g., nanotechnology, water, agriculture, economics) so that the JPI is also cross-disciplinary science based. The future will require a more coherent and comprehensive coordinated approach when designing policies, while at the same time putting issues of health and healthy lifestyles at the centre of these policies (e.g., educational, innovation, agricultural, municipal). In addition, increased attention for a global perspective on policy and the topics of the JPI HDHL is important.

Key players

Stakeholders can become key players and in this way play a significant role in achieving the overall vision and goals of the JPI HDHL and its Research Areas. Therefore, the key players of the JPI, their role and how they can participate in the implementation of the SRA through Joint Actions is described in the Implementation Plan 2016-2018.

Appendix 1 – development of the second edition of the SRA

As described in the work plan of the first Coordination and Support Action of the JPI HDHL the update of the first edition of the SRA is based on the outcomes of the Foresight Activities and the input of the members of the Scientific Advisory Board (SAB) and the Stakeholder Advisory Board (SHAB). All changes have been discussed and approved by the Management Board of JPI HDHL

Foresight Activities

The first stage of the Foresight Activities included an exercise in which existing foresight activities were mapped. This resulted in eight core drivers that are likely to impact the future of food, nutrition, health and physical activity in Europe. The second stage of the Foresight activities included a workshop in which the eight core drivers were discussed, leading to the identification of five key challenges and opportunities for the JPI HDHL. The two activities resulted in the Foresight Report that was used to update the SRA.

Input from the SAB and the SHAB

To gather input from the Scientific Advisory and Stakeholder Advisory Boards a questionnaire was developed on the update of the SRA. The questionnaire concerned all chapters of the SRA and included questions on comprehensiveness of the chapters, clarity of the goals and scope of the three Research Areas, stakeholders, additional research challenges and the description of the horizontal issues. Furthermore, the eight core drivers and five key challenges and opportunities resulting from the Foresight Activities were described and it was asked if these were sufficiently covered in the SRA and if not, how they should be covered in the update. 9 out of 13 SAB members and 8 out of 15 SHAB members completed the questionnaire. Furthermore, the input from the SAB and SHAB members on the questionnaire and their priorities for the update of the SRA were discussed during the SAB meeting on the 11th of November 2014 and the SHAB meeting on the 5th of December 2014.

Summary and analysis of suggestions

The input from the SAB and the SHAB was summarised and compared to the current SRA. The input was analysed by using the following criteria:

Exclusion criteria:

- The topic fits already within a higher abstract theme or topic already described in the SRA and is considered to be a point of attention that could be taken into account when developing Joint Actions, e.g., to do research on the effect of policies targeting the food industry could be part of the forthcoming Joint Action on policy interventions.
- The topic is considered to be more of interest to the food industry rather than to the public sector.
- The topic should be mentioned in one of the Implementation Plans rather than the SRA of JPI HDHL, e.g., how the Joint Actions relate to the SRA.

Inclusion criteria:

- The topic is considered to fit clearly within the current framework of the SRA and is mentioned multiple times by different SAB and/or SHAB members and/or is an outcome of the foresight activities.

Annex – contributions

Members of the Scientific Advisory Board

Research Area 1: Determinants of diet and physical activity

- Prof. Dr Lynn Jayne Frewer, School of Agriculture, Food and Rural Development, Newcastle University, Newcastle upon Tyne, United Kingdom
- Prof. Dr Knut-Inge Klepp, The Norwegian Directorate of Health, Oslo, Norway
- Prof. Dr Ilse De Bourdeaudhuij, Department of Movement and Sports Sciences, Ghent University, Ghent, Belgium
- Prof. Dr Wolfgang Ahrens, Leibniz Institute for Prevention Research and Epidemiology – BIPS, Bremen, Germany
- Prof. Dr Maria Daniel Vaz de Almeida, University of Porto, Porto, Portugal

Research Area 2: Diet and food production

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Research Area 3: Diet-related chronic diseases

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Members of the Stakeholder Advisory Board

Research Area 1: Determinants of diet and physical activity

- EC-DG SANCO
- European Association for the Study of Obesity (EASO)
- World Health Organisation (WHO)
- Federation of European Nutrition Societies (FENS)
- European Science Advisory Network for Health (EuSANH)
- European Public Health Association (EUPHA)\

Research Area 2: Diet and food production

- The European Consumers Organisation (BEUC)
- International Life Sciences Institute (ILSI Europe)
- European Technology Platform 'Food for Life'
- European Food Information Council (EUFIC)

- European Technology Platform 'Plants for the future'
- European Federation of Food Science & Technology (EFFoST)

Research Area 3: Diet-related chronic diseases

- European Society for Clinical Nutrition and Metabolism (ESPEN)
- European Society for Paediatric Gastroenterology, Hepathology and Nutrition (ESPGHAN)
- European Federation of the Association of Dieticians (EFAD)

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Colophon

Strategic Research Agenda 2012-2020 and beyond
Joint Programming Initiative A healthy diet for a healthy life

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