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Nutrition practice and research in the age of nutritional neuroscience

Júlia Dubois Moreira[1], Gilciane Ceolin[2], Letícia Carina Ribeiro[3], Luciana da Conceição Antunes[3], Débora Kurrle Riege[1]

[1] Universidade Federal de Santa Catarina, Programa de Pós-Graduação em Nutrição, Departamento de Nutrição. Florianópolis, SC, Brasil. Correspondence to: JD MOREIRA. E-mail: <juliamoreira@gmail.com>.
[2] University of British Columbia, Faculty of Pharmaceutical Sciences. Vancouver, British Columbia, Canadá.
[3] Universidade Federal de Santa Catarina, Departamento de Nutrição. Florianópolis, SC, Brasil.

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ABSTRACT

Objective
To explore current issues regarding the inclusion of nutritionists in Nutritional Neuroscience, addressing key concepts, main areas of research, and their potential, in addition to knowledge gaps requiring further attention.

Methods
This theoretical and reflective article discusses major research topics in Nutritional Neuroscience, including eating behavior and its influence on human health, the relationship between nutrition and nutritional status and cognitive function (memory and mood disorders), the role of nutrition in neurodevelopmental disorders, its implications for the treatment of neurological diseases and epilepsy. This discussion is supported by scientific literature and clinical guidelines and protocols developed by specialized agencies in food, nutrition, and medical care.

Results
Nutritional Neuroscience examines the interplay between brain function and food intake, aiming to broaden the understanding of how dietary habits, nutrient consumption, and nutritional status influence brain function, as well as their implications in normal homeostatic processes and their impact on brain health, neurobiological mechanisms, and pathological conditions. In this article, we address the aspects of eating behavior and the role of nutrition in psychiatric and neurodevelopmental disorders, memory, and neurological diseases, which are areas considered the most prominent and promising within the field.

Conclusion
Nutritional Neuroscience represents a promising field for nutritionists in both research and professional practice. Strengthening the educational foundation of nutritionist training by integrating the best available evidence is essential to support effective and evidence-based practice in this area.

Keywords: Food. Eating behavior. Neuroscience. Nutrition. Psychiatry.

INTRODUCTION

Eating is a fundamental human behavior, considered the conscious process of searching for foods that satisfy hunger, promote physical and emotional well-being, and support life in a societal context [1]. Signals are sent from the brain to peripheral organs to seek foods that provide the organic energy and nutrients necessary to maintain life.

Similarly, signals are transmitted from the periphery to the Central Nervous System (CNS) to regulate chemical reactions and the release of neurotransmitters, thereby maintaining coordinated brain activity and function [2,3]. Nutritional Neuroscience (NN) is grounded in the concept of a "bidirectional conversation" between the CNS and peripheral systems. This field is used in scientific research to explore how dietary components – such as proteins, carbohydrates, fats, and supplements, including phytonutrients – affect the central and peripheral nervous systems, neurochemistry, neurobiology, behavior, and cognition [4]. Some researchers have introduced the term "neuronutrition" within the context of NN to emphasize the relationship between diet, brain health, and cognitive function [5-7]. Neuronutrition encompasses not only the study of dietary patterns but also the intake of specific nutrients for the prevention and treatment of disorders affecting both the central and peripheral nervous systems [5]. Accordingly, NN aims to generate evidence on the connections between food consumption – its quality and quantity – and brain function, including their implications in both normal (homeostatic) and pathological processes. NN also investigates how nutrition can promote mental wellbeing and brain health, supporting the prevention and management of metabolic, neurological, neuropsychiatric, and neurodevelopmental disorders. More recently, the term Nutritional Psychiatry (NP) has been introduced to define a growing area of research focused on the relationship between diet and mood disorders [8,9]. The NP examines how unhealthy dietary patterns may contribute to the onset or worsening of psychiatric disorders, such as mood and anxiety disorders, and how healthy eating habits and targeted nutrient intake may aid in their treatment and management.

Although the first evidence of the effects of a ketogenic diet on the reduction of epileptic seizures emerged over a century ago [10,11], it is only in the last 15 years that NN has gained more consistent attention from nutrition professionals. Advances in neuroscience have enhanced our understanding of the behavioral aspects of nutritional treatment, bridging the gap between nutrition science and brain function. This growing intersection has contributed significantly to the management of chronic diseases by highlighting the relationship between food choices, brain function, and overall human health. In parallel, increasing research has explored the role of specific nutrients in the prevention and treatment of conditions involving the CNS. More recently, the renewed interest in the intricate connection between the digestive system – particularly the gut – and brain function, known as the gut-brain axis [12], has further engaged nutrition professionals in scientific discourse and events focused on brain health.

In Brazil, despite the growing number of courses, publications, and professionals emphasizing expertise in NN and NP, it is important to note that neither NN nor PN is formally recognized as a specialty within the field of nutrition [7,13,14]. To date, no official data have been found regarding the practice of nutritionists specifically within NN or NP in Brazil, possibly because these areas are not included in the list of recognized nutritionist specialties, as outlined in Resolution No. 689, dated May 4, 2021. This resolution governs the recognition of nutrition specialties and the registration of specialist titles within the Federal and Regional Councils of Nutrition System. While the resolution defines several areas of specialization, the titles most closely related to NN and NP – "XXVI - Nutrition in Mental Health" and "XXVII – Nutrition in Eating Disorders" – do not fully encompass the breadth of topics and approaches involved in NN and NP. With the exception of these two specialties, the responsibilities associated with NN and NP typically fall under the broader domain of Clinical Nutrition. In this context, nutritionists are tasked with assessing nutritional status, prescribing diets and meal plans to promote health and/or support nutritional recovery, and implementing nutrition education strategies tailored to individual health needs. These duties are defined in CFN Resolution No. 600, dated February 25, 2018, which defines the areas of practice and responsibilities of nutritionists

and establishes minimum reference parameters for effective service delivery across different fields. Notably, this resolution does not include mental health as a designated area of practice.

Nutritional Neuroscience and NP are recognized as areas of scientific research that aim to expand the understanding of health professionals of the connections between food, nutrition, and health – particularly in relation to the CNS. This article seeks to explore the integration of nutrition professionals into the field of NN, discussing key concepts, major research areas, their potential contributions, and the existing knowledge gaps that warrant further investigation. To this end, we present a theoretical and reflective discussion based on main research themes within NN, including eating behavior and its influence on human health, the relationship between nutrition and nutritional status and memory and mood disorders, the nutritional aspects associated with neurodevelopmental disorders, and the role of nutrition in the treatment of neurological conditions, including epilepsy. The discussion is informed by scientific literature, identified through a non-systematic search designed to support the key arguments with relevant evidence without aiming to be exhaustive. Efforts were made to include both national and international sources. Additionally, clinical protocols and guidelines issued by agencies specializing in food, nutrition, and medical care were also included to enrich the analysis.

The role of eating behavior in nutrition

The ability of an organism to sense its physiological needs – known as interoception [15] – and subsequently initiate behaviors that secure the resources necessary for its survival is essential for maintaining organ system function, ensuring quality of life, and supporting both physical and mental health. This ability also plays a critical role in disease prevention. Numerous biological signals have evolved to regulate eating behavior, underscoring the essential roles of food and nutrition in sustaining human life across all levels of biological and social organization [15,16]. Eating behavior and related decision-making processes are governed by complex neurobiological mechanisms. Recent studies in both human and animal models have shown multiple factors influence an individual's ability to make food choices that promote well-being. These include biological and physiological variations in signaling pathways that regulate homeostatic, hedonic, and executive functions, the surrounding food environment, life-stage-specific exposures, and the presence of chronic conditions, such as obesity and its associated comorbidities [17,18].

Briefly, eating behavior is influenced by both homeostatic signals, which are physiologically driven, and hedonic signals, which are associated with the pursuit of pleasure and reward. These factors involve continuous communication between the brain and peripheral organs and are modulated by executive functions involved in decision-making processes [17]. Appetite and food intake can be hyperstimulated by environments rich in food rewards, leading to excessive consumption of calories and nutrients. Additionally, biological dysfunction in appetite-regulating pathways may contribute to the development of food-related disorders, such as obesity and eating disorders [19]. Thus, there is ongoing interaction between the homeostatic and hedonic systems governing food intake. While homeostatic regulation of body weight is driven by a balance between energy intake and expenditure based on physiological needs, hedonic control strongly influences eating behavior through motivation for pleasure and the reward value of food. Homeostatic signals rely on hormonal and biochemical messengers released from peripheral organs, which act on brain regions such as the hypothalamus and rhombencephalon. In contrast, hedonic control involves cortical and subcortical brain areas and is influenced by the sensory appeal of food, as well as the intensity and frequency of exposure to food-related stimuli in the environment [18]. Moreover, the decision to

start eating and what will be ingested also involves the control of executive functions processed in the corticolimbic system, particularly the prefrontal cortex [20]. Eating behavior is ultimately shaped by a complex integration of information, including input from the sensory systems (visual, olfactory, gustatory, and auditory), visceral and nutrient signals, motivational states, environmental cues, and any relevant pathophysiological conditions, allowing individuals to adapt their food choices to their environment.

Understanding the complexity of eating behavior is essential to fully understand and implement treatment strategies for diseases associated with dysfunctional eating behaviors, such as eating disorders and obesity. This knowledge supports the creation of more humane, evidence-based, effective nutritional strategies, thereby promoting the advancement of nutritional sciences and public health. Food and nutrition education is an important aspect of the training and work of nutritionists. When combined with neuroscientific evidence on human eating behavior and the pathophysiological aspects of eating disorders and chronic diseases, nutritionists can generate more effective treatments for coping with such health problems [21]. More recently, advances in the pharmacological treatment of obesity using GLP-1 agonists have fostered discussions on the role of nutritionists in this new context [22]. New forms of nutritional care for people living with obesity that combine aspects of psychology with nutritional care have been proposed so that these patients can be better served [23], without resorting to approaches that foster stereotypes and prejudice in the context of care [24].

The role of food and nutrition in memory

The relationship between cognition, memory, and nutrition is interdependent. Memory processes can influence decisions around food choices, eating behavior, and nutrient intake. In contrast, nutritional status has a direct impact on cognitive processes, including memory. Increasingly, research has focused on the role of nutritional status and the potential protective effects of specific nutrients in protecting cognitive function and delaying the progression of conditions that impair memory, such as dementia and neurodegenerative diseases (especially Alzheimer's disease).

Obesity is a well-established risk factor for cognitive decline, stroke, Alzheimer's disease, and vascular dementia [25-27]. Accordingly, current clinical guidelines for dementia prevention consider obesity a major modifiable risk factor [28,29]. A large meta-analysis involving over 1 million people demonstrated that being overweight is a significant risk factor for dementia [30]. Specifically, the analysis revealed that a 5 kg/m^2 increase in Body Mass Index (BMI) was associated with a 0.71 risk of dementia (95% CI: 0.66–0.77) when BMI was measured less than 10 years before diagnosis, a 0.94 risk (95% CI: 0.89–0.99) when assessed 10 to 20 years prior, and a 1.16 risk (95% CI: 1.05–1.27) when measured more than 20 years before diagnosis. This association likely reflects two distinct processes: a long-term detrimental effect of elevated BMI on cognitive health and a reverse causality effect, in which higher BMI appears protective in the short term due to weight loss associated with the early, preclinical stages of dementia [30].

In the field of nutrition, the relationship between diet quality and cognitive function, particularly memory, has been extensively studied. The evidence suggests an association between dietary quality and cognitive performance [31]. Studies analyzing dietary patterns and the frequency of consumption of specific foods (such as sugary beverages and fast food) have shown a relationship between these eating habits and various aspects of cognition and memory [32-34]. Notably, even in the absence of obesity, diets high in ultra-processed foods and low in polyphenols, antioxidants,

and omega-3 polyunsaturated fatty acids have been associated with impaired memory performance [35,36]. The Mediterranean diet has consistently been associated with a slower decline in cognitive function and a reduced risk of dementia. In contrast, Western dietary patterns are linked to accelerated cognitive decline and may increase the risk of developing dementia [37]. Some studies, including that by Hallböök et al. [38], suggest that ketogenic diets may exert neuroprotective effects. More recently, adherence to the Planetary Health Diet, a plant-forward dietary pattern that emphasizes fruits, vegetables, whole grains, and healthy fats while limiting animal products, refined grains, added sugars, and unhealthy fats, has also been associated with a slower decline in memory and global cognitive function [39]. However, accurately identifying these associations in human studies presents methodological challenges. Diets are difficult to control in free-living populations, and directly measuring nutrient intake often requires costly and invasive methods, such as blood sampling or supplementation trials. As a result, most studies on the impact of diet on cognitive performance rely on food frequency questionnaires to estimate dietary intake based on self-reported consumption over a specific period. While widely used, food frequency questionnaires depend on memory-based reporting, which may limit their reliability, particularly in studies assessing the relationship between diet and memory function [40].

Much of the existing evidence on the impact of diet on memory and cognition has focused on neurodegeneration and age-related memory decline. However, an increasing number of studies in healthy young adults have reported negative correlations between self-reported intake of dietary fats and sugars and performance on memory tests. Nutritional research has also examined the influence of memory on energy and nutrient intake. Early evidence for the role of memory in appetite regulation came from observations of individuals with amnesia, who often exhibited disturbances in hunger and satiety cues. In 1985, Hebben et al. [41] reported that the famous amnesic patient H.M., who suffered profound memory loss following brain surgery to treat epilepsy, rarely experienced sensations of hunger or thirst, even after extended periods without food or water. The study of cognition and memory in the regulation of food intake is particularly important, considering growing evidence that obesity is associated with cognitive deficits.

There is currently no robust evidence supporting specific nutritional therapies for cognitive recovery in individuals yet. Nonetheless, nutritionists still play a crucial role in guiding the development of structured eating routines and encouraging the consumption of nutrients in an adequate and balanced manner to foster healthier dietary habits, which have been consistently linked to improved mental health outcomes.

The role of diet and nutrition in mood disorders

In studies on nutrition and mood disorders, including major depressive disorder and bipolar disorder, numerous studies have explored the relationship between both individual nutrients and overall dietary patterns as potential preventive or adjuvant treatment strategies. This interest stems from the biological underpinnings of mood disorders, which are often associated with oxidative stress, persistent low-grade inflammation, mitochondrial dysfunction, and immune system dysregulation [42,43]. Nutrients such as omega-3 fatty acids and vitamin D are among the most studied in relation to depression because of their proposed roles in modulating inflammatory markers and interacting with key neurotransmitters, such as serotonin and dopamine, alongside other neurobiological mechanisms [44,45]. Few studies have directly assessed the effects of dietary intake and specific nutrients on mood. However, a recent review highlighted the potential of omega-3 polyunsaturated fatty acids, vitamins C and E, and zinc in alleviating symptoms of depression[46]. Other nutrients,

including B-complex vitamins, various antioxidants, amino acids such as tryptophan, and certain herbal supplements, are also being studied for their possible role in managing symptoms in individuals with mood disorders. However, more robust studies are necessary to establish their efficacy and inform clinical recommendations [47].

Studies on dietary patterns have adopted different approaches to explore the relationship between mood disorders and both unhealthy and healthy diets [43]. Diets characterized by low consumption of fruits and vegetables (key sources of dietary fiber) and high intake of processed foods, refined grains, sugars, and artificial additives have been associated with an increased risk of depressive symptoms in individuals without a history of depression [48]. Furthermore, adherence to Western dietary patterns and diets considered to have a "high inflammatory index" has been linked to greater severity of depressive symptoms among individuals diagnosed with mood disorders [49]. In a cohort study involving individuals with bipolar disorder, improved diet quality was associated with favorable changes in gut microbiota composition, which in turn were associated with improvements in bipolar disorder symptoms [50]. Despite these findings, clinical trials investigating the effects of dietary interventions in patients with bipolar disorder remain limited.

From the perspective of healthy eating, observational studies have also shown that a higher intake of fruits and vegetables is associated with a reduced risk of depression in both adults and older adults (>65y) [49,51]. Research examining vegetarian and vegan diets in relation to depression and bipolar disorder has suggested potential protective effects against severe symptoms. However, many of these studies have not evaluated the nutritional quality of these diets in terms of specific nutrient adequacy [52,53]. Clinical trials investigating various dietary interventions have generally found that reducing the intake of high-fat and high-sugar foods and replacing them with higher-fiber, lower-fat alternatives is associated with a decrease in depressive symptoms [54]. The ketogenic diet has also been studied in the context of depression and bipolar disorder, though further research is needed before clinical application, as existing studies are limited by small sample sizes, and considering the potential protocol-related risks [55]. Additionally, clinical studies examining the Mediterranean diet or improvements in diet quality have reported positive effects on depressive symptom reduction [56-58].

A healthy and balanced diet is recommended as an adjuvant strategy in the treatment of mood disorders [59]. In this context, nutritionists play a vital role in guiding and supporting affected individuals in structuring their eating routines, preventing nutritional deficiencies, and restoring nutritional status when necessary. When combined with the use of medications and therapies, a well-planned diet not only provides the essential nutrients required for optimal brain and body function but also helps patients establish consistent daily habits and improve their overall well-being and support greater engagement in their social life.

The role of diet and nutrition in neurodevelopmental disorders: Autism Spectrum Disorder (ASD) and Attention-Deficit/Hyperactivity Disorder (ADHD)

In recent years, the increasing diagnosis of neurodevelopmental disorders, such as autism Spectrum Disorder (ASD) and Attention-Deficit/Hyperactivity Disorder (ADHD), combined with the widespread dissemination of related information on social media and in mainstream media, has contributed to growing public interest in the role of diet and eating behaviors associated with these conditions, particularly among children with ASD. Both ASD and ADHD have a strong genetic and hereditary basis, accounting for approximately 98% of cases, while environmental factors

appear to play a comparatively smaller role. Notably, comorbidity between the two disorders is high, reaching around 35% [60]. Although ASD and ADHD are distinct in terms of clinical and neurological characteristics, they often present similar signs and symptoms, such as executive dysfunction, hyperfocus, heightened environmental sensitivity, and increased sensory perception. These features can manifest as restlessness (often referred to as "stimming" in ASD and hyperactivity in ADHD), low threshold for frustration, anxiety, and avoidant behaviors that resemble procrastination [61,62]. The intensity of symptom expression varies among individuals and is categorized as levels of support in ASD (Levels 1, 2, and 3) and levels of severity in ADHD (mild, moderate, and severe) [63]. Currently, ASD and ADHD are not classified as diseases but rather as a spectrum of atypical brain functions, with those affected being called neuroatypical, neurodivergent, or neurodiverse [64]. Nonetheless, regardless of the level of support or severity, both ASD and ADHD can significantly impact child development and last throughout life, requiring specialized monitoring and tailored therapeutic interventions to address these challenges and achieve a better quality of life and greater independence.

Some researchers and health professionals have attempted to investigate the link between the clinical manifestations of ASD with the ingestion of certain foods or nutrients, such as gluten, milk, and lactose, as well as with food allergies, intolerances, gastrointestinal infections, intestinal parasites, and gut dysbiosis, among other factors. However, to date, no study has been conclusive. The mistaken belief that ASD is caused by certain foods or nutrients has contributed to the spread of unproven dietary interventions, such as the ketogenic or low-carbohydrate diet, excessive use of dietary supplements, deworming protocols, and even enemas, which are sometimes promoted as ways to control symptoms or even "cure" affected individuals. The same misconceptions extend to ADHD, where it is often speculated, without scientific basis, that sugar, artificial food colorings, ultra-processed foods, or excessive screen time during childhood are causal factors. These inaccuracies not only lack empirical support but can also divert attention from evidence-based interventions. Furthermore, such unproven pseudo-treatments may not only delay access to proven, effective therapies but may also pose health risks to the individuals who use them. Recent systematic reviews have concluded that there is no robust evidence for the adoption of restrictive diets, including gluten-free, lactose-free, dairy-free, ketogenic, or low-carb diets, or nutritional supplements such as omega-3 fatty acids, vitamin D, probiotics, or vitamin B12 in the treatment of ASD or ADHD [65-67]. Furthermore, from the perspective of food and nutritional inclusion, the adoption of unnecessarily restrictive interventions is not only unjustified but also potentially harmful, as it may further limit social participation without offering any proven clinical benefit.

Neurodiverse children and adults do not have different nutritional needs compared to neurotypical individuals of the same age group. Like the general population, they are susceptible to common eating-related issues [68]. However, the clinical manifestations of ASD and ADHD can uniquely influence eating behaviors and nutritional status, exacerbating dysfunctional behaviors related to food intake, disrupting eating routines, and interfering with the development of appropriate and healthy eating habits [68]. Most of the recommended interventions for neurodevelopmental disorders are behavioral in nature and involve developing cognitive, sensory, motor, social, and behavioral skills to improve the individual's relationship with food through gradual skill and experience acquisition [69]. To implement such strategies effectively, a multidisciplinary team is necessary, tailored to the individual's specific needs. This team may include professionals such as a nutritionist, neurologist, psychiatrist, psychologist, physiotherapist, occupational therapist, speech therapist, neuropsychopedagogue, or physical educator.

In the field of food and nutrition, special attention should be paid to the intrinsic factors that influence food choices and eating routines. For neurodiverse individuals, nutritionists should assist in the planning and organizing a structured and healthy eating routine, develop strategies to gradually expand eating experiences, help reduce stress and anxiety during mealtimes, and investigate, prevent, and treat potential nutritional deficiencies, food allergies, or intolerances when present [68].

Some studies have attempted to elucidate the behavioral aspects of eating in individuals with ASD. The main findings include a dietary pattern with low food variety, high food rejection, and low consumption of plant-based and protein-rich foods. As a result, individuals with ASD often exhibit low consumption of proteins, calcium, zinc, and B-complex vitamins, alongside a higher intake of refined carbohydrates [70-72]. These characteristics may be closely linked to the clinical characteristics of ASD, such as cognitive rigidity, which can lead to resistance to trying new foods and preparations, difficulty mixing different food items, and strict adherence to eating rituals. Other characteristics include hyperfocus that may cause an intense preference for specific types, textures, or shapes of food, contributing to episodes of binge eating and challenges in eating outside the home, sensory hypersensitivity that can cause difficulties with new textures, smells, colors, and flavors, sometimes resulting in physical discomfort and potentially contributing to the development of Avoidant/Restrictive Food Intake Disorder (ARFID) [73] and delays in neuropsychomotor development that may impair autonomy in making food choices and eating independently [74]. Gastrointestinal symptoms are also commonly reported in individuals with ASD and are frequently misinterpreted as food allergies or intolerances [75]. Therefore, careful investigations should be conducted to avoid unnecessary food and nutrient exclusions. When nutrient deficiencies are confirmed through laboratory testing, targeted nutrient supplementation should be administered. In Brazil, the dietary and nutritional profiles of individuals with ASD have been examined by national researchers and nutritionists, contributing to a growing body of evidence on nutritional care for this population [76-80]. One notable initiative is the TEA Brazil Network, linked to the *Universidade Federal de Pelotas*. This research network, supported by the Department of Science and Technology and funded by the Ministry of Health in partnership with National Council for Scientific and Technological Development, aims to review existing laws and public policies related to ASD, from diagnosis to intervention, while also promoting publications and scientific evidence on the disorder (more information is available at: https://wp.ufpel.edu.br/redeteabrasil/).

Studies on the dietary profile of individuals with ADHD have identified a pattern commonly referred to as "unhealthy," characterized by high consumption of fast foods, snack foods, ultra-processed ready-to-eat products, sweets, and sugary drinks, alongside low intake of vegetables. This dietary pattern has been associated with excessive consumption of sugar, salt, trans and saturated fats, and reduced intake of vitamin B12 [81-84]. Several clinical characteristics of ADHD contribute to these eating behaviors. These include impulsivity and deficits in inhibitory control, which increase susceptibility to food-related environmental cues, such as advertising. Individuals may also experience difficulty stopping eating, a tendency toward addictive behaviors (including food and substance use), and challenges in emotional regulation. The pursuit of immediate gratification further increases the likelihood of choosing readily available, palatable foods such as fast food. Additionally, executive dysfunction can impair the ability to plan, organize, and maintain structured eating routines, while hyperfocus may make it difficult to disengage from other activities or regulate food intake. The nutritional management of children with ADHD has been reviewed by Brazilian researchers [85,86], who emphasize that improving dietary patterns by promoting a healthier diet can reduce symptoms and have significant health benefits.

Although there is no formally established scientific definition, some nutrition professionals working with neurodiverse individuals have adopted the term "Feeding Therapy" to describe their area of practice. This term has gained visibility, particularly on social media platforms, in the context of supporting children with varying degrees of food selectivity. The purpose of feeding therapy is to help individuals develop skills that improve mealtime experiences by increasing food acceptance as well as providing autonomy in eating and the ability to make healthier food choices [87]. Feeding therapy combines the principles of nutrition education with strategies similar to those used in Occupational Therapy, particularly those grounded in sensory integration approaches [88].

Thus, it becomes evident that behavioral strategies represent the first line of action for nutritionists involved in the care of neurodiverse individuals. Ongoing neuroscience studies that seek to elucidate the mechanisms associated with the effectiveness of such strategies will not only broaden our understanding of brain functioning in individuals with ASD and ADHD but also contribute to the development and validation of evidence-based practices in the field of food and nutrition. This knowledge is essential for promoting a more inclusive approach to dietary care for neurodiverse populations. Similarly, well-designed randomized controlled trials with larger and more representative sample sizes are needed to determine whether specific subgroups of individuals with ASD or ADHD may benefit from particular dietary interventions or nutritional supplements.

The role of diet and nutrition in neurological diseases

Food and nutrition are increasingly recognized as important factors in both the prevention and management of neurological diseases. Nutrient imbalances have been associated with various neurological conditions, and a growing body of research supports the use of nutraceuticals and specific dietary interventions as complementary strategies in the treatment of these disorders [89]. In response to this emerging evidence, regulatory agencies have begun to establish nutritional guidelines for neurological diseases [90,91]. At the international level, the European Society for Clinical Nutrition and Metabolism has recently updated two important guidelines. One addresses the nutritional management of patients with dementia and Alzheimer's disease [91], while the other provides broader guidance for the nutritional care of individuals with neurological diseases, including conditions such as stroke and Parkinson's disease [90]. These guidelines cover critical aspects such as the use of supplements, dysphagia management, and other measures aimed at preventing malnutrition and preserving nutritional status. In Brazil, although the Ministry of Health has published treatment protocols for Alzheimer's and Parkinson's diseases, these documents do not include detailed guidance on nutritional management [92,93]. This is a critical omission, as such diseases often compromise an individual's nutritional autonomy, increase the risk of malnutrition, and can lead to a significant decline in nutritional status [94,95]. Thus, nutritionists are the most suitable professionals to assess, diagnose, and monitor the nutritional needs of individuals with Alzheimer's or Parkinson's disease, as well as recommend nutritional support when the need is identified, both in clinical and home settings, as outlined by the CFN in Resolution No. 600/2018.

Considering the role of nutritional imbalances, some studies have explored the impact of malnutrition and specific nutrients on the development and progression of neurological conditions such as stroke, neuroinflammation, Parkinson's disease, Alzheimer's disease, multiple sclerosis, and conditions related to chronic stress [96-98]. In addition to the direct effects of nutrient deficiencies, pharmacological treatments can also cause fluctuations in nutrient levels and contribute to neurological symptoms. For example, levodopa, a commonly prescribed medication for Parkinson's disease, acts as a zinc-chelating agent. Zinc is a vital micronutrient involved in numerous physiological

functions, including those of the integumentary, immune, and nervous systems. Studies have shown that patients with Parkinson's disease who use levodopa may exhibit reduced zinc levels, which can result in symptoms such as taste disturbances, stomatitis, dermatitis, and a variety of neuropsychiatric symptoms, including depression, anxiety, and sleep disorders. These effects are likely related to the anti-inflammatory and antioxidant properties of zinc, as well as its regulatory role in neurotransmitter systems, particularly serotonin and glutamate receptors [99].

The use of specific foods and diets, specifically nutraceuticals, has shown potential in the prevention and management of many neurological conditions. Nutrient-dense diets, such as the Mediterranean diet and diets rich in omega-3 fatty acids, have been associated with neuroprotective effects and cardiometabolic benefits. In contrast, diets high in processed foods, saturated fats, and trans fats are linked to chronic low-grade systemic inflammation, which plays a contributory role in neuroinflammatory mechanisms involved in the pathogenesis of neurodegenerative diseases [4]. There is also growing evidence supporting the potential use of vitamin D supplementation in individuals with Alzheimer's disease, Parkinson's disease, and other neurological diseases, as low serum levels of vitamin D have been consistently associated with an increased risk of cognitive decline [4].

An increasingly recognized example of dietary intervention in neurological care is the use of the ketogenic diet for the treatment of pharmacoresistant epilepsies [100,101]. The efficacy of the ketogenic diet in managing pharmacoresistant epilepsies is well-supported by scientific evidence and is based on metabolic changes and neuroprotective mechanisms associated with ketogenesis. Ketone bodies, produced through the oxidation of fatty acids, either during fasting states or via high-fat, low-carbohydrate diets, exhibit significant antioxidant and neuroprotective properties. These mechanisms help protect neuronal cells from damage following seizures, promote an anti-seizure metabolic state, and modulate excitatory/inhibitory balance in the CNS, as well as the gut-brain axis and neuroplasticity. Additionally, the ketogenic diet has been shown to reduce the production of reactive oxygen species and neuroinflammation [102]. Beyond pharmacoresistant epilepsies, the ketogenic diet has also been studied as a potential intervention in conditions such as migraine, Alzheimer's disease, Parkinson's disease, ASD, amyotrophic lateral sclerosis, and brain neoplasms. However, findings in these areas remain inconclusive [103-105]. In cases of epilepsy, it is the neurologist's responsibility to identify patients who may benefit from the ketogenic diet. Once prescribed, the nutritionist plays a central role in implementing the dietary protocol, working closely with the patient and caregivers to prescribe the dietary plan, provide education and support to families, and monitor both metabolic and neurological outcomes as part of an interdisciplinary team. The International League Against Epilepsy maintains a global network of ketogenic diet treatment centers for epilepsy (https://www.ilae.org/patient-care/ketogenic-diets/international-centers#SA). In Brazil, eight centers are currently registered with the International League Against Epilepsy. Four are located in the state of São Paulo (affiliated with Universidade de Campinas, Faculdade de Medicina da Universidade de São Paulo and Universidade de São Paulo – Ribeirão Preto), and others are located in Pernambuco, Rio de Janeiro (Universidade Federal Fluminense), Curitiba, and Santa Catarina (linked to the University Hospital of Universidade Federal de Santa Catarina). Additionally, other specialized institutions with nutritionists trained in ketogenic therapy include the Epilepsy and Functional Neurosurgery Unit in Natal, RN, the Albert Sabin Children's Hospital in Fortaleza-CE, and the Santos Dumont Institute in Macaíba-RN.

Reflections and future directions

Brazil currently holds the highest number of reported cases of depression and anxiety worldwide. In addition, the rising prevalence of obesity, the increasing incidence of eating disorders,

the growing number of neurodiverse diagnoses, and the elevated risk of neurological diseases due to population aging are all critical public health challenges that should guide and inform professional practice in the field of nutrition. Within this context, nutrition professionals who are capable of bridging the gap between nutrition and mental health are poised to play a transformative role in both individualized care and population-level strategies. Despite the expanding interest in NN, scientific literature does not always translate into best practices. Many nutritionists continue to disseminate nutritional information and interventions lacking a solid evidence base, often via social media and even at scientific events. This disconnect is partly attributable to gaps in undergraduate education. The current National Curricular Guidelines for nutrition programs in Brazil [106] do not require the inclusion of dedicated coursework in neuroscience or in the behavioral sciences that are fundamental to understanding eating behavior, mental health, and neurological function. Compounding this issue is the scarcity of specialized, high-quality training in the areas of neuroscience, neurology, psychiatry, and psychology. As a result, many trained professionals propagate scientifically erroneous ideas, contributing to misinformation and often engaging in iatrogenic behaviors with a strong pseudoscientific connotation. From an evidence-based nutrition perspective, especially within the scope of NN, it is essential to acknowledge and address these training deficiencies. Investing in specialized education and continued professional development is crucial to ensure that nutritionists are equipped to deliver accurate, effective, and timely interventions tailored to the needs of each individual.

CONCLUSION

Nutritional Neuroscience (or neuronutrition) is an emerging and promising field for nutritionists, offering significant opportunities in both scientific research and clinical practice. A solid understanding of the neurobiological foundations of eating behavior and the basic principles of neuroscience equips nutritionists to more effectively support changes in eating habits that promote healthier dietary patterns at both individual and population levels. Furthermore, education and training in related areas such as psychology and psychiatry help nutritionists to be better equipped to work with individuals affected by eating and mood disorders, who often require specialized, interdisciplinary care. In the management of neurological diseases, nutritionists play a critical role in restoring nutritional status and adapting dietary strategies to meet the specific needs of each patient. Similarly, in the care of neurodiverse individuals, nutrition professionals assist in the development of healthy eating routines that foster greater autonomy, nutritional adequacy, and better decision-making regarding food choices. Therefore, the inclusion of nutritionists in multidisciplinary mental health care teams is essential to provide more humanized, individualized, and holistic care for patients.

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