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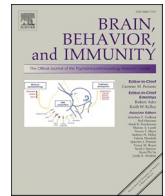
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## Towards new nutritional policies for brain health: A research perspective on future actions

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### 1. Health and economic costs associated with brain health conditions

Around 165 million Europeans are living with a brain disorder and more than 1 in 3 people will suffer from a neurological and/or psychiatric disorder at some point<sup>1</sup>. These numbers translate into an immense health and financial burden for society. In Europe, treating brain conditions accounts for 35 % of Europe's total disease burden with a yearly cost of almost €800 billion<sup>1</sup>. Poor diet is a major (but one of the few modifiable) risk factor for brain disorders. There is substantial evidence from the significant scientific efforts to date that shows that nutrition impacts brain health across the life course.

### 2. So why then is the full potential of nutrition not utilized to improve brain health?

Diseases associated with brain health are highly prevalent and neurological and mental disorders account for the loss of the equivalent of one year of full health (Global Burden of Disease Collaborative Network, 2019). Stroke accounts for more than 1 million deaths per year and dementias and Parkinson's disease complete the top 3 causes of death due to neurological disorders in Europe (Global Burden of Disease Collaborative Network, 2019). Additionally, mental health conditions such as depression, anxiety and schizophrenia are leading causes of disability (Global Burden of Disease Collaborative Network, 2019). Obesity is a risk for brain health with rates increasing rapidly in most EU Member States (EUROSTAT, xxxx). Of concern is that obesity is increasingly prevalent in children and increasing numbers of women enter pregnancy with obesity with serious long-term consequences for

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Healthy food for all is a responsibility of policy and requires public funding	
<p><b>Increase scientific evidence:</b></p> <ol style="list-style-type: none"> <li>1. Identify nutrients that impact on brain health Invest in clinical research and develop Knowledge Platforms aimed at harmonization and standardization of study designs</li> <li>2. Identify the neuronal circuits, cells and molecules linking nutrition with brain health Increase understanding of underlying mechanisms including the contribution of hormonal, immune and microbiome systems and integrate this with research on food choices</li> <li>3. Bridge basic science mechanisms to clinical outcomes by identifying biomarkers Support Experimental Medicine studies that identify early-stage markers that are predictive clinical outcome</li> </ol>	<p><b>Produce effective messages concerning the role of food for brain health:</b></p> <ol style="list-style-type: none"> <li>1. Implement dietary recommendations Develop a broad range of effective options e.g., reformulation, food fortification, subsidized access to nutritious foods, aligned with sustainable development goals</li> <li>2. Personalise nutrition Develop recommendations to improve intake of key nutrients tailored to individuals and specific life stages</li> <li>3. Improve nutritional education Push nutritional education up the agenda for health care professionals and governmental bodies</li> </ol>

Fig. 1. Policy priorities.

their children's brain health (Cirulli et al., 2020). These challenges go beyond individual responsibility and require a holistic approach in which governments, food industry and society work together to tackle the issues.

### 3. The potential of nutrition for brain health

Nutrition affects all aspects of brain development and function. Nutrition based interventions can provide an effective, safe and affordable option for the risk reduction and treatment of otherwise difficult to treat conditions. It can support brain health at the population level by shifting the overall prevalence of a condition. For example, there is a clear link between diet and risk of dementia and dietary interventions have been shown to delay the onset or progression of the disease (Jacka et al., 2017). Trials on depression show that addressing diet quality is a cost-effective way to improve symptoms (Jacka et al., 2017).

Across the lifespan there are different nutritional needs. Intervening in early life is crucial because important developmental processes are occurring that give rise to individual risk/resilience trajectories and nutritional interventions can affect both the mother and the offspring: alongside its well-documented effect on prevention of neural tube disorders, supplementation with folic acid before and during pregnancy lowers the risk of developing autism in the offspring (Li et al., 2019). Also, there is evidence that the elimination of food additives reduces ADHD symptoms (Li et al., 2019; Sonuga-Barke et al., 2013). Nutrition also exerts an effect on brain health by interacting with the immune system. For example, obesity is an inflammatory state and some of the deleterious effects of obesity may be modulated via the immune system. Further, nutritional interventions which alter immune response may also impact brain health/cognitive function.

Convincing evidence for nutritional intervention requires a substantive body of high-quality data. Yet, evaluation of the effect of single nutrients on brain health is difficult to investigate because nutrients often rarely act alone and affect multiple processes. Also, effects on a specific brain health domain may only be visible in a vulnerable population e.g., supplementation is most effective in deficiency or disease

states. These challenges mean that nutrition in the context of brain health is an under-investigated scientific area, but also it is under-researched as it has not (yet) been prioritized by funding bodies.

### 4. Foods are not drugs

In the prevention of brain and mental disorders, or in the treatment of milder forms of brain and mental disorders, a nutritional intervention is preferable to a pharmaceutical in terms of side effects and consumer acceptance, providing that there is a valid evidence base to demonstrate clinical efficacy for the individual nutritional intervention. However, research into the efficacy of nutrients on brain health is more complex than studying drugs (Sorkin et al., 2016). Studying nutrients requires expensive randomized controlled trials that cannot simply adopt protocols used for pharmaceutical studies. Also, because nutrients act via multiple mechanisms it is difficult to understand the exact mechanism of action which complicates the development of health claims. Furthermore, the business models and the possible return on investment are different. With rare exceptions, specific nutrients cannot be commercially protected in the same way that new pharmaceuticals can, although safety assessment may require similar investment. Moreover, food manufacturers need to incorporate the nutrients of interest into an attractive product that can be consumed voluntarily on a regular basis to achieve the beneficial effect. The investment needed to test and formulate the product is unlikely to be matched by the returns on investment. Improving intake of dietary fibre could have beneficial effects on many aspects of brain health, but costly large scale clinical trials are not likely to lead to any proprietary knowledge. The food industry has a role to play in building the evidence base but cannot act alone. Harvesting the health and cost saving potential of nutritional interventions to improve brain health is a public health issue that is impossible to address without public funding.

### 5. Building consumer awareness and trust

Consumers value the mental health benefits that come from a balanced diet. Nearly 9 in 10 adults said they would eat a healthier diet

if they knew it would lower the risks of cognitive decline (87 %) and heart disease (88 %) (Retrieved from Brain Health and Nutrition Survey, 2018). However, they are often faced with a barrage of inconsistent findings. In 2018, 80 % of consumers reported coming across conflicting information about nutrition (Vijaykumar et al., 2021) resulting in a lack of trust. Social influencers are a popular source of nutritional information, yet their advice is rarely founded on solid evidence. There is also a lack of nutritional knowledge in the professional health care community and a lack of consensus on nutritional advice. This may be because nutritional education in the medical curriculum is sparse, and the role of dietitians in prevention and management of brain disorders is limited. The quality and strength of the evidence needs to be improved using existing data as well as new clinical studies and the evidence should be accessible and disseminated clearly and consistently.

## 6. BRAINFOOD priorities

Given the potential of nutrition for brain health, Europe-wide investments in research to enable evidence building, in addition to developing appropriate measures to education of health care professionals on these themes, is urgently required. Substantial action from policy makers is needed to enable knowledge building on diets supporting brain health, and to making it to accessible for all, is called for. (Fig. 1).

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

No data was used for the research described in the article.

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