

Original Article



Physicians' Understanding of Nutritional Factors Determining Brain Development and Cognition in the Middle East and Africa

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ABSTRACT


Purpose: Proper nutrition is essential for brain development during infancy, contributing to the continued development of cognitive, motor, and socio-emotional skills throughout life. Considering the insufficient published data in the Middle East and North Africa, experts drafted a questionnaire to assess the opinions and knowledge of physicians on the impact of nutrition on brain development and cognition in early life.

Methods: The questionnaire consisted of two parts: The first focused on the responders' demographic and professional characteristics and the second questioned the role of nutrition in brain development and cognition. Descriptive statistics were used to summarize respondents' characteristics and their responses to questions.

Results: A total of 1,500 questionnaires were distributed; 994 physicians responded. The majority of the surveyed physicians (64.4%) felt that nutrition impacts brain development in early childhood (0–4 years), with almost 90% of physicians agreeing/strongly agreeing that preventing iron, zinc, and iodine deficiency would improve global intelligence quotient. The majority of physicians (83%) agreed that head circumference was the most important measure of brain development. The majority of physicians (68.9%) responded that the period from the last trimester until 18 months postdelivery was crucial for brain growth and neurodevelopment, with 76.8% believing that infants breast-fed by vegan mothers have an increased risk of impaired brain development.

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Conclusion: The results of this study show that practicing physicians significantly agree that nutrition plays an important role in brain and cognitive development and function in early childhood, particularly during the last trimester until 18 months postdelivery.

Keywords: Neurodevelopment; Nutrition; Middle East

INTRODUCTION

The growth and development of the human brain is heterogeneous over time, but the brain's capacity and structure are shaped before the age of 3 years [1]. Failure to optimize development in early life will likely have long-term effects on adult mental health and personal potential [1]. It is well established that infancy is the most important period for brain development [2]. Breast-feeding was shown to enhance brain development and capacity. A meta-analysis indicated that, after the adjustment of appropriate key cofactors, breast-feeding was associated with significantly higher scores for cognitive development than formula feeding [3].

Improper nutrition risks disruption of this rapid process, which provides a basis for the continued development of cognitive, motor, and socio-emotional skills throughout life [2]. Energy and several nutrients including the micronutrients vitamin B12, folate, choline, zinc, and iron and essential fatty acids are vital to avoid developmental problems [2]. The long-term effects of individual nutrient deprivation on brain function are not entirely clear [2,4]. According to the World Health Organization, several Middle Eastern countries commonly report deficiencies and/or inadequate intake or status of calcium, iodine, iron, zinc, vitamin A, vitamin D, and folate across all age groups, including children [5,6].

Studies that have evaluated the knowledge and practices of healthcare providers for the prevention of nutritional deficiencies in patients across the Middle East and North Africa (MENA) region have not been conducted. Therefore, a group of experts across the region came together with the aim of developing a questionnaire to assess the opinions and knowledge of physicians on the impact of nutrition on brain development and cognition in early life.

MATERIALS AND METHODS

The questionnaire was developed by a working group of experts in the field of pediatric gastroenterology, nutrition, and pediatric neurologists from Egypt, Iran, the Kingdom of Saudi Arabia, Kuwait, Lebanon, Morocco, and the United Arab Emirates. The questionnaire circulated electronically among all coauthors, and a face-to-face meeting was organized to reach a final consensus.

The questionnaire consisted of two parts: the first focused on the responders' demographic and professional characteristics and the second part included questions regarding the role of nutrition in brain development and cognition. The questionnaire was in English or French (the latter in Algeria and Morocco). The survey assessed physicians' opinions on and understanding of the factors affecting brain development and cognition, with a focus on the role of nutrition and specific micronutrients.

Convenience sampling was used to collect data; surveys were distributed at national and regional meetings of healthcare professionals involved in pediatric care across the MENA region for anonymous completion, either electronically or in paper format. Descriptive statistics were used to summarize the characteristics of the respondents and their responses to the questions.

RESULTS

Physicians' characteristics

A total of 1,500 questionnaires were distributed; 994 physicians responded (**Table 1**). Overall, approximately 55% of the respondents were pediatricians, who stated that they saw more outpatients than did family physicians (**Table 2**).

Perception of factors affecting child development

Of the 994 respondents, 66.7% considered that nutrition affects gross motor development, while 73.8% and 69.9% considered that nutrition affects physical development and mental development, respectively. Physicians were asked to select factors that were least impacted by nutrition, and of all the respondents, 36.2% felt that hearing was least affected by nutrition,

Table 1. Self-reported physician demographics and professional characteristics

Characteristics	Value
Total respondents	994
Sex	
Male	534 (54.9)
Female	439 (45.1)
Not reported	21
Age (yr)	
<30	22 (2.3)
30–40	584 (61.4)
40–50	259 (27.2)
50–60	74 (7.7)
>60	12 (1.3)
Specialty	
Family physician	350 (38.7)
Pediatricians	555 (61.3)
Not reported	89
Practice setting*	
Government	641 (64.5)
Private facility	301 (30.3)
University/medical school	132 (13.3)
Practice location	
Urban	802 (84.7)
Rural	145 (15.3)
Not reported	47

Values are presented as number (%).

*Respondents could select multiple options.

Table 2. Number of outpatient consultations per physician

Physician	Number of patients				
	<25 wk	25–50 wk	50–100 wk	>100 wk	Unknown
Total	280	227	219	260	8
Family	106	80	88	75	1
Pediatrician	153	118	116	166	2
Unknown	21	29	15	19	5

followed by vocabulary development (31.6%), intelligence quotient (IQ) (20.4%), and visual development (11.9%).

Nutrients and brain development

The majority of the physicians (64.4%) felt that nutrition played an important role in brain development in early childhood (0–4 years). Additionally, almost all of the physicians agreed (44.4%) or strongly agreed (45.0%) that there is a cause-and-effect relationship between nutrition and cognition. A small number of physicians (1.9%) disagreed, whereas 8.6% remained neutral.

Over 85% of respondents agreed that more than one nutrient affects cognitive development. The majority (69.2%) of the physicians ranked iron as the most important nutrient for brain development and cognition, and almost 90% of physicians agreed that preventing iron, zinc, and iodine deficiencies would improve global IQ (Table 3).

Monitoring development

Head circumference was significantly considered to be the most important growth parameter that can be used to monitor brain development (83.1%). In comparison, infant length (8.7%),

Table 3. Physician perception of the impact of specific nutrients on the brain and cognitive development

Impact of nutrients	Value
Total respondents	994
More than one nutrient affects cognitive development	
Strongly agree	391 (39.8)
Agree	461 (46.9)
Neutral	90 (9.2)
Disagree	40 (4.1)
Not reported	12
Nutrient important for brain development and cognition*	
LCPUFAs	569 (57.8)
Iron	681 (69.2)
Folate	410 (41.7)
Choline	253 (25.7)
Lutein	220 (22.4)
Iodine	330 (33.5)
Not reported	10
Preventing iron deficiency will help maintain normal brain development*	
Strongly agree	389 (39.5)
Agree	453 (45.9)
Neutral	107 (10.9)
Disagree	37 (3.8)
Not reported	8
Preventing iron, zinc, and iodine deficiency will improve global intelligence quotient*	
Strongly agree	475 (49.3)
Agree	406 (41.3)
Neutral	79 (8.0)
Disagree	23 (2.3)
Not reported	11
Nutrient triads supporting mental development	
Calcium-phosphorus-magnesium	149 (15.3)
Choline-lutein-DHA	358 (36.8)
Iron-vitamin D-zinc	391 (40.1)
Nucleotides-vitamin A- α -lactalbumin	76 (7.8)
Not reported	20

Values are presented as number (%).

LCPUFA: long-chain polyunsaturated fatty acid, DHA: docosahexaenoic acid.

*Respondents could select multiple options.

body weight (6.6%), and mid-arm circumference (1.6%) were less common responses. A little over half of the physicians (56.2%) agreed that brain magnetic resonance imaging (MRI) would be able to detect abnormalities caused by nutritional deficits. Of the remaining physicians, 21.4% disagreed on the usefulness of brain MRI to detect nutrition-related abnormalities, and 22.4% remained neutral.

Maternal nutrition and infant development

The majority of physicians either agreed (41.9%) or strongly agreed (34.9%) that babies breast-fed by vegan mothers have an increased risk of impaired brain development. Less than 15% of respondents remained neutral on the topic, while 8.2% disagreed with the statement.

The majority (68.9%) of physicians believed that the most crucial period for brain growth and neurodevelopment is from the last trimester until 18 months postdelivery. Preschool was the second most common answer (25.8%), followed by late childhood (3%) and adolescence (2.2%).

DISCUSSION

Policy makers significantly emphasize that the ‘first 1,000 days’ from conception is a golden opportunity to influence outcomes in later life [1]. Clinical and epidemiological studies of neurodevelopment suggest that a window extending to 3 years is key for anatomical and functional brain development [1]. It has been well established that nutrition plays a fundamental role in development from infancy to later life. Improper nutrition risks disruption of this rapid process, which is the basis for the development of cognitive, motor, and socio-emotional skills throughout life [2]. Breast-feeding is definitely the best way to feed infants. An unadjusted benefit of 5.32 (95% confidence interval [CI], 4.51–6.14) points in cognitive function was observed for breast-fed compared to formula-fed children [2]. After the adjustment of covariates, the increment in cognitive function was still 3.16 (95% CI, 2.35–3.98) points [2]. This adjusted difference was significant and homogeneous. Significantly higher levels of cognitive function were observed in breast-fed than in formula-fed children at 6–23 months, and these differences were stable across successive ages. Low-birth-weight infants showed larger differences (5.18 points; 95% CI, 3.59–6.77) than normal-birth-weight infants (2.66 points; 95% CI, 2.15–3.17), suggesting that premature infants acquire more benefits in cognitive development from breast milk than full-term infants [2]. Finally, the cognitive developmental benefits of breast-feeding increased with duration [2]. Breast-feeding protects children from infections and malocclusion, reduces the risk for overweight and diabetes, and enhances intelligence [7].

It is important to clarify that physicians who responded to this survey care mostly for patients in the middle and upper socioeconomic class. The awareness of the effect of nutrition (or lack thereof) on brain development may not be as established among all physicians practicing across the MENA region. Circumstantial evidence suggests that brain development follows epigenetic mechanisms that are influenced by environmental factors such as nutrition, leading to long-lasting or even heritable changes in biological programs [4]. It is important to emphasize that the majority of physicians responding to this survey agreed that more than one nutrient affects cognitive development, with many speculating that long-chain polyunsaturated fatty acids (LCPUFAs), iron, folate, choline, lutein, and iodine are the most important nutrients. This is consistent with the evidence from observational studies suggesting that micronutrients including omega-3 fatty acids, vitamin B12, folic

acid, choline, iron, iodine, and zinc play an important role in the cognitive development of children [4,8,9]. Emerging evidence indicates that nutrition in the early life can significantly influence neurodevelopment, affecting later life health outcomes, neurocognitive performances, and disease risks. Inadequate early life nutrition has been associated with some neuropsychiatric disorders [10]. Epigenetic mechanisms could play a crucial role, imprinting the genomes in early life, with the individual more susceptible to develop diseases later in life. Children adequately nourished are more likely to reach their developmental potential in cognitive, motor, and socio-emotional abilities, with positive societal effects [10]. The prevention of iron deficiency anemia in infancy is important for brain development since it was shown that adolescents who received iron-fortified formula as infants from 6 to 12 months at levels recommended by the USA had poorer cognitive outcomes compared to those who received a low-iron formula [11]. Nutrient deficiencies are common during the early adoption period in international adoptees from three global regions, and iron and zinc deficiencies are associated with poorer neurodevelopmental outcomes [12]. Prenatal selenium intake is associated with cerebellum length and width measured by cranial ultrasonography [13]. Long-term dietary variation in selenium influences oxidative stress that impacts cognitive functions [14]. Total neurocognitive development in infants was positively associated with serum calcium levels [15]. Therefore, calcium supplementation may improve neurocognitive development in malnourished infants [15]. Low vitamin D status in pregnancy is associated with offspring language and motor development, particularly in young children [16]. An insufficient iodine intake in pregnancy was associated with lower infant language skills up to 18 months [17]. However, the use of iodine-containing supplements was not associated with beneficial effects [17]. Experimental studies have demonstrated that the cytoarchitecture of the cerebral cortex can be irreversibly disturbed in iodine deficiency, causing abnormal neuron migratory patterns that are associated with cognitive impairment in children [18]. Regarding zinc, no association was found between zinc intake and mental and motor development in infants [19]. Although no significant effects of maternal vitamin B12 supplementation were observed on cognitive development in 9-month-old infants, increased maternal total homocysteine levels were associated with poorer cognitive performance in some of the subdomains of Bayley Scales of Infant Development-III [20]. Supplementing gangliosides and phospholipids in wild-type animals and healthy infants suggests some positive effects on cognitive performance [21].

We believe that physicians' knowledge on LCPUFAs and choline reflects the success of continuing medical education (CME) programs conducted over the past two decades as no such information was included in medical education programs prior to the late 1990s. Although CME has evidently impacted on physicians' overall awareness of micronutrients, recent clinical and preclinical evidence has demonstrated that docosahexaenoic acid and arachidonic acid are important components of neuronal membranes and perinatal LCPUFA supplementation leads to improved cognition and sensorimotor integration [22]. Furthermore, studies have shown that iodine deficiency during fetal development and early childhood is associated with cognitive impairment [23-25]. A growing body of evidence suggests that folate and metabolically related B vitamins are essential for brain health across all age groups due to their role in the production of neurotransmitters [26]. Additionally, the role of iron in myelination, neurotransmitter function, and neuronal metabolism has been suggested as a possible explanation for the associations of iron with behavioral and developmental functioning [27]. These recent studies may have influenced physicians' opinion and explain why the vast majority of physicians responding to this survey agreed that preventing iron, zinc, and iodine deficiencies would likely improve global IQ and promote cognitive and mental development.

However, there is insufficient evidence to support the routine supplementation of these nutrients in infants for cognitive enhancement or global IQ improvement.

Although approximately half of the physicians surveyed agreed that brain MRI would be able to detect abnormalities due to nutritional deficits, this still needs to be thoroughly investigated in clinical studies. Only a few studies have investigated the usefulness of MRI for detecting nutritional deficiencies [28-30]. For instance, one study showed that thinning of the corpus callosum and brain atrophy can be observed in children with vitamin B12 deficiency [28]. Another study concluded that, in children older than 2 years with developmental delays, proton magnetic resonance spectroscopy detected a decrease in N-acetylaspartate/creatine and increase in choline/creatine ratios in the frontal and parieto-occipital subcortical white matter [29]. Adults who had iron deficiency anemia in infancy have been shown to have default mode network patterns reminiscent of patients with neurodegenerative diseases, such as Alzheimer's disease, frontotemporal dementia, multiple sclerosis, autism, and Parkinson's disease [30].

The majority of the physicians responding to this survey expressed concerns about impaired brain development in children being breast-fed by vegan mothers. Since there is limited evidence on the effects of vegan or vegetarian diets in pregnancy, it may be considered non-detrimental considering that careful attention is paid to vitamin and trace element requirements [31].

Study limitations

This survey provides a perspective on the current opinion of physicians in selected countries from the Middle East, North Africa, and Pakistan and their understanding of nutritional factors affecting neurodevelopment and cognition in infants. The main limitation in this study is that the information is primarily based on survey responses from a selected group of physicians who may not be representative of all physicians in their country or region. The physicians who completed the questionnaire were self-selecting, which can introduce bias. This is particularly important because of the large and diverse physician population in this region.

In conclusion, this initiative provides important insights regarding the understanding that physicians in the Middle East, North Africa, and Pakistan have on the factors that affect neurodevelopment and cognition in infants. Our survey results show that majority of physicians practicing in this region are in agreement that nutrition plays an important role not only in overall development but also, most notably, in brain and cognitive function in early childhood. Additionally, considering that maternal nutrition plays a key role in fetal, neonatal, and infant outcomes, public health policies focusing on children's development should consider the nutritional requirements of expectant and breast-feeding mothers.

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