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Vitamin B_{12} intake during pregnancy linked to child speech development and intelligence quotient

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ABSTRACT

Background Nutrient deficiencies during pregnancy may affect offspring development. We aim to examine the association between prenatal vitamin B_{12} intake and children's cognitive development.

Methods A total of 5151 mother–child pairs from the Czech part of ELSPAC study were included in the analysis. Dietary information was obtained during pregnancy using food frequency questionnaire. Parents reported on their child's speech and language development at 18 months, 3, 5 and 7 years. Intelligence quotient (IQ) was measured at 8 years in subcohort of 854 children.

Results Children of mothers with higher vitamin B_{12} intake demonstrated higher scores in language ($B = 0.20$, 95% CI 0.06, 0.34) and talking and understanding ($B = 2.39$, 95% CI 0.97, 3.80) in a fully adjusted model at 18 months. Additionally, they were more likely to get maximum points in the intelligibility test at age 3 (OR = 1.05, 95% CI 1.01, 1.09) in unadjusted model, however, not in fully adjusted model. We found a positive effect of higher vitamin B_{12} intake on verbal IQ ($B = 1.08$, 95% CI 0.09, 2.08).

Conclusions We identified consistent associations between prenatal vitamin B_{12} intake and children's cognitive development. The results suggest that inadequate vitamin B_{12} during pregnancy may negatively affect children's cognitive development, particularly in speech and language.

Keywords: children; epidemiology; food and nutrition

Introduction

Maternal diet during pregnancy is a key determinant of the offspring's prenatal development. Deficiencies in nutrient intake may have an effect on children's health outcomes and their neurocognitive development.[1–4] While the effects of several nutrients, e.g. folic acid and iron or iodine have been well described before,[5,6] the evidence about prenatal maternal vitamin B_{12} intake and children's neurocognitive development is inconsistent.[5]

Vitamin B_{12} is necessary for intrauterine foetal development, particularly for the nervous system during childhood. It contributes to axon myelination, essential for impulse conduction from cell to cell, and protects neurons from degeneration.[7] Vitamin B_{12} also supports brain growth, neurogenesis and synaptic connectivity, especially in the auditory and visual cortices.[8] Disruptions in myelination can significantly impact central nervous system function later in childhood, resulting in slower conduction in the auditory and visual systems, which can interfere with learning and social interactions.[9–11] Additionally, vitamin B_{12} is active in the metabolism of both fatty acids and amino acids[12] and is a required cofactor in one-carbon metabolism; its deficiency leads to elevated levels of homocysteine.[13] Elevated homocysteine levels during pregnancy may cause adverse outcomes in offspring, such as lower scores in expressive language and gross motor domains.[14] Therefore, vitamin B_{12} is essential for the normal

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function of the nervous system and may potentially impact memory, language and visual and auditory processing in the child.

Several studies from diverse populations described associations between mother's vitamin B_{12} intake during pregnancy and cognitive and language outcomes of their children with mixed results. For example, a recent study from northern Spain found that medium vitamin B_{12} levels in the first trimester were associated with better infant motor, language and cognitive performance 40 days after birth[15] and higher working memory scores in 4 years old children.[16] Additionally, data from the Avon Longitudinal Study of Parents and Children (ALSPAC) study showed that children of mothers with low prenatal vitamin B_{12} intake had reduced ability in speech, language and mathematics in childhood.[17] According to systematic review, observational studies demonstrated an association between low maternal vitamin B_{12} status and worse longer-term cognitive functioning.[13] Not all studies, however, show consistent results. In a study of US mothers and children, maternal vitamin B_{12} intake from food and supplements was negatively associated with offspring's receptive language at age 3 years[18] with no effect observed by age 7.[19] Similarly, Wu *et al*.[20] found no association with children's language, cognitive and motor skills at the age of 1.5 in a Canadian study.

Given the inconsistent evidence in the literature, the objective of our study was to analyze the association between maternal vitamin B_{12} intake during pregnancy and the cognitive outcomes of children, especially language outcomes in a longitudinal study of children from Central Europe where such analysis has not been conducted to date.

Methods

Study sample

European Longitudinal Study of Pregnancy and Childhood (ELSPAC) is a population-based prospective longitudinal birth cohort study. The study was initiated by the World Health Organization for Europe in 1985 and coordinated by Bristol University (ALSPAC) to collect data across Europe. In the Czech part of ELSPAC study (ELSPAC-CZ), pregnant women with residence in the Brno and Znojmo regions and with expected delivery between 1 March 1991 and 30 June 1992 were enrolled. Information on 5151 mother–child pairs was available.[21]

Parents filled out self-reported questionnaires about health, lifestyle, dietary habits, demographic, psychosocial factors and environmental exposures about themselves and their child before birth, and 6 months, 18 months, and 3, 5, 7, 11, 15 and 19 years after birth. All participants in the study were invited to participate in psychological assessments, including IQ testing at age 8. Those who were willing and able to attend went through the psychological examination done by trained psychologists. We used questionnaire data from the prenatal period, the 18 months after birth, and at ages 3, 5 and 7 years. Further, we used data from psychological examinations done on the subsample of 854 children at 8 years.

Dietary intake

To estimate maternal prenatal vitamin B_{12} intake in the ELSPAC-CZ study, we used the food frequency questionnaire (FFQ) data. Self-reported FFQ with 145 items in 36 separate food groups was administered at 32 weeks of gestation. On a five-point scale from *never or rarely* to *more than once a day*, women reported how frequently they consumed particular foods or drinks during their pregnancy. We used 17 food groups to estimate vitamin B_{12} intake (Supplementary Table S1) and excluded those where vitamin B_{12} does not naturally occur based on the methodology described before.[22] Briefly, individual food items within each food group were combined with vitamin B_{12} content data from national databases and reported as μg per 100 g or 100 ml.[23–25] A weighted average of portion size was estimated for each food group, and total daily vitamin B_{12} intake was calculated by multiplying the frequency of consumption by the quantity of vitamin B_{12} per 100 g/ml and portion size (Figs 1 and 2).

Outcomes

Speech and language

At the 18th month of children's age, several domains of speech and language development were measured by adapted questions from Denver scale[26] (language—word combina-

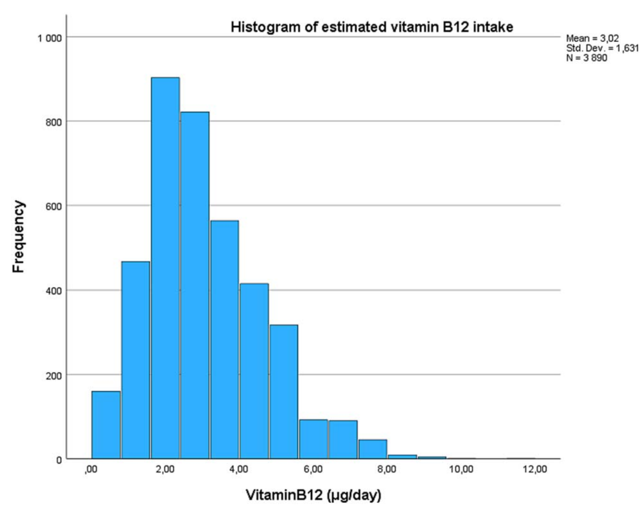

Fig. 1 Histogram of estimated vitamin B_{12} intake for initial sample.

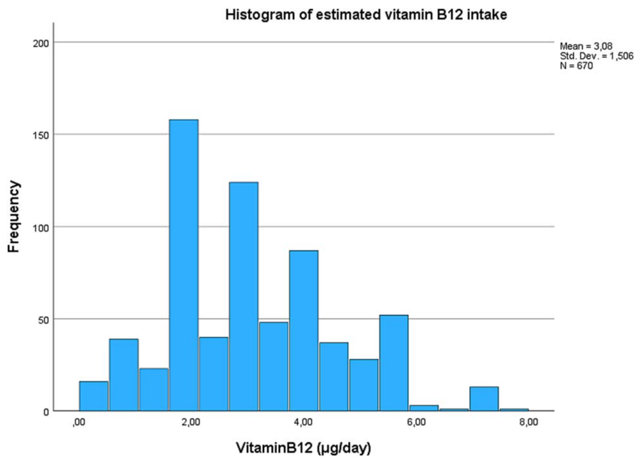

Fig. 2 Histogram of estimated vitamin B_{12} intake for subsample.

tion, use of plurals and negative sentences), and MacArthur Infant Communication questionnaire[27] (talking and understanding). Intelligibility (referring to how well are children understood) was measured at 3, 5 and 7 years of children's age. The scales were back translated from the English original to Czech language and their cultural appropriateness was evaluated via a pilot study prior to the data collection.[28]

Language

A group of 12 questions related to elementary expressions (e.g. She/he says mom and dad, colors, her/his name), word combinations, plurals and negatives were answered on the following scale: 0—no, does not yet; 1- yes, once or twice; 2-yes, very good. The total language score was calculated as a sum of all items.

Talking and understanding

A list of 134 words divided into 10 categories (sounds of animals, animals, vehicles, food and drinks, clothes, body parts, rooms and house equipment, outdoor, activity and communication, characteristics and feelings) was provided in the questionnaire. Vocabulary knowledge of a child was reported on the following scale: 0—no does not say yet; 1—understands but does not say; 2—says and understands. Early communication (e.g. pointing with a finger, waving to say goodbye) was measured with a group of 10 questions with possible answers on a scale: 0—no, does not yet; 1—sometimes; 2—often. To measure understanding, parents were asked a total of 13 questions: *Which of these following questions does your child understand* (e.g. Are you hungry?, Come here.) and possible answers were recorded on a scale: 0—no; 1—yes. The talking and understanding score was calculated as a sum of all items.

Intelligibility

Mothers answered three single questions *Do* (1) *you,* (2) *family and* (3) *visitors understand what the child says*? using a scale a scale: 0—rarely; 1—mostly; 2—sometimes at 3 years of age and: 0—never, 1—sometimes, 2—often and 3—always at 5 and 7 years of age, respectively. Intelligibility scores for each age were calculated as a sum. Due to the highly left skewed distribution of the data, we classified the intelligibility scores into binary variables with those who got maximum points and those who did not.

IQ

The individual psychological examination of children was carried out on the subset of the sample. IQ was measured by Wechsler Intelligence Scale for Children III (WISC-III) at 8 years of age.[29] Performance and verbal IQ scores were calculated using 10 of the original 12 subtests of WISC-III.

Covariates

Birth and pregnancy covariates considered in the analysis included sex of the child (male; female), birthweight (<2500 g; ≥2500 g), head circumference, mother's age, mother's body mass index (BMI) prior to pregnancy, alcohol consumption during the first 3 months of pregnancy (yes; no), smoking status during the pregnancy (non-smoker; ex-smoker; smoker), total energy intake and use of dietary supplements during pregnancy. Further socio-demographic and lifestyle factors of mothers and fathers collected during pregnancy were included: maternal education (primary; vocational; secondary; university), paternal education (primary; vocational; secondary; university), number of other children younger than 15 years of age in the same household and number of adults (including mother) over 18 years of age in the same household. Additionally, factors reported at the child's 18-month follow-up included breastfeeding (yes—ever or still breastfed; no—never breastfed), and if the mother worked at 18th month of children's age (yes; no).

Analytical sample and multiple imputation of missing data

The initial sample for outcomes from 18 months to 7 years of child's age consisted of 5151 women and children who entered the study and had completed the prenatal questionnaire, and at least one postnatal questionnaire. Within this cohort, missing data ranged from 0.1% to 40.0% across all study variables (Table 1). Within a subcohort of 854 children for whom IQ measurements at the age of 8 were available, missing data ranged from 0.5 to 23.7% (Table 2). To handle missing data, Markov chain Monte Carlo method was applied.

Table 1 Maternal, paternal and children's descriptive characteristics of the initial and imputed sample

Variable	*N = 5151* *Original initial sample*		*N = 5151* *Imputed sample*	
	N	*Mean (SD) or valid %*	*N*	*Mean (SD) or %*
Vitamin B_{12} intake (μg/d)	3890	3.0 (1.6)	5151	3.1 (1.6)
Maternal age (years)	5144	24.8 (4.8)	5151	24.7 (4.8)
BMI prior to pregnancy (kg/m^2)	3760	22.1 (3.3)	5151	22.1 (3.3)
Head circumference (cm)	4912	34.6 (1.4)	5151	34.6 (1.4)
Mean energy intake (MJ)	3890	5.9 (2.2)	5151	5.9 (2.2)
Sex of the child				
Female	2493	48.4	2495	48.4
Male	2655	51.6	2656	51.6
Missing	3			
Birthweight				
<2500 g	266	5.3	274	5.3
≥2500 g	4765	94.7	4877	94.7
Missing	120			
Education—mother				
Primary	282	7.1	386	7.5
Vocational	1359	34.4	1808	35.1
Secondary	1588	40.2	2047	39.7
University	722	18.3	910	17.7
Missing	1200			
Education—father				
Primary	210	5.3	295	5.7
Vocational	1801	45.6	2377	46.1
Secondary	917	23.2	1190	23.1
University	1018	25.9	1289	25.0
Missing	1205			
Alcohol consumption during the first 3 months of pregnancy				
No	2673	69.2	3567	69.2
Yes	1192	30.8	1584	30.8
Missing	1286			
Smoking status during the pregnancy				
Non-smoker	2289	58.6	3003	58.3
Ex-smoker	1301	33.3	1719	33.4
Smoker	317	8.1	429	8.3
Missing	1244			
Dietary supplements during the pregnancy				
Yes	1986	51.4	2617	50.8
No	1876	48.6	2534	49.2
Missing	1289			
Adults (including mother) in the same household				
0–1	177	4.5	251	4.9
2	2474	63.0	2746	53.3
3	495	12.6	940	18.2
≥4	781	19.9	1214	23.6
Missing	1224			

(*Continued*)

Table 1 Continued

Variable	N = 5151 Original initial sample		N = 5151 Imputed sample	
	N	Mean (SD) or valid %	N	Mean (SD) or %
Other children in the same household				
0	1734	45.3	2498	48.5
1	1642	42.9	2109	40.9
2	363	9.5	448	8.7
≥3	91	2.3	96	1.9
Missing	1321			
Working status of mother[a]				
No	3202	93.5	4718	91.6
Yes	222	6.5	433	8.4
Missing	1727			
Breast feeding status[a]				
Yes	3146	91.9	4828	93.7
No	278	8.1	323	6.3
Missing	1727			
Test				
18-month language	3451	12.8 (5.2)	5151	12.5 (5.0)
18-month talking and understanding	3410	162.3 (54.4)	5151	158.7 (53.1)
3-year intelligibility	3498	5.6 (0.8)	5151	5.4 (0.8)
5-year intelligibility	3404	7.7 (2.5)	5151	7.3 (2.4)
7-year intelligibility	3092	7.9 (2.6)	5151	7.3 (2.5)

[a]Reported at the child's 18-month follow-up.

The presented results are pooled estimates from 50 imputed data sets.

Statistical analysis

To examine the association between prenatal vitamin B_{12} intake and children's speech and language development at 18 months, linear regression models were applied on study outcomes. Logistic regression was used to address intelligibility outcomes, and linear regression was performed to test the association between vitamin B_{12} intake and children's IQ on sample subset with available IQ data. Vitamin B_{12} was treated as a continuous variable as well as a categorical variable split into quartiles. The fourth quartile (the highest vitamin B_{12} intake) was a reference category. We tested the associations between vitamin B_{12} intake and selected outcomes in non-adjusted Model 0 and two multivariable models. Model 1 adjusted for mother's age, mother's BMI prior to pregnancy, sex of the child, birthweight and head circumference, and Model 2 further adjusted for smoking and alcohol intake during pregnancy, total energy intake and dietary supplement use during pregnancy, maternal and paternal education, number of children younger than 15 years of age in the same household, number of adults over 18 years of age in the same household, breastfeeding reported at 18th month of children's age and if the mother worked at 18th month of children's age. Statistical analysis was conducted using IBM SPSS Statistics 29 with a selected significance level of 0.05.

Results

Descriptives

Characteristics of the original study sample of 5151 mother–child pairs and a subsample of 854 children at 8 years old, including descriptive statistics of speech and language outcomes, as well as IQ are presented in Tables 1 and 2.

Speech and language

Both scores were positively associated with vitamin B_{12} intake in all models (Table 3). Children of mothers with higher vitamin B_{12} intake scored higher in language ($B = 0.20$, 95% CI 0.06, 0.34) and talking and understanding ($B = 2.39$, 95%

Table 2 Maternal, paternal and children's descriptive characteristics of the IQ subsample and imputed sample

Variable	*N = 854* *Original subsample*		*N = 854* *Imputed subsample*	
	N	*Mean (SD) or valid %*	*N*	*Mean (SD) or %*
Vitamin B_{12} intake (μg/d)	670	3.1 (1.5)	854	3.1 (1.5)
Maternal age (years)	850	26.0 (4.9)	854	26.1 (4.9)
BMI prior to pregnancy (kg/m_2)	654	22.0 (3.2)	854	22.2 (3.3)
Head circumference (cm)	815	34.4 (1.3)	854	34.4 (1.3)
Mean energy intake (MJ)	670	5.9 (1.9)	854	5.9 (1.9)
Sex of the child				
Female	417	48.8	417	48.8
Male	437	51.2	437	51.2
Birthweight				
<2500 g	44	5.3	45	5.3
≥2500 g	790	94.7	809	94.7
Missing	20			
Education—mother				
Primary	19	2.9	51	5.9
Vocational	163	24.5	202	23.7
Secondary	320	48.1	386	45.2
University	163	24.5	215	25.2
Missing	189			
Education—father				
Primary	17	2.6	68	8.0
Vocational	262	39.3	315	36.9
Secondary	157	23.6	200	23.4
University	230	34.5	271	31.7
Missing	188			
Alcohol consumption during the first 3 months of pregnancy				
No	447	67.1	511	59.8
Yes	219	32.9	343	40.2
Missing	188			
Smoking status during the pregnancy				
Non-smoker	422	63.2	504	59.0
Ex-smoker	201	30.1	266	31.2
Smoker	45	6.7	84	9.8
Missing	186			
Dietary supplements during the pregnancy				
Yes	420	62.9	532	62.3
No	248	37.1	322	37.7
Missing	186			
Adults (including mother) in the same household				
0–1	30	4.4	43	5.0
2	469	70.1	513	60.1
3	61	9.2	128	15.0
≥4	109	16.3	170	19.9
Missing	185			

(*Continued*)

Table 2 Continued

Variable	*N = 854* *Original subsample*		*N = 854* *Imputed subsample*	
	N	*Mean (SD) or valid %*	*N*	*Mean (SD) or %*
Other children in the same household				
0	294	45.1	401	47.0
1	285	43.7	361	42.2
2	54	8.3	71	8.3
≥3	19	3.0	21	2.5
Missing	202			
Working status of mother[a]				
No	732	92.9	790	92.5
Yes	57	7.1	64	7.5
Missing	54			
Breastfeeding status[a]				
Yes	744	92.7	789	92.4
No	59	7.3	65	7.6
Missing	51			
Test				
8-year IQ verbal	854		104 (16.8)	
8-year IQ perform	854		106 (16.9)	
8-year IQ total	854		106 (16.2)	

[a]Reported at the child's 18-month follow-up.

CI 0.97, 3.80) in fully adjusted models (Model 2). Complete results showing fully adjusted models with all covariates are presented in Supplementary Table S2.

A positive association was observed with intelligibility at 3 years of age in non-adjusted Model 0 (OR = 1.05, 95% CI 1.01, 1.09), however, not in fully adjusted Model 2 (OR = 1.03, 95% CI 0.99, 1.07). There were no associations at later ages in all models (Table 4).

IQ

The total IQ as well as results in IQ subtests at 8 years of age was positively associated with maternal vitamin B_{12} intake in non-adjusted models and Model 1 (Table 5). The results of the fully adjusted model (Model 2) showed vitamin B12 intake significantly associated only with verbal (B = 1.08, 95% CI 0.09, 2.08) IQ score. The association with other covariates in a fully adjusted model is shown in Supplementary Table S3.

To verify the robustness of our results and considering the right-skewed distribution of vitamin B_{12} intake, we also conducted an analysis using quartiles of B12 intake. The results (Supplementary Tables S4, S5 and S6) were consistent with those obtained using B12 as a continuous predictor, confirming that lower maternal B12 intake is associated with poorer outcomes in children's speech and IQ scores. This trend was statistically significant for language, talking and understanding outcomes at 18 months and for verbal and total IQ in fully adjusted models at age 8 years. Notably, the lowest quartile was significantly associated with poorer outcomes compared to the highest quartile (used as the reference).

Discussion

Main finding of this study

In this study, we analysed the effect of maternal prenatal vitamin B_{12} intake on the language and cognitive development of offspring. We examined various outcomes, including speech and language development reported by parents and IQ measured during individual psychological examinations. Firstly, we found that higher maternal vitamin B_{12} intake during pregnancy was positively linked to higher speech and language scores in children at 18 months of age. However, while no further significant associations were identified in the domain of intelligibility tests, we still noted significant associations with IQ, particularly the verbal subtest, at 8 years of age for children whose mothers had higher vitamin B_{12} intake. This trend was observed both for vitamin B_{12} treated as a continuous and categorical variable.

Table 3 The effect of vitamin B_{12} intake on speech and language tests outcomes in children

Test	*Model 0*		*Model 1*		*Model 2*	
	B [95% CI]	*P value*	*B [95% CI]*	*P value*	*B [95% CI]*	*P value*
18-month language	0.11 [0.01; 0.22]	0.035	0.13 [0.03; 0.24]	0.013	0.20 [0.06; 0.34]	0.006
18-month talking and understanding	1.41 [0.27; 2.56]	0.016	1.64 [0.51; 2.77]	0.005	2.39 [0.97; 3.80]	<0.001

Model 0 unadjusted. Model 1 adjusted for mother's age, mother's BMI prior to pregnancy, sex of the child, birthweight and head circumference. Model 2 further adjusted for alcohol consumption during the first 3 months of pregnancy, smoking status during the pregnancy, total energy intake and dietary supplement use during pregnancy, maternal and paternal education, number of children younger than 15 years of age in the same household, number of adults over 18 years of age in the same household, breast feeding reported at 18th month of children's age and if the mother worked at 18th month of children's age.

Table 4 The effect of vitamin B_{12} intake on intelligibility tests outcomes in children

Test	*Model 0*		*Model 1*		*Model 2*	
	OR [95% CI]	*P value*	*OR [95% CI]*	*P value*	*OR [95% CI]*	*P value*
3-year intelligibility	1.05 [1.01; 1.09]	0.021	1.04 [1.00; 1.08]	0.079	1.03 [0.99; 1.07]	0.199
5-year intelligibility	1.02 [0.98; 1.06]	0.369	1.01 [0.97; 1.05]	0.651	1.01 [0.97; 1.05]	0.800
7-year intelligibility	1.02 [0.98; 1.06]	0.330	1.01 [0.97; 1.05]	0.581	1.01 [0.97; 1.05]	0.731

Model 0 unadjusted. Model 1 adjusted for mother's age, mother's BMI prior to pregnancy, sex of the child, birthweight and head circumference. Model 2 further adjusted for alcohol consumption during the first 3 months of pregnancy, smoking status during the pregnancy, total energy intake and dietary supplement use during pregnancy, maternal and paternal education, number of children younger than 15 years of age in the same household, number of adults over 18 years of age in the same household, breast feeding reported at 18th month of children's age and if the mother worked at 18th month of children's age.

Table 5 The effect of vitamin B_{12} intake on intelligence tests outcomes in children

Test	*Model 0*		*Model 1*		*Model 2*	
	B [95% CI]	*P value*	*B [95% CI]*	*P value*	*B [95% CI]*	*P value*
8-year IQ verbal	1.37 [0.53; 2.21]	0.001	1.40 [0.58; 2.23]	<0.001	1.08 [0.09; 2.08]	0.033
8-year IQ perform	1.09 [0.23; 1.94]	0.013	1.15 [0.33; 1.97]	0.006	0.46 [−0.52; 1.44]	0.360
8-year IQ total	1.20 [0.38; 2.02]	0.004	1.25 [0.47; 2.04]	0.002	0.79 [−0.15; 1.73]	0.100

Model 0 unadjusted. Model 1 adjusted for mother's age, mother's BMI prior to pregnancy, sex of the child, birthweight and head circumference. Model 2 further adjusted for alcohol consumption during the first 3 months of pregnancy, smoking status during the pregnancy, total energy intake and dietary supplement use during pregnancy, maternal and paternal education, number of children younger than 15 years of age in the same household, number of adults over 18 years of age in the same household, breast feeding reported at 18th month of children's age and if the mother worked at 18th month of children's age.

What is already known on this topic

Our findings are supported by many previous studies. For instance, a recent study found a positive association between vitamin B_{12} intake and early vocabulary and word combination scores at 24 and 38 months, respectively, in the ALSPAC cohort.[17] Additionally, children born to mothers with low vitamin B_{12} intake were less likely to be understood at 6 years. Preconception supplementation with vitamin B_{12} has been shown to improve cognition and language skills at 2 years of age in a randomized controlled trial,[30] as well as to result in higher scores on expressive language at 30 months.[31] Furthermore, elevated maternal total homocysteine levels (indicating lower vitamin B_{12} level) were associated with poorer expressive language performance in infants.[32] However, some studies found no association between vitamin B_{12} and cognitive outcomes,[19] or results in adverse direction—lower maternal vitamin B_{12} status was associated with higher verbal fluency scores at 9–10 years.[33] Results concerning children's IQ are less clear. Using the same outcome (total IQ), earlier analysis of ALSPAC data showed no association with maternal vitamin B_{12} intake.[34] Similarly, other observational studies showed weak or no associations with intelligence or cognitive abilities.[9,35,] While we did not find significant associations with total IQ either, it is noteworthy that the effect of vitamin B_{12} remained evident specifically in the verbal subtest, maintaining a consistent trend from 18 months onwards. Language development is a fundamental aspect of cognitive growth, serving both as a key of communication and a critical tool for learning and social interaction. Research has shown that early language skills significantly shape broader cognitive abilities,[36] and are strong predictors of later academic success and social integration.[37]

What this study adds

This study is the first large-scale study that looked at this association in Central European populations and strengthened present findings emphasizing the importance of vitamin B_{12} intake during prenatal period particularly at the time, when dietary patterns prioritizing plant sources were becoming more popular. However, given the mixed results from existing literature, our results must be interpreted with caution and respect to all limitations. Further research is needed to explore the mechanisms underlying the observed association. Additionally, future studies could investigate the optimal dose of vitamin B_{12} supplementation during pregnancy and the effects of supplementation on other health outcomes. Our categorical analysis indicates that the fourth quartile, which approached the recommended dietary reference values set by EFSA[38] (4.5 μ/g), supports the notion that increasing vitamin B12 intake may be beneficial.

Limitations of this study

The presented study has several limitations that should be considered when interpreting the findings. The main limitation is the use of self-reported data from FFQ, which may result in imprecise estimates of nutrient intake. As we did not have biological samples from the cohort participants, we were unable to assess the validity of the dietary measure. Additionally, FFQ captures dietary intake over a prolonged time period, which can lead to inaccuracies in assessing food intake at specific time points. Considering that brain development is influenced by the frequency and timing of nutrient intake, it is important to recognize that the impact of any nutrient deficiency can vary at different stages of development.[11] In addition, our study employed the WISC-III to measure IQ in 8 years old children. The test was translated into Czech from the third British version of the WISC scale,[39] lacking specific validation and standardization for the Czech children population. The observed association in our study might be influenced by the limitations of the IQ test used. Although we account for a large number of potential confounders, we cannot exclude possible effect of other factors, mainly the residual confounding of multiple nutrients and their interactions. Emphasizing the importance of adequate nutrient intake during pregnancy for neurodevelopment, it is crucial to highlight the significance of vitamin B_{12}. Vitamin B_{12} plays a pivotal role in the synthesis of DNA, myelin and neurotransmitters, making it essential for proper neurological development, especially during early life.[7] The observed associations between prenatal vitamin B_{12} intake and speech and language outcomes may be attributed to the crucial role of vitamin B_{12} in neurodevelopment. Adequate vitamin B_{12} levels during pregnancy may contribute to optimal neural connectivity and function, potentially influencing speech and language development in children.

Conclusion

This study provided important insights into the role of maternal nutrition during pregnancy in the children's cognitive abilities. We found consistent associations between prenatal vitamin B_{12} intake and cognitive development. The observed associations suggest that a diet low in vitamin B_{12} during pregnancy may negatively affect children's cognitive development, particularly in speech and language. Thus, a healthy pregnancy diet with enough vitamin B_{12} sources should be emphasized.

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Supplementary data

Supplementary data are available at the *Journal of Public Health* online.

Conflict of interest

The authors have no competing interests to declare that are relevant to the content of this article.

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Author contributions

All authors made contributions to the study conception or design. Substantial contributions to conception and design, acquisition of data or analysis and interpretation of data and final approval of the version to be published were performed by EH, GKJ, TP, LA and HP. The first draft of the manuscript was written by EH and all authors commented on previous versions of the manuscript.

Data availability

The data that support the findings of this study are available from RECETOX, Faculty of Science, Masaryk University but restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of RECETOX, Faculty of Science, Masaryk University.

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