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Mothers' knowledge of nutritional programming influences DHA intake in children – analysis of nutrition of children aged 13-36 months in Poland

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ABSTRACT

Introduction: Nutritional programming theory states that a deficiency or excess of nutrients can permanently alter a child's metabolism. The detrimental effects of such deviation can cause health problems even during adulthood. Although this concept has existed for over a dozen years, it is not always used in practice. This research investigated the awareness of Polish mothers in terms of nutritional programming and its correlation with children's nutrition.
Material and methods: The study was conducted using a questionnaire that verified the mothers' nutritional programming knowledge, nutrition during pregnancy, and their children's nutritional intake. The questionnaire was available online on various parents' Facebook groups, forums, and websites concerning children's nutrition. There were 363 women, 20-43 years old, with children under the age of 3, participating in this study. The survey was conducted in Poland from 2019 to 2021.
Results: Fourty four percent of mothers did not recognize the term 'nutritional programming'. The level of mothers' education was of primary importance, as those with a lower education overestimated their knowledge of nutritional programming. The majority of mothers were not knowledgeable about dietary recommendations for children. There was a correlation between mothers' knowledge, breastfeeding, and docosahexaenoic acid intake in children. Mothers with proper nutritional knowledge breastfed longer ($p = 0.041$) and more often ($r = 0.128$, $p = 0.017$, 95% CI: 0.023-0.230). The higher the mother's education level, the higher was the intake of DHA in children ($r = 0.294$, $p = 0.006$, 95% CI: 0.477-0.086).
Conclusions: The obtained results demonstrate that the level of awareness among mothers in this study was insufficient. This resulted in inadequate nutritional dietary intake among children. Mothers, especially those with lower education, must be adequately instructed on children's nutrition.

KEY WORDS: infant, child nutrition, development, early nutrition, breastfeeding.

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INTRODUCTION

Nutritional programming explains the relationship between children's nutrition at the early stages of their development and their health during adulthood. Scientists distinguish critical periods of children's development, which occur in intrauterine life up to three years of age. Children develop rapidly during critical periods. According to nutritional programming, a deficiency or an excess of nutrients can permanently alter a child's metabolism, exert long-lasting, irreversible effects and significantly affect its health in adulthood [1-5].

Disturbances in organs' metabolism and morphology cause irreversible consequences [5-8]. Nutritional programming explains the correlation between low birth weight and the prevalence of cardiovascular disease, obesity, osteoporosis, hypertension, impaired glucose tolerance, insulin resistance, and type 2 diabetes in adult life [9-13].

Several environmental factors may influence metabolic programming, especially children's nutrition, breastfeeding, and the moment when solid food is introduced to children's diets [4, 14]. A mother's nutrition during pregnancy, her eating behaviors, and the knowledge of healthy eating habits are also crucial [4, 14]. Pregnant women's diets should be well balanced and adjusted to individual needs [12]. The connection between a mother's nutrition and a child's health is evident. An optimal supply of macronutrients, micronutrients, and vitamins during the pre-contraceptive period, pregnancy, and lactation positively affects intrauterine growth and the mother's health [15]. Adequate fat and folic acid supply in the mother's diet is essential for the child's nervous system [15, 16]. Although the concept of nutritional programming has existed for over a dozen years, it is not always used in practice [7, 17]. The World Health Organization (WHO) recommends breastfeeding as the best way to provide infants with all the nutrients needed during their first six months of life. Breastfeeding should be continued as long as it is desired by both mother and child [17]. Long-chain polyunsaturated fatty acids (LC-PUFA) in mother's milk stimulate the development of a child's brain, and decrease the risk of developing insulin resistance and the prevalence of type 1 diabetes [18-20]. Breastfeeding supports a healthy gut microbiome and the development of normal immune responses to antibodies [21, 22].

Experts recommend introducing complementary feeding between the fifth and seventh months of a child's development. Parents should introduce gluten at any moment between the fourth and the twelfth month of a baby's life [17].

A mother's diet during pregnancy and the child's nutrition up to the age of three have the most significant impact on the child's health [4]. According to research, even though parents' knowledge of children's nutrition is growing, parents still make many mistakes in feeding their children [23].

This study aimed to investigate the awareness of Polish mothers in terms of nutritional programming and its correlation with children's nutrition. The authors assessed whether mothers' awareness converts to practical knowledge, positively impacts the number of macro- and microelements in children's diets, and aids in choosing the right moment to introduce solid foods.

MATERIAL AND METHODS

PARTICIPANTS

Initially, 427 Polish women, 20-43 years old, with children under 3, agreed to participate in the study. Sixty four women failed to complete the original questionnaire created by the researchers. The questionnaire verified mothers' knowledge of nutritional programming, nutrition during pregnancy, and their children's nutrition. It also included questions about the mothers' age, education, place of residence, and childbirth delivery methods. It comprised 10 open interrogatives and 25 closed interrogatives (single and multiple-choice). We created two study groups based on the obtained results: the first group consisted of children whose mothers declared knowledge of nutritional programming (GR1 – 202 mothers). The second group included children of mothers who stated that they did not know anything about nutritional programming (GR2 – 161 mothers)). After analyzing the answers provided by mothers in the questionnaire, we divided group GR1 into two subgroups. Mothers in GR1A (158 mothers) possessed an accurate knowledge of nutritional programming and provided correct answers to questions about nutritional programming and child nutrition. Mothers in GR1B (44 mothers) claimed to have knowledge but provided incorrect answers to test questions.

Mothers were required to provide children's gestational weight and their weight after 2, 4, 6, and 12 months (if eligible). Additionally, they provided information about their children's menu over an average 3-day period, including meals, snacks, and fluids. This eating schedule had to include one weekend day. The questionnaire was divided into parts. Before completing the last part, mothers were trained by a dietitian and instructed on how to complete the food diary. The instructions were included as a separate part of the questionnaire. They contained simple hints on filling in the food diary correctly and a link to the page to help determine the proper food portions (www.ilewazy.pl). Then mothers were asked to complete the diary according to the instructions. Contact details (e-mail and telephone number) to a dietitian were also provided in case of questions. Several mothers contacted a dietitian to clarify their doubts. The questionnaire was available online on various parents' Facebook groups, forums, and websites concerning children's nutrition. The questionnaire was available online due to increased mothers' activity on the Internet, especially social media. The questionnaire was initially in Polish.

Eligible participants were mothers of healthy children under the age of 3, born between the 36^{th} and 42^{nd} week of pregnancy, and who gave written consent. The exclusion criteria were: premature birth (before the 37^{th} week of pregnancy), history of chronic systemic diseases, enteral and parenteral nutrition, gastrointestinal diseases resulting in digestion and absorption disorders, and other severe systemic diseases (cancer, endocrinopathies, connective tissue diseases, kidney diseases, diabetes); a lack of consent, mothers under 18 years of age. The survey was conducted in Poland from 2019 to 2021.

DIETARY INTAKE

Children's diets were analyzed using Dietetyk 2015 (Jumar Software, Poznań, Poland). The average daily intake of energy, macronutrients (proteins, fats, carbohydrates), and micronutrients (iron, vitamin D, docosahexaenoic acid – DHA) was calculated for children from each of the 3 groups and compared to the recommended dietary allowance (RDA) according to Polish nutritional standards [16]. We assessed the supply of macronutrients in children's diets to evaluate their meals' qualitative and quantitative composition and verify whether they are appropriately balanced. We also chose to assess vitamin D, omega-3 acids (especially DHA), and iron, as these are the most common and diagnosed deficiencies among children [24]. Diets were analyzed based on nutritional records collected via a 3-day diary. The NutritionData.com database was also applied in the study. When analyzing each meal, technological losses (e.g., cooking, frying) were considered. The dietary supplementation was not included in the assessment. Obtained data were then compared between the groups to determine whether the mothers' knowledge about children's nutrition influences their practical skills of providing children with a balanced diet.

STATISTICAL METHODS

Obtained data were analyzed using MedCalc 19.6 (MedCalc Software, 1993-2020) and GraphPad Prism 5.01 (GraphPad Software, Inc., La Jolla, CA, USA) statistical software. For all parameters, medians, and 1^{st}-3^{rd} quartiles were calculated unless indicated otherwise. The Shapiro-Wilk test was used to check the normality of the data distribution. Statistical differences between groups were tested using the Kruskal-Wallis test, a post-hoc test (Dunn's multiple comparison test), and χ^2 for multidimensional contingency tables. The linear correlation between parameters was analyzed using Spearman's test. A p-value of < 0.05 was considered statistically significant. Statistical analyses were conducted on the basis of descriptive statistics. The nutritional status of the children was evaluated based on the standardized Z-score for weight concerning the cut-off points established by the WHO [25]. The standard weight falls within the range of the Z-score from –2SD to 1SD, underweight: < –2SD to –3SD, overweight: 1SD to < 2SD, obese from 2SD to 3SD.

ETHICAL CONSIDERATION

All subjects gave their informed consent for inclusion before participating in the study. At the beginning of the questionnaire, a mother was asked to read the informed consent form and consent to collect and process personal data form. She was then asked to consent to the participation and data processing. Should the mother not agree to one of the above, she did not pass on to the main content of the questionnaire. The research was conducted in accordance with the Declaration of Helsinki, and the Bioethical Committee approved the protocol of the Poznań University of Medical Sciences, Poland (decision no 723/19).

RESULTS

STUDY POPULATION

Fifty six percent (n = 202) of all mothers declared knowledge of the rules of nutritional programming. The analysis of their answers indicated that 44% of mothers possessed accurate knowledge (group GR1A, n = 158), while 12% (n = 44) falsely assumed that they were aware of nutritional programming (group GR1B). On the other hand, 44% of all mothers claimed that this concept was unfamiliar to them (group GR2, n = 161).

The most popular source of information on children's nutrition during their first 1000 days was the Internet (73% of all mothers). Other popular sources included physicians, dietitians, and nurses (17% of mothers). Sixteen percent of mothers did not search for information on children's nutrition. Thirty seven percent of mothers claimed to search for new information on children's nutrition constantly. A dietitian was recognized as the greatest authority in nutrition (34%). Mothers were eager to acquire knowledge from a physician (19%) and family members (12%).

Mothers were asked to self-assess their knowledge of nutritional programming. Seventy seven percent of mothers in GR1A, 68% in GR1B, and 63% in GR2 indicated their level as 'very good', 'quite good' or 'satisfactory' while 23% of mothers in GR1A, 32% in GR1B, and 37% in GR2 estimated their knowledge as 'unsatisfactory'.

The majority of respondents lived in medium-sized (up to 500,000 inhabitants – 37%) or large cities (over 500,000 inhabitants – 35%) and held a university degree (79%). Data concerning mothers' age, place of residence, education, and their children's age are shown in Table 1. Mothers with a lower level of education overestimated their knowledge of children's nutrition ($p < 0.001$). Mothers in GR2 were statistically significantly older than mothers in GR1A and GR1B ($p < 0.05$). There was a weak correlation between mothers' age and their level of knowledge on nutritional programming: the older the mothers were, the lower was their knowledge ($r = 0.128$, $p = 0.017$, 95% CI: 0.023-0.230).

MOTHER'S NUTRITION DURING PREGNANCY

Eighty nine percent of all mothers paid attention to what they had been eating during pregnancy, and 86% of them modified their diets. Table 2 presents detailed results on mothers' nutrition during pregnancy.

CHILDREN'S NUTRITION

Eighty seven percent of all mothers breastfed their children. The medians and the 1^{st} and the 3^{rd} quartiles of breastfeeding duration (in months) were: GR1A: M = 8 (4-14), GR1B: M = 4 (2-7.5), GR2: M = 6 (4-13). Mothers

TABLE 1. Mothers' age, education, place of residence, and children's age

Parameters	GR1A (*n* = 158)	GR1B (*n* = 44)	GR2 (*n* = 161)	*p*-value
Age, median (1st-3rd quartile)				
Mothers (years)[1]	30.0[a] (28.0-33.0)	29.0[b] (25.5-33.5)	32.0[a,b] (29.0-35.0)	0.004
Children (months)[1]	12.0 (5.0-18.0)	14.0 (9.0-24.0)	11.5 (5.0-18.0)	ns
Place of residence[2], %				
Village	31	17	25	ns
A city with fewer than 500 thousand residents	38	56	32	
A city with more than 500 thousand residents	32	27	43	
Education[2], %				
Primary	2[c]	21[c,d]	1[d]	0.001
Secondary	18[c]	27[c,d]	15[d]	
Higher	82[c]	52[c,d]	84[d]	

[1]Kruskal-Wallis test, post-hoc test (Dunn's multiple comparison test). [2]χ^2 for multidimensional contingency tables
GR1A – mothers with knowledge on nutritional programming, GR1B – mothers who think they have knowledge, GR2 – mothers without knowledge on nutritional programming, ns – not significant
Values marked with the same letters do not differ statistically significantly. [a,b] = $p < 0.05$; [c,d] = $p < 0.001$

TABLE 2. Factors characterising nutrition during pregnancy

Factor	GR1A, % (*n* = 158)	GR1B, % (*n* = 44)	GR2, % (*n* =161)
Diet during pregnancy			
Paid attention to diet	92	66	92
Believed diet was very important to child's development	95	70	98
Followed the recommendations from health specialists	5	2	19
Modified their diets during pregnancy	88	66	92
Supplemented folic acid	84	39	84
Ate more vegetables and fruits	72	43	59
Gave up drinking coffee	26	39	24
Ate for two	0	20	4
Excluded some foods	42	49	50
Blue cheese	18	25	14
Raw meat and fishes	25	18	18
Sweets	18	20	17
Fast-food	8	7	6
Dietary supplements	100	92	86
Folic acid	100	86	92
Vitamin D	69	50	62
Iron	59	50	65
Iodine	20	18	36
DHA	63	32	60
Omega-3 acids	53	39	52
Multivitamins	23	7	17
Other	7	2	5
None	0	8	14

GR1A – mothers with knowledge on nutritional programming, GR1B – mothers who think they have knowledge, GR2 – mothers without knowledge on nutritional programming in GR1A breastfed their babies significantly longer than mothers in GR1B (p = 0.041). There was a weak correlation between breastfeeding and knowledge on nutritional programming – mothers with actual knowledge breastfed more often (r = 0.115, p = 0.029, 95% CI: 0.216-0.012).

Most mothers introduced solid foods at the right time. However, there were some irregularities: some mothers introduced solids relatively late (after 7 months or later). Table 3 presents detailed results on children's nutrition.

In another part of the questionnaire, mothers were asked to give information on their children's weight (kg) at birth and specific monthly intervals (after 2 months, 4 months, 6 months, and 12 months). Table 4 presents body weight deviations in the study groups. The Z-score for children's weight was calculated to evaluate the influence of mothers' awareness on children's nutrition (Table 5). We assessed whether the children's weight at selected intervals, and the amount of weight gained between those months, differed depending on mothers' knowledge of nutritional programming. There was a significant difference in weight gain between birth and the first month of life in GR1A, GR1B, and GR2.

In the last part of the questionnaire, mothers were asked to write down a three-day menu of their children's regular diet. More than 300 of them (363) completed menus and listed all meals and beverages in exact quantities. Obtained variables were compared with dietary requirements for children up to three years [14, 16].

TABLE 3. Factors characterising children's nutrition

Factor	GR1A, % (n = 158)	GR1B, % (n = 44)	GR2, % (n = 161)
Breastfeeding	92	77	84
Believed that mother's milk is the best for children	86	68	79
Cared for establishing closeness with their babies	55	20	45
Appreciated the ease of accessing and administering milk	44	14	34
Formula	50	55	62
Fluids other than milk during the first six months	52	43	57
Spring water	40	68	25
Mineral water	29	37	31
Fruit juices and compotes	18	47	14
Time of introducing solid foods			
After 2 months	0	3	0
After 4 months	24	25	35
After 5 months	55	38	51
After 7 months	20	31	13
After 9 months	1	3	1
Introducing gluten			
After 2 months	0	3	0
After 4 months	24	25	35
After 5 months	55	38	51
After 7 months	20	31	13
After 9 months	1	3	1
Dietary supplements	95	82	89
Vitamin D	95	82	89
DHA	14	37	7
Multivitamins	8	33	7
Probiotics	15	7	12
Iron	1	0	1
Other	2	0	3
None	5	18	11

GR1A – mothers with knowledge on nutritional programming, GR1B – mothers who think they have knowledge, GR2 – mothers without knowledge on nutritional programming

TABLE 4. Body weight deviations in the study groups

Clinical parameters (body weight, kg)	GR1A ($n = 158$)	GR1B ($n = 44$)	GR2 ($n = 161$)	p-value
	Median (1st-3rd quartile)			
Birth weight[1]	3.370 (3.110-3.690)	3.420 (3.100-3.820)	3.530 (3.160-3.920)	ns
After 1 month[1]	4.525 (4.000-5.000)	4.500 (4.000-5.000)	4.850 (4.320-5.500)	ns
After 3 months[1]	6.100 (5.600-6.670)	6.150 (5.500-7.000)	6.100 (5.800-7.000)	ns
After 6 months[1]	7.400 (6.870-8.000)	7.800 (7.000-8.200)	7.500 (6.800-8.000)	ns
After 12 months[1]	10.000 (9.000-11.000)	10.750 (9.500-11.300)	10.000 (9.095-10.850)	ns

[1]Kruskal-Wallis test, post-hoc test (Dunn's multiple comparison test)
GR1A – mothers with knowledge on nutritional programming, GR1B – mothers who think they have knowledge, GR2 – mothers without knowledge on nutritional programming, ns – not significant

TABLE 5. *Z*-score for weight

Clinical parameters (*Z*-score)	GR1A ($n = 158$)	GR1B ($n = 44$)	GR2 ($n = 161$)
	Median (1st-3rd quartile)		
Birth weight[1]	0.218 (–0.259-0.814)	0.309 (–0.318-1.095)	0.509 (–0.168-1.227)
ΔBirth weight – 1 month[1]	1.145[a] (0.509-1.618)	1.145[b] (0.152-1.700)	0.600[a,b] (–0.082-1.200)
ΔBirth weight – 3 months[1]	0.891 (0.172-1.563)	0.792 (0.356-1.948)	0.814 (0.124-1.401)
ΔBirth weight – 6 months[1]	0.748 (–0.292-1.312)	0.800 (–0.149-1.414)	0.626 (0.020-1.291)
ΔBirth weight – 12 months[1]	0.608 (–0.607-1.179)	0.071 (–0.271-0.889)	0.455 (–0.529-1.094)

[1]Kruskal-Wallis, post-hoc tests (Dunn's multiple comparison test); values marked with the same letters do not differ statistically significantly; [a,b] = $p < 0.05$
GR1A – mothers with knowledge on nutritional programming, GR1B – mothers who think they have knowledge, GR2 – mothers without knowledge on nutritional programming

TABLE 6. Dietary intake in children

Dietary intake (% RDA)	GR1A ($n = 158$)	GR1B ($n = 44$)	GR2 ($n = 161$)
	Median (1st-3rd quartile)		
Calories[1]	92.0 (85.0-110.0)	97.0 (90.8-108.3)	105.0 (85.0-117.5)
Proteins[1]	250.5 (206.5-317.0)	188.0 (150.8-290.3)	270.5 (157.0-313.0)
Fats[1]	73.5 (61.5-89.0)	92.0 (83.3-97.3)	82.0 (65.0-107.5)
Carbohydrates[1]	88.5 (72.0-108.5)	93.0 (78.0-111.8)	109.5 (86.5-125.0)
Vitamin D[1]	43.5 (16.0-113.0)	47.0 (25.8-60.5)	35.0 (9.0-67.0)
Iron[1]	73.0 (52.0-84.0)	79.0 (53.5-108.3)	77.0 (60.5-98.0)
DHA[1]	62.5[a] (33.5-84.5)	40.0 (23.8-53.8)	33.0[a] (17.5-51.5)

[1]Kruskal-Wallis test, post-hoc test (Dunn's multiple comparison test); values marked with the same letters do not differ statistically significantly; [a] = $p < 0.05$
GR1A – mothers with knowledge on nutritional programming, GR1B – mothers who think they have knowledge, GR2 – mothers without knowledge on nutritional programming, RDA – Recommended Dietary Allowance according to Polish nutritional standards [16]

Table 6 presents the outcomes. There was a significant difference between children in GR1A and GR2 in DHA intake. There was a correlation between mothers' level of education (primary, secondary, higher) and DHA intake in children: the higher the level of the mothers' education, the higher the intake of DHA in children ($r = 0.294$, $p = 0.006$, 95% CI: 0.477-0.086). Total energy intake, as well as macroelement (proteins, fats, carbohydrates) and microelement (vitamin D, iron) intake, did not differ significantly between GR1A, GR1B and GR2 groups.

DISCUSSION

The study aimed to investigate the awareness of Polish mothers of nutritional programming and its correlation with children's nutrition. This research found a statistically significant correlation between mothers' education and their knowledge of nutritional programming. In 2010, a survey was conducted on a group of children ($n = 400$, 148 girls and 222 boys) [24]. Its results indicated that children's nutrition depended on the education received by their parents, their place of residence, and their age [24]. Proper nutrition among children is strongly dependent on the level of education achieved by their mothers [26-28]. According to Vollmer *et al.* higher maternal and paternal education levels are associated with lower childhood undernutrition [28]. Maternal education positively influences children's nutritional status [26, 27]. Paternal education is considered just as crucial as its maternal counterpart for childhood malnutrition [26].

Eighty seven percent of all mothers breastfed their babies. Eighty one percent of all mothers indicated breast milk as the healthiest option for infants. According to previous research, breastfeeding reduces the risk of obesity in children by 20% [1]. Breastfeeding improves the lipid profile, lowers blood pressure, and reduces the risk of developing insulin resistance when older [4, 14, 21, 22].

There was a correlation between the level of mothers' education and the time they stopped breastfeeding. Another study also indicated that the mother's educational level and maternal nutrition knowledge contributed to significant differences in breastfeeding duration [29]. Better educated mothers (university vs. secondary school education p = 0.002) breastfed their children longer (17 weeks vs. 11 weeks, p = 0.002) than mothers with secondary school education [29]. In 2014, a study was conducted on 2280 children [19]. Scientists collected data concerning the children's nutrition and evaluated their development over three years. Children who had been breastfed for at least 4 months had significantly improved mobility. Moreover, they developed better adaptive functioning and communication skills [19].

The body weight of 79% of the infants was normal. Twenty percent of the infants were overweight or at risk of becoming overweight, whereas 1% were underweight. Compared to nutritional status in the PITNUTS study, fewer children are malnourished, but more are overweight or at risk of becoming overweight [30]. However, these differences can be explained by the lack of representativeness of the studied sample compared to the cited study. There was a significant difference in weight gain after the first month: children of mothers with a lower nutritional knowledge gained weight more rapidly. However, this was not caused by quantitative or qualitative differences in children's diets, as most children were still being breastfed. Knowledge of nutritional programming and recommendations regarding infant nutrition is closely related to the appropriate recognition and response to the cues of hunger and satiety in children [31]. Nutrition experts' recommendations made it clear that the caregiver decides what, how, and in what form to give food to the child, and the child decides if and when to eat the food [17]. Mothers without proper nutritional knowledge experience difficulties recognizing and responding to hunger and satiety signals from babies, which may be associated with more rapid weight gain in their babies shortly after birth.

Parents often seek information on the adequate supply of beverages for children of different ages. Experts point out that parents give their children fruit juice too often, since it is a product designed predominantly for adults [2]. We obtained similar results. Thirty nine percent of mothers were not conscious that children younger than 6 months do not need any fluids other than milk, as long as the weather is not hot and the child is healthy [17].

Adequate protein intake in children's diets (5-15% of energy requirements up to 2 years of age, for the age group 2-3 years: 10-20%) is crucial [16, 17]. Excessive protein intake entails growth stimulation and adipocyte formation, leading to rapid weight gain and, as a consequence, obesity and cardiovascular disease [1]. Fats should make up 40-60% of the total energy requirement for infants and 35-40% for children between 1 and 3 years of age. The recommended daily intake of docosahexaenoic acid (DHA) is 100-250 mg [16, 17, 32, 33]. Carbohydrates should supply about 40-45% of the total energy requirement for children aged 0-6 months, and later – 45-55% [16, 17].Iron, iodine, vitamin A, vitamin D, and selenium profoundly affect children's development. Meeting a child's nutritional needs is essential. Iron deficiency may irreversibly damage the functioning of the central nervous system and increase the risk of morbidity in case of infection [34, 35]. Vitamins A and D and selenium ensure the proper functioning of the immune system [34, 35].

Ignorance of the rules of child nutrition and macro- and microelement intake results in errors during meal preparation [23, 29]. The authors of research from 2010 observed that the average total energy intake in children aged 1-3 years old was 1217.5 kcal (SD = 331.8), which was 122% of the recommended daily requirement [24]. On the other hand, 25% of children ate too few calories [24]. In this study, the analysis of children's menus did not show any significant differences in calorie intake among the three groups.

Nutrition experts warn against too much protein in children's diets [24]. According to research from 2010, the average supply of protein in daily menus was about 42.5 g, which was 304% of the recommended daily requirement [24]. As reported by the PITNUTS study, children's protein intake was significantly higher than population norms [30]. The analysis of obtained menus showed that children ate too many proteins. A high protein intake entails growth stimulation and adipocyte formation, leading to rapid weight gain and, in consequence, obesity and cardiovascular disease [1].

After conducting the study in 2010, experts observed that most children's diets (as many as 60% of the study group) were lacking in dietary fats and unsaturated fatty acids [24]. In our research, the daily recommended requirement for dietary fats was rarely met in all 3 groups. The deficiency of fats is associated with a low intake of long-chain omega-3 fatty acids [24, 36]. DHA, a major lipid in the brain, is essential for maintaining normal brain functions [37]. A lack of it may reduce visual acuity and lead to cognitive impairment and higher blood pressure [24, 35, 37, 38]. However, there was a correlation between the mothers' level of education and DHA intake. Children of mothers with knowledge of nutritional programming consumed more DHA. Deficiencies of vitamin D and iron were also present. According to statistics, between 12% and 30% of babies suffer from iron deficiency anemia [39]. Iron deficiency leads to disturbed development of the nervous and immune systems. In later life, the use of iron dietary supplements does not reverse the dangerous consequences of iron deficiency in early childhood [16, 39].

We did not take supplements into consideration in dietary intake. Dietary supplements consumed by both mothers and children varied in the content of nutrients. There was some doubt about the frequency of taking supplements. Thus, it would be difficult to account for their consumption properly. We analyzed the supply of DHA only from children's diets according to the assumption that the primary source of DHA should be food and the supplement should not replace a balanced diet. However, supplements in the case of DHA or vitamin D can be a significant source of these nutrients.

According to Newberry *et al*., postnatal supplementation with omega-3 fatty acids may be beneficial in terms of improving infant cognition or immunity [40]. However, there is no consistent evidence of effects of omega-3 fatty acid supplementation or fortification on peripartum maternal or infant health outcomes [40]. According to the European Vitamin D Association (EVIDAS) and other scientific societies and national consultants, during infancy and up to six months of age, children should receive 400 IU/day vitamin D supplementation, and at the age of 6 months to 1 year they should receive 400-600 IU/day, depending on the daily amount of vitamin D taken with food [41, 42]. Research on the impact of vitamin D supplementation on a child's health is inconclusive [43]. However, indirect evidence supports the contention that 400 IU of vitamin D daily supplementation prevents and treats rickets [43].

Parents made mistakes when introducing complementary food to children's diets. Twenty five percent of mothers gave their children solid food for the first time during their first four months of life. In the PITNUTS study, 61.1% of children received complementary feeding earlier than recommended (before the 5th month of life) [30]. These results unequivocally indicate that most of the participating mothers did not know the optimal age for introducing complementary foods. In another study, experts point out that maternal age, educational level, and nutrition knowledge significantly increased the age at which infants were introduced to solid foods [29]. That contributed to the delayed introduction of complementary foods (6 months of age or later) [29]. Gluten should be introduced between the 4th and 12th months of a child's life [17]. In this study, all but one of the mothers (GR1B) chose the right moment to introduce gluten to children's diets. This suggests that the issue is popular among mothers, probably due to its prevalence in the media [44]. Mothers are keen on finding answers to questions online [44]. Unfortunately, this is not always the most appropriate method of acquiring information. Some websites might provide information that does not follow current evidence-based nutrition guidelines. Nutritionists should monitor the process of parents' education regarding nutrition [45, 46].

LIMITATIONS OF THE STUDY

The authors' failure to obtain data from fathers limited this study in that respect. However, the questionnaire mostly contained questions about breastfeeding and pregnant women's nutrition. The representativeness of the study group and the limited possibility of extrapolating the results to the general population are worth considering.

Using only social media to distribute the survey influenced the representativeness of the group (e.g., in view of the level of education) and therefore influenced the results. Although the online questionnaire was an attractive tool, since we were not limited by the time or place of collecting information, the collected data were incomplete in several areas (e.g., many mothers did not provide the children's menus described above). Access to the Internet and social media also limits the choice of potential research participants. The choice of social media as the place of distribution of the questionnaire probably resulted in the overrepresentation of people with higher education and the inclusion of mainly young people in the study (the median age in all three groups is around 30 years of age).

The reliability of food diaries always raises doubts, even if the respondents are highly educated. However, mothers were trained how to fill in the food diary.

Although other studies indicated parental feeding mistakes, our study is the first to reveal the relationship between a mother's knowledge about nutritional programming and the supply of nutrients in children's diets.

CONCLUSIONS

Almost half of the mothers did not recognize the concept of nutritional programming. Awareness among mothers in this study was insufficient. This resulted in inadequate nutritional dietary intake among children. Mothers, especially those without higher education and with a tendency to overestimate their knowledge, should be appropriately educated in terms of nutritional programming. Mothers' awareness of nutritional programming can enhance children's development by protecting them from metabolic disorders and their future implications. There was a correlation between mothers' knowledge, breastfeeding, and docosahexaenoic acid intake in children. Proper maternal nutritional knowledge can improve the quality of children's lives.

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DISCLOSURE

The authors report no conflict of interest.

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AUTHORS' CONTRIBUTIONS

DW, JP, WC, SDC prepared the concept of the paper. DW, TP, MD collected data. DW, TP, MD analysed data. DW wrote the article. All authors have given their approval to the final version of the paper.