Public Health Nutrition: 16(8), 1390–1402 doi:10.1017/S1368980013000293

Use of dietary supplements in pregnant women in relation to sociodemographic factors – a report from The Environmental Determinants of Diabetes in the Young (TEDDY) study

Carin Andrén Aronsson[1,*], Kendra Vehik[2], Jimin Yang[2], Ulla Uusitalo[2], Kristen Hay[3], Gesa Joslowski[4], Anne Riikonen[5], Lori Ballard[2], Suvi M Virtanen[5,6] and Jill M Norris[7], on behalf of the TEDDY Study Groupt

[1]Department of Clinical Sciences, Lund University, CRC, Bldg. 60:11, Jan Waldenströms gata 35, SE 20502 Malmö, Sweden: [2]Pediatrics Epidemiology Center, University of South Florida, Tampa, FL, USA: [3]Pacific Northwest Diabetes Research Institute, Seattle, WA, USA: [4]Research Institute of Child Nutrition, Dortmund, Germany: [5]National Institute for Health and Welfare, Nutrition Unit, Helsinki, Finland: [6]Science Center of Pirkanmaa Hospital District, Tampere, Finland: [7]Colorado School of Public Health, University of Colorado, Denver, CO, USA

Submitted 9 July 2012: Final revision received 22 November 2012: Accepted 17 January 2013: First published online 4 March 2013

Abstract

Objectives: The aim of the present study was to examine the prevalence and associated factors of dietary supplement use, particularly supplements containing vitamin D and fatty acids, in pregnant women enrolled in a multi-national study.
Design: The Environmental Determinants of Diabetes in the Young (TEDDY) study is a prospective longitudinal cohort study. Maternal dietary supplement use was self-reported through questionnaires at month 3 to 4 postpartum.
Setting: Six clinical research centres; three in the USA (Colorado, Georgia/Florida and Washington) and three in Europe (Sweden, Finland and Germany).
Subjects: Mothers (n 7326) to infants screened for high-risk HLA-DQ genotypes of type 1 diabetes.
Results: Ninety-two per cent of the 7326 women used one or more types of supplement during pregnancy. Vitamin D supplements were taken by 65 % of the women, with the highest proportion of users in the USA (80·5 %). Overall, 16 % of the women reported taking fatty acid supplements and a growing trend was seen in all countries between 2004 and 2010 ($P < 0{\cdot}0001$). The use was more common in Germany (32 %) and the USA (24 %) compared with Finland (8·5 %) and Sweden (7·0 %). Being pregnant with the first child was a strong predictor for any supplement use in all countries. Low maternal age (<25 years), higher education, BMI $\geq 25{\cdot}0\,kg/m^2$ and smoking during pregnancy were factors associated with supplement use in some but not all countries.
Conclusions: The majority of the women used dietary supplements during pregnancy. The use was associated with sociodemographic and behavioural factors, such as parity, maternal age, education, BMI and maternal smoking.

Keywords
Dietary supplements
Pregnancy
TEDDY
Vitamin D
Fatty acids

Dietary supplements contribute to the total nutrient intake in pregnant women. It has been reported that among women using supplements containing vitamin D, more than 50 % of the total vitamin D intake is provided by the supplement[1,2] and that vitamin D and fatty acids from food and supplements are significantly correlated with maternal and cord blood serum levels[2,3]. Further, high intake of vitamin D and n-3 fatty acids from both foods and dietary supplements during pregnancy has been reported to be associated with reduced risk of islet autoimmunity and development of type 1 diabetes (T1D) in the offspring[4,5]. It is hypothesized that the immune-regulatory properties of vitamin D and the anti-inflammatory properties of the long-chain n-3 fatty acids may inhibit the pathogenesis of T1D[6,7].

Pregnant women are encouraged to enhance their diet during pregnancy to meet increased needs for most nutrients. There are no explicit recommendations regarding consumption of dietary supplements, but women with poor diets, iron-deficiency anaemia, vegans, smokers and women carrying two or more fetuses are recommended to enhance their diet with a prenatal dietary supplement[8]. The prevalence of supplement use during pregnancy has been reported to be as high as 80 %[1,2,9]. However, there

† Members of the TEDDY Study Group are listed in Appendix 1.

*Corresponding author: Email carin.andren_aronsson@med.lu.se

are few such studies, especially in the USA[10]. The National Health and Nutrition Examination Survey (NHANES) has monitored the use of dietary supplements in the US population since the 1970s, but the sample size of pregnant women is too small to draw conclusions regarding dietary supplement use during pregnancy among US women[11]. Supplement use is also reported to be related to sociodemographic variables[10,12]. NHANES showed that dietary supplement use in the adult population varied by education level, weight status and ethnicity[11]. Supplement use during pregnancy appears to vary among ethnic and socio-economic groups and interact with factors such as supplement use before pregnancy and smoking[10]. Supplement use during pregnancy has been reported to be related to age, education, smoking and BMI in the Nordic countries[1,9,13,14].

The primary aim of the present study was to describe the prevalence of dietary supplement use, and particularly the use of supplements containing vitamin D and fatty acids, in pregnant women whose children were at increased genetic risk of T1D. We also wanted to identify sociodemographic and behavioural factors associated with supplement use.

Materials and methods

Participants

The Environmental Determinants of Diabetes in the Young (TEDDY) is a prospective study designed to examine dietary and environmental exposures on islet autoimmunity and the development of T1D among children with high-risk HLA-DQ genotypes in the USA, Finland, Germany and Sweden[15]. Infants are followed from birth until T1D is diagnosed or until the child is 15 years old. A total of 424 788 newborns were screened between September 2004 and February 2010, and 8677 HLA eligible infants were enrolled in the study[16]. Ongoing monitoring for diet, infectious agents, other environmental exposures and autoimmunity status are completed with interviews, questionnaires, food records and laboratory tests. Detailed study design and methods have been previously published[17].

Information on dietary supplement consumption was asked at month 3 to 4 postpartum from 8677 women. The following women were excluded: (i) mothers of 850 children (9·8 %) who had not completed the 9-month clinic visit, where all sociodemographic data were collected; (ii) mothers of sixty-six children (0·8 %) with missing supplement use data; (iii) mothers of 178 children (2·1 %) due to missing or extreme anthropometric measures (BMI $<$ 16·0 or $>$50·0 kg/m^2); and (iv) mothers of 257 children (3·0 %) with incomplete or missing sociodemographic data, resulting in a total of 7326 mothers with complete data. Written informed consents were obtained for all study participants from a parent or primary caregiver, separately, for genetic screening and participation in prospective follow-up. The study was approved by local Institutional Review Boards (six clinical centres in four countries) and is monitored by an External Advisory Board formed by the National Institutes of Health.

Questionnaires

A questionnaire containing questions on illnesses, medications, smoking habits, alcohol intake, diet and dietary supplement use during pregnancy was mailed to the women of enrolled children and was completed at month 3 to 4 postpartum. Dietary supplements were defined as supplements that contain one or any combination of the following substances: a vitamin, mineral, herb or other botanical substance, and amino acids, in accordance with the US Dietary Supplement Health and Education Act of 1994. Homeopathic and protein supplements were not coded as dietary supplements in TEDDY[18]. Dietary supplements taken due to medical condition or illness were also included. The women reported product name, frequency per week and duration of usage during pregnancy. Supplements were classified into twenty-seven single supplements and ten multivitamin/mineral subgroups based on their nutrient profiles (Appendix 2)[19]. A dietary supplement user was defined as anyone who reported taking at least one supplement at least once during the pregnancy.

Maternal education was recorded on a ten-category scale to accommodate for different education systems in each country, which was then aggregated into two categories, basic primary education (primary school through trade school) and higher education (completed trade school or higher), to achieve comparability across countries. Maternal age was defined as the woman's age at time of delivery and was treated as both a continuous and a categorical variable ($<$25·0 years, 25·0–29·9 years, 30·0–34·9 years and $\geq$35·0 years). Pre-pregnancy BMI was calculated by using mother's self-reported weight (in kilograms) before pregnancy divided by the square of height (in metres) and was categorized based on the WHO classification[20]. Smoking and alcohol consumption during pregnancy were defined as 'yes' if reported, regardless of frequency and duration. Birth order of the TEDDY child (first-born *v.* others) was determined by the question 'Is this your first child?' Maternal diabetes status during pregnancy was self-reported and was grouped into four groups: 'no diabetes', 'type 1 diabetes', 'gestational diabetes and type 2 diabetes' and 'unknown'. Race/ethnicity was analysed only in the US women and was categorized in five groups (non-Hispanic white, African Americans, Hispanics, all other races and unknown).

Statistical analyses

Data were analysed using the SAS® statistical software package version 9·2. Categorical variables were analysed using the Pearson χ^2 test or Fisher's exact test and continuous variables were analysed using ANOVA. Multiple logistic regression analysis was used to determine the

independent factors associated with maternal use of supplements containing vitamin D and fatty acids. All models were assessed overall and separately by country.

Results

The distribution of characteristics of the study population across the four countries is provided in Table 1. Germany had the highest maternal age (mean 31·6 years) followed by Sweden, the USA and Finland ($P<0·0001$). Pre-pregnancy BMI was higher among US women compared with the European women ($P<0·0001$). Finland had the highest proportion of women with higher education followed by Germany, the USA and Sweden ($P<0·0001$). A greater proportion of German women reported smoking and drinking during pregnancy than women from the other countries ($P<0·0001$). The use of dietary supplements during pregnancy was common among women in all countries (Table 2). The highest percentage of users was in the USA (96·4 %) while the lowest was in Finland (87·1 %) Users tended to be older women (≥35·0 years), to be pregnant with their first child and to have a higher educational level compared with non-users. In both the USA and Finland, drinking alcohol during pregnancy was more common among supplement users than non-users, although these differences were not seen in Germany and Sweden. Smoking was more often reported among the non-users in all four countries. A higher percentage of women with BMI ≥ 25·0 kg/m^2 was seen among non-users in Germany ($P=0·0003$) and Sweden ($P<0·0001$) but not in the USA and Finland.

Predictors of any dietary supplement use during pregnancy

Results of the multivariable analysis demonstrated that in all countries, women who were pregnant with their first child were more likely to use supplements (Table 3). Younger women (<25·0 years) were less likely to use supplements compared with older women. Women with higher education in the USA and Sweden, but not in Finland and Germany, were more likely to use dietary supplements.

Table 1 Cohort characteristics by country (*n* 7326): The Environmental Determinants of Diabetes in the Young (TEDDY) study

	USA (*n* 2961)		Sweden (*n* 2231)		Finland (*n* 1622)		Germany (*n* 512)		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Maternal age (years)	30·6[b]	5·7	30·8[b]	4·6	30·5[c]	5·0	31·6[a]	4·9	
Pre-pregnancy BMI (kg/m^2)	25·6[a]	6·0	24·3[b]	4·6	24·2[b]	4·6	24·2[b]	4·9	
	n	%	*n*	%	*n*	%	*n*	%	*P*
Maternal education									<0·0001
Basic primary	483	16·3	751	33·7	157	9·7	70	13·7	
Higher education	2478	83·7	1480	66·3	1465	90·3	442	86·3	
Mother's first child									<0·0001
Yes	1247	42·1	1064	47·7	731	45·1	259	50·6	
No	1714	57·9	1167	52·3	891	54·9	253	49·4	
Pre-pregnancy BMI (kg/m^2)									<0·0001
<18·5	86	2·9	64	2·9	54	3·3	26	5·1	
18·5–24·9	1604	54·2	1398	62·7	1042	64·2	316	61·7	
≥25·0	1271	42·9	769	34·4	526	32·4	170	33·2	
Smoking during pregnancy									<0·0001
Yes	294	9·9	276	12·4	227	14·0	104	20·3	
No	2667	90·1	1955	87·6	1395	86·0	408	79·7	
Drinking during pregnancy									<0·0001
Yes	1164	39·3	624	28·0	493	30·4	237	46·3	
No	1797	60·7	1607	72·0	1129	69·6	275	53·7	
Maternal diabetes status during pregnancy									<0·0001
None	2644	89·3	2092	93·8	1336	93·8	344	67·2	
T1D	102	3·4	39	1·8	61	3·8	94	18·4	
Gestational or T2D	167	5·7	68	3·0	175	10·8	21	4·1	
Unknown/missing	48	1·6	32	1·4	50	3·0	53	10·3	
TEDDY child with T1D in FDR									<0·0001
Yes	327	11·0	144	6·5	147	9·1	196	38·3	
No	2634	89·0	2087	93·5	1475	90·9	316	61·7	
Race/ethnicity*									
Non-Hispanic white	2193	74·0							
African Americans	62	2·1							
Hispanic	508	17·2							
All other	130	4·4							
Unknown/missing	68	2·3							

T1D, type 1 diabetes; T2D, type 2 diabetes; FDR, first-degree relative (mother, father and/or siblings).
[a,b,c]Mean values within a row with unlike superscript letters were significantly different ($P<0·05$).
*US mothers only.

Table 2 Distribution and description of non-users and any supplement users, by respondent characteristics: The Environmental Determinants of Diabetes in the Young (TEDDY) study

	USA					Sweden					Finland					Germany				
	Non-users		Users			Non-users		Users			Non-users		Users			Non-users		Users		
	n	%	*n*	%	*P*	*n*	%	*n*	%	*P*	*n*	%	*n*	%	*P*	*n*	%	*n*	%	*P*
	106	3·6	2855	96·4		245	11·0	1986	89·0		209	12·9	1413	87·1		38	7·4	474	92·6	
Mother's first child																				
Yes	23	21·7	1224	42·9	<0·0001	91	37·1	973	49·0	0·0005	72	34·5	659	46·6	0·0009	14	36·8	245	51·7	0·0782
Maternal education																				
Higher education	60	56·6	2418	84·7	<0·0001	121	49·4	1359	68·4	<0·0001	187	89·5	1278	90·5	0·6573	31	81·6	411	86·7	0·3758
Maternal age (years)																				
<25·0	35	33·0	433	15·2	<0·0001	41	16·7	140	7·0	<0·0001	40	19·1	180	12·7	0·0095	7	18·4	37	7·8	0·0719
25·0–29·9	28	26·4	731	25·6		76	31·0	603	30·4		58	27·8	503	35·6		10	26·3	118	24·9	
30·0–34·9	31	29·3	953	33·4		87	35·5	808	40·7		63	30·1	472	33·4		15	39·5	179	37·0	
≥35·0	12	11·3	738	25·8		41	16·7	435	21·9		48	23·0	258	18·3		6	15·8	140	29·5	
Smoking																				
Yes	23	21·7	271	9·5	<0·0001	52	21·2	224	11·3	<0·0001	45	21·5	182	12·9	0·0008	14	36·8	90	19·0	0·0085
Drinking																				
Yes	31	29·2	1133	39·7	0·0307	56	22·9	568	28·6	0·0588	49	23·4	444	31·4	0·0193	22	57·9	215	45·4	0·1359
Maternal diabetes status																				
None	90	84·9	2554	89·5	0·3727	220	89·8	1872	94·3	0·0099	169	80·9	1167	82·6	0·6947	23	60·5	321	67·7	0·5416
T1D	4	3·8	98	3·4		10	4·1	29	1·5		7	3·4	54	3·8		5	13·2	89	18·8	
GDM/T2D	10	9·4	157	5·5		9	3·7	59	3·0		24	11·5	151	10·7		2	5·3	19	4·0	
Unknown	2	1·9	46	1·6		6	2·4	26	1·3		9	4·3	41	2·9		8	21·0	45	9·5	
TEDDY child's birth year																				
2004/2005	12	11·3	292	10·2	0·7612	67	27·4	424	21·4	0·2441	62	29·7	291	20·6	0·0266	2	5·3	65	13·7	0·1327
2006	20	18·9	456	16·0		45	18·4	385	19·4		37	17·7	261	18·5		13	34·2	86	18·1	
2007	26	24·5	624	21·9		50	20·4	394	19·8		38	18·2	306	21·7		6	15·8	89	18·8	
2008	22	20·8	680	23·8		37	15·1	352	17·7		37	17·7	235	16·6		7	18·4	107	22·6	
2009/2010	26	24·5	803	28·1		46	18·8	431	21·7		35	16·8	320	22·6		10	26·3	127	26·8	
Pre-pregnancy BMI (kg/m^2)																				
<18·5	2	1·9	84	2·9	0·0683	9	3·7	55	2·8	<0·0001	4	1·9	50	3·5	0·1249	4	10·5	22	4·6	0·0003
18·5–24·9	47	44·3	1557	54·5		122	49·8	1276	64·2		126	60·3	916	64·8		12	31·6	304	64·1	
≥25·0	57	53·8	1214	42·5		114	46·5	655	33·0		79	37·8	447	31·6		22	57·9	148	31·2	

T1D, type 1 diabetes; T2D, type 2 diabetes.

Table 3 Adjusted sociodemographic predictors for any dietary supplement use during pregnancy, by country: The Environmental Determinants of Diabetes in the Young (TEDDY) study

	USA			Sweden			Finland			Germany		
	OR	95 % CI	*P*	OR	95 % CI	*P*	OR	95 % CI	*P*	OR	95 % CI	*P*
Mother's first child												
No	1·00			1·00			1·00			1·00		
Yes	3·18	1·94, 5·21	<0·0001	1·98	1·46, 2·70	<0·0001	1·75	1·26, 1·45	0·0008	3·18	1·40, 7·25	0·0058
Maternal education												
Basic primary	1·00			1·00			1·00			1·00		
Higher education	2·39	1·47, 3·89	0·0005	1·62	1·20, 2·17	0·0015	0·90	0·54, 1·48	NS	1·24	0·45, 3·41	NS
Maternal age (years)												
<25·0	0·56	0·32, 0·97	0·0385	0·47	0·29, 0·74	0·0013	0·52	0·33, 0·83	0·0193	0·40	0·12, 1·37	NS
25·0–29·9	1·00			1·00			1·00			1·00		
30·0–34·9	1·03	0·60, 1·76	NS	1·16	0·82, 1·63	NS	0·90	0·61, 1·32	NS	1·27	0·51, 3·18	NS
≥35·0	2·14	1·06, 4·34	0·0347	1·43	0·94, 2·18	NS	0·71	0·46, 1·10	NS	2·31	0·75, 7·10	NS
Pre-pregnancy BMI (kg/m^2)												
<18·5	1·84	0·43, 7·86	NS	0·71	0·33, 1·52	NS	2·08	0·73, 5·96	NS	0·24	0·07, 0·91	0·0352
18·5–24·9	1·00			1·00			1·00			1·00		
≥25·0	0·76	0·50, 1·14	NS	0·64	0·48, 0·84	0·0017	0·82	0·60, 1·12	NS	0·22	0·10, 0·48	0·0001
TEDDY child with T1D in FDR												
No	1·00			1·00			1·00			1·00		
Yes	1·56	0·71, 3·43	NS	0·60	0·37, 0·96	0·0331	3·44	1·11, 10·70	0·0328	2·00	0·87, 4·60	NS
Smoking during pregnancy												
No	1·00			1·00			1·00			1·00		
Yes	0·65	0·38, 1·10	NS	0·67	0·46, 0·97	0·0326	0·56	0·38, 0·83	0·0036	0·65	0·29, 1·47	NS
Drinking during pregnancy												
No	1·00			1·00			1·00			1·00		
Yes	1·14	0·73, 1·78	NS	1·18	0·85, 1·64	NS	1·54	1·08, 2·19	0·0160	0·48	0·27, 1·02	NS
TEDDY child's birth year												
2004/2005	1·00			1·00			1·00			1·00		
2006	0·99	0·47, 2·11	NS	1·35	0·89, 2·04	NS	1·42	0·90, 2·23	NS	0·19	0·04, 0·92	0·0394
2007	1·05	0·51, 2·17	NS	1·29	0·86, 1·93	NS	1·84	1·18, 2·88	0·0069	0·42	0·08, 2·31	NS
2008	1·41	0·67, 2·96	NS	1·58	1·02, 2·44	0·0420	1·49	0·94, 2·36	NS	0·58	0·11, 3·07	NS
2009/2010	1·45	0·70, 2·97	NS	1·53	1·01, 2·30	0·0431	2·27	1·42, 3·63	0·0006	0·46	0·09, 2·33	NS
Race/ethnicity*												
Non-Hispanic white	1·00											
African Americans	0·78	0·26, 2·32	NS									
Hispanic	0·80	0·49, 1·30	NS									
All other	0·60	0·24, 1·44	NS									
Missing/unknown	0·71	0·21, 2·43	NS									

T1D, type 1 diabetes; FDR, first-degree relative (mother, father and/or siblings).
Separate multivariate models, including the variables listed above, were run for each country.
*US mothers only.

Women who smoked during pregnancy were less likely to use dietary supplements in Finland and Sweden, but not in the USA and Germany. In Finland, women were more likely to be supplement users if the child had a first-degree relative diagnosed with T1D or if they reported alcohol consumption during pregnancy. Women in Sweden and Germany with a pre-pregnancy BMI ≥ 25·0 kg/m^2 were less likely to use any dietary supplement during pregnancy. Race/ethnicity among US women did not predict dietary supplement use.

Use of supplements containing vitamin D or fatty acids

The overall proportion of women using supplemental vitamin D from either single or multivitamin preparations was 65 % (4768/7326) and of those, 62 % (2972/4768) used vitamin D supplements throughout the entire pregnancy. The remaining women (38 %) were using supplements on average for 24·7 (SD 10·2) weeks during pregnancy. In the USA, 81 % of the women reported using vitamin D-containing supplements while the proportion of women using supplements was lower in the European countries, with 71 % in Finland, 48 % in Sweden and 33 % in Germany (Table 4). For dietary supplements containing fatty acids, the overall proportion of users was 16 % (1161/7326) and of those, 53 % (616/1161) used the fatty acid supplements throughout the entire pregnancy. The mean duration for the remaining 47 % was 21·3 (SD 9·9) weeks. The highest proportion of fatty acid supplement users was found in Germany (32 %). In the USA, 24 % of the women used such supplements compared with less than 10 % in Finland and Sweden (Table 5).

The prevalence of vitamin D supplement use during pregnancy was relatively stable through the study screening years (2004–2010), except that it increased from 63 % to 79 % in Finland ($P < 0·0001$; Fig. 1). Meanwhile, consumption of fatty acid supplements grew in all countries during this 5-year period ($P < 0·0001$). The greatest change was seen in the USA and Germany, with an increase in supplement use by 60 %.

Predictors of supplements containing vitamin D during pregnancy

Being pregnant with the first child was a common predictor for use of vitamin D-containing supplements in all TEDDY countries (Table 4). Higher education in the USA and Sweden, but not in Finland and Germany, was a predictor for vitamin D use. Higher maternal age (≥30·0 years) was also a predictor for vitamin D supplement use in the USA and Sweden, but not in Germany; and was a predictor of less use in Finland (≥35·0 years). Women in Sweden with a pre-pregnancy BMI ≥ 25·0 kg/m^2 were less likely to use vitamin D supplements. Women in the USA, Finland and Germany who smoked during pregnancy were less likely to use vitamin D supplements, while alcohol consumption during pregnancy was not associated with the use of vitamin D supplements. In the USA, women with race/ethnicity other than non-Hispanic white were less likely to use vitamin D supplements.

Predictors of supplements containing fatty acids during pregnancy

Older maternal age, ≥30·0 years in the USA and Germany and ≥35·0 years in Sweden, was associated with using supplements containing fatty acids (Table 5). Higher maternal education was associated with fatty acid supplements use in the USA only. Women pregnant with the first child or with higher maternal age were more likely to use dietary supplements containing fatty acids, except in Finland. Smoking was a predictor of less use in the USA and Germany but not in Finland and Sweden. Women with BMI ≥ 25·0 kg/m^2 in the USA and Finland were less likely to use fatty acid supplements. Birth year of the child was associated with a growing prevalence of fatty acid supplement use in all countries. There was no difference in use by race/ethnicity among the US women.

Discussion

To the best of our knowledge, the current study is the first international prospective cohort study presenting data on maternal dietary supplement use from four countries. High prevalence of any dietary supplement use, ranging from 87 % in Finland to 96 % in the USA, was observed in pregnant women participating in the TEDDY study. Women who were pregnant with their first child were more likely to take supplements. In both the USA and Sweden, supplement users were more likely to have a higher education. Younger women (<25·0 years) were less likely to use any supplements during their pregnancy in all countries except in Germany. The association between demographic and lifestyle factors and dietary supplement use during pregnancy observed in the TEDDY population was consistent with the literature[1,9,13,14].

In the present study, supplement use was self-reported by mothers at months 3 to 4 postpartum. The questionnaires were checked by trained study personnel for completeness during the first clinic visit. Self-reported supplement use may be associated with both over- or under-reporting, but studies on dietary supplement use during pregnancy have reported a high correlation between biomarker concentrations and intake estimated by self-reported methods[2,3,21].

A healthy pre-pregnancy BMI has often been associated with maternal supplement use, but we did not see a clear association across countries in our analysis. One reason may be due to different cut-off points. We used the current WHO classification without differentiating between overweight and obesity[20]. Other studies have used different cut-off points, often in four levels, that define underweight and normal weight slightly differently and separate overweight (BMI = 25·0–30·0 kg/m^2) from obese (BMI > 30·0 kg/m^2)[1,9,14,22]. Our results showed

Table 4 Adjusted sociodemographic predictors for use of supplements containing vitamin D during pregnancy, by country: The Environmental Determinants of Diabetes in the Young (TEDDY) study

Users (single or MVM preparations):	USA			Sweden			Finland			Germany		
	n 2383; 80·5 %			*n* 1060; 47·5 %			*n* 1158; 71·4 %			*n* 167; 32·6 %		
	OR	95 % CI	*P*	OR	95 % CI	*P*	OR	95 % CI	*P*	OR	95 % CI	*P*
Mother's first child												
No	1·00			1·00			1·00			1·00		
Yes	1·29	1·05, 1·58	0·0160	1·62	1·35, 1·94	<0·0001	1·71	1·34, 2·18	<0·0001	1·73	1·14, 2·62	0·0098
Maternal education												
Basic primary	1·00			1·00			1·00			1·00		
Higher education	1·53	1·18, 1·98	0·0013	1·79	1·47, 2·17	<0·0001	1·05	0·72, 1·54	NS	1·93	0·96, 3·86	NS
Maternal age (years)												
<25·0	0·58	0·43, 0·77	0·0002	0·70	0·48, 1·01	0·0536	0·73	0·51, 1·05	NS	0·72	0·31, 1·66	NS
25·0–29·9	1·00			1·00			1·00			1·00		
30·0–34·9	1·39	1·07, 1·80	0·0149	1·39	1·12, 1·72	0·0023	1·10	0·83, 1·47	NS	0·92	0·56, 1·53	NS
≥35·0	1·31	0·98, 1·75	NS	1·30	1·08, 1·67	0·0435	0·67	0·49, 0·92	0·0143	0·94	0·55, 1·62	NS
Pre-pregnancy BMI (kg/m^2)												
<18·5	1·41	0·78, 2·55	NS	0·82	0·49, 1·39	NS	1·28	0·66, 2·46	NS	1·11	0·46, 2·71	NS
18·5–24·9	1·00			1·00			1·00			1·00		
≥25·0	0·88	0·73, 1·08	NS	0·78	0·65, 0·94	0·0074	0·83	0·66, 1·06	NS	0·74	0·48, 1·12	NS
Smoking during pregnancy												
No	1·00			1·00			1·00			1·00		
Yes	0·67	0·50, 0·90	0·0069	0·81	0·61, 1·07	NS	0·52	0·38, 0·71	<0·0001	0·29	0·14, 0·58	0·0005
Drinking during pregnancy												
No	1·00			1·00			1·00			1·00		
Yes	1·22	0·99, 1·49	NS	1·05	0·86, 1·27	NS	1·26	0·98, 1·62	NS	0·91	0·60, 1·36	NS
TEDDY child's birth year												
2004/2005	1·00			1·00			1·00			1·00		
2006	0·78	0·52, 1·18	NS	0·78	0·60, 1·02	NS	1·23	0·88, 1·73	NS	1·99	0·95, 4·16	NS
2007	0·69	0·47, 1·01	NS	0·90	0·69, 1·17	NS	2·28	1·62, 3·23	<0·0001	2·81	1·34, 5·90	0·0156
2008	0·69	0·47, 1·01	NS	0·96	0·73, 1·26	NS	1·55	1·09, 2·20	0·0152	2·03	0·98, 4·20	NS
2009/2010	0·73	0·50, 1·06	NS	1·22	0·94, 1·58	NS	2·19	1·56, 3·09	<0·0001	1·40	0·68, 2·90	NS
Race/ethnicity*												
Non-Hispanic white	1·00											
African Americans	0·50	0·28, 0·88	0·0163									
Hispanic	0·61	0·48, 0·77	<0·0001									
All other	0·61	0·40, 0·95	0·0272									
Missing/unknown	0·46	0·26, 0·79	0·0052									

MVM, multivitamin/mineral.
Separate multivariate models, including the variables listed above, were run for each country.
*US mothers only.

Table 5 Adjusted sociodemographic predictors for use of supplements containing fatty acids during pregnancy, by country: The Environmental Determinants of Diabetes in the Young (TEDDY) study

Users (single or MVM preparations):	USA			Sweden			Finland			Germany		
	n 704; 23·8 %			*n* 156; 7·0 %			*n* 138; 8·5 %			*n* 163; 31·8 %		
	OR	95 % CI	*P*	OR	95 % CI	*P*	OR	95 % CI	*P*	OR	95 % CI	*P*
Mother's first child												
No	1·00			1·00			1·00			1·00		
Yes	1·79	1·49, 2·15	<0·0001	2·69	1·89, 3·84	<0·0001	1·27	0·88, 1·82	NS	2·42	1·58, 3·73	<0·0001
Maternal education												
Basic primary	1·00			1·00			1·00			1·00		
Higher education	1·59	1·16, 2·20	0·0046	1·03	0·71, 1·50	NS	0·75	0·40, 1·40	NS	1·22	0·62, 2·40	NS
Maternal age (years)												
<25·0	0·63	0·45, 0·89	0·0093	0·57	0·26, 1·22	NS	0·38	0·19, 0·79	0·0092	1·14	0·47, 2·74	NS
25·0–29·9	1·00			1·00			1·00			1·00		
30·0–34·9	1·60	1·26, 2·01	<0·0001	1·35	0·90, 2·03	NS	0·83	0·54, 1·27	NS	2·87	1·65, 4·99	0·0002
≥35·0	1·65	1·28, 2·12	<0·0001	1·92	1·21, 3·06	0·0059	1·24	0·77, 1·99	NS	2·93	1·63, 5·27	0·0003
Pre-pregnancy BMI (kg/m^2)												
<18·5	1·42	0·84, 2·40	NS	0·75	0·26, 2·15	NS	0·56	0·17, 1·84	NS	1·03	0·40, 2·66	NS
18·5–24·9	1·00			1·00			1·00			1·00		
≥25·0	0·76	0·64, 0·91	0·0032	0·81	0·57, 1·17	NS	0·66	0·44, 0·98	0·0412	1·16	0·76, 1·77	NS
Smoking during pregnancy												
No	1·00			1·00			1·00			1·00		
Yes	0·48	0·32, 0·71	0·0002	0·95	0·54, 1·67	NS	0·79	0·44, 1·41	NS	0·38	0·20, 0·75	0·0049
Drinking during pregnancy												
No	1·00			1·00			1·00			1·00		
Yes	1·17	0·97, 1·40	NS	1·01	0·71, 1·45	NS	0·82	0·55, 1·23	NS	0·95	0·63, 1·44	NS
TEDDY child's birth year												
2004/2005	1·00			1·00			1·00			1·00		
2006	1·75	1·13, 2·73	0·0128	3·46	3·49, 8·45	0·0043	1·80	0·88, 3·66	NS	1·81	0·80, 4·09	NS
2007	2·69	1·80, 4·07	<0·0001	8·70	3·87, 19·55	<0·0001	2·87	1·51, 5·48	0·0014	2·99	1·35, 6·65	0·0070
2008	3·71	2·47, 5·56	<0·0001	10·07	4·48, 22·66	<0·0001	3·46	1·80, 6·63	0·0002	2·60	1·19, 5·66	0·0165
2009/2010	4·96	3·33, 7·40	<0·0001	7·70	3·43, 17·30	<0·0001	3·42	1·82, 6·45	0·0001	4·21	1·96, 9·04	0·0002
Race/ethnicity*												
Non-Hispanic white	1·00											
African Americans	1·04	0·53, 2·02	NS									
Hispanic	0·94	0·72, 1·22	NS									
All other	1·03	0·68, 1·57	NS									
Missing/unknown	0·95	0·53, 1·72	NS									

MVM, multivitamin/mineral.
Separate multivariate models, including the variables listed above, were run for each country.
*US mothers only.

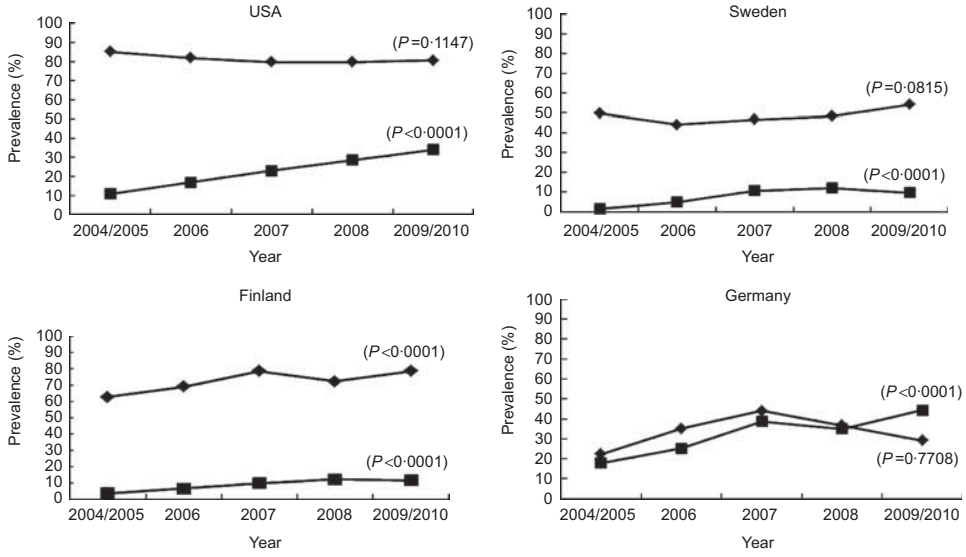

Fig. 1 Trends in reported intake of dietary supplements containing vitamin D (—♦—) and fatty acids (—■—) during pregnancy between 2004 and 2010, by country: The Environmental Determinants of Diabetes in the Young (TEDDY) study

that overweight women in Sweden and Germany were less likely to use dietary supplements and overweight women in the USA and Finland were less likely to use supplements containing fatty acids.

One of the few recent studies on maternal supplement use and sociodemographic factors from the USA reports that iron supplementation is associated with ethnicity[23]. We did not observe differences regarding race/ethnicity when looking at any supplement use. This may be due to the definition of supplement use, although most of the prenatal multivitamins contain iron. Our description of any dietary supplement use is very broad, it may contain supplement use for health-seeking reasons (enhance the diet) and for medical reasons (e.g. anaemia). We do not have information about the reason why women use dietary supplements and are therefore not able to separate these behaviours. However, when looking at vitamin D-containing supplements, women with race/ethnicity other than non-Hispanic white were less likely to use these supplements.

The variable maternal education only affected women in the USA and Sweden. It has been implied that a higher education level gives a greater awareness of the role of nutrition in good health[24,25]. Factors such as being pregnant with the first child and higher maternal age may also indicate higher awareness regarding possible mechanisms in diet-related health. In our study, the use of supplements containing fatty acids may give a better picture of a health-seeking behaviour during pregnancy. An adequate intake of DHA in pregnant women is critical to development of the fetal brain in the third trimester[26], and has also been linked to reduced risk of T1D in the offspring[4]. The recommended DHA intake should preferably come from consumption of one or two fish meals per week or a dietary supplement[27]. However, despite higher needs during pregnancy, women often decrease fish consumption due to warnings about contaminants such as methyl mercury and dioxins. Reduced or altered fish consumption together with low frequency of fatty acid supplementation may lead to insufficient exposure to long-chain *n*-3 fatty acids *in utero*[27]. The use of fatty acid supplementation during pregnancy was not common in the TEDDY population, with less than 10 % in Finland and Sweden but higher in the USA (24 %) and Germany (32 %). In Norway, a Nordic country with a long-standing tradition of cod-liver oil use, the prevalence of fatty acid supplement use was 59 % among pregnant women[1]. The lower prevalence in TEDDY could be compared with another Nordic country, Denmark, where only 4 % of women reported use of fish oil formulations during pregnancy[28]. The use of fatty acid supplementation has increased in all TEDDY countries. Birth year of the child was a factor that was significant across all countries. The later the child was born during the TEDDY screening period, the more likely it was that the mother used fatty acid supplements. This could reflect different trends in the prenatal supplement markets, but could also be due to revised national recommendations.

There are very few studies on prevalence of supplement use during pregnancy in the USA, but in a study on pregnant women in California during 2006–2008, 89 % of the women reported using dietary supplements[2]. More studies from Europe have presented data on maternal supplement use. In the DIPP study in 1998–2000, 85 % of the women reported taking dietary supplements[9]. In the All Babies in Southeast Sweden (ABIS) study in Sweden, 56 % of the women took some type of dietary supplement during pregnancy in 1997–1999[13]; this can be compared with, almost 10 years later, the 89 % of Swedish women in TEDDY who reported any supplement use. The high

Table 6 Country-specific dietary supplement recommendations for pregnant women (TEDDY screening period 2004–2010)

	USA*[8]	Sweden[30]	Finland[31]	Germany[29]
Folic acid	400 μg/d during first trimester	400 μg/d during first trimester	400 μg/d during first trimester	400 μg/d during first trimester
Iron	27 mg/d	100 mg/d in second half of pregnancy – recommendation removed in 2008		
Iodine				100–(150) μg/d
Vitamin D			10 μg/d during winter months	
DHA (22 : 6*n*-3)		Women who do not eat fish: 200 mg/d – recommendation since 2008		Women who do not eat fish: 200 mg/d – recommendation since 2008

TEDDY, The Environmental Determinants of Diabetes in the Young.
*A prenatal multivitamin/multimineral supplement is recommended for women with iron-deficiency anaemia, poor-quality diets, vegans, vegetarians, smokers and women carrying two or more fetuses.

prevalence of supplement use in all TEDDY countries may be attributed to the recommendations on supplementation during pregnancy. The folic acid recommendation of 400 μg/d before getting pregnant and for the first trimester is given in all countries. Most countries recommend iron supplementation if the status is too low, often during the second half of the pregnancy. In the USA, health-care providers recommend women to use a standard prenatal multivitamin/multimineral supplement throughout pregnancy and even before becoming pregnant[8]. In Europe, there are variations in additional supplement recommendations and they have changed during the TEDDY study period. In Germany, prenatal iodine supplementation is recommended[29]. Since 2008, both Germany and Sweden have clarified the benefits of eating fish during pregnancy[29,30] in their national recommendations. Women who do not eat fish are recommended to eat 200 mg DHA/d during pregnancy. In Finland, pregnant women are currently recommended to take 10 μg of supplemental vitamin D daily throughout the year; before 2011, vitamin D supplements were recommended to be used only during winter months[31]. Table 6 summarizes the country-specific recommendations regarding dietary supplementation during pregnancy. Country-specific recommendations on vitamin D and fatty acids were reflected in our data. Countries with vitamin D recommendations had higher prevalence of supplement use than countries without specific recommendations.

Our findings may not be readily generalized to the general population due to our selection criterion of high-risk HLA genotypes representing approximately 5% of the population, but the results are important and comparable with other longitudinal studies.

Conclusion

The present study captured a high prevalence of supplement use during pregnancy in the USA, Sweden, Finland and Germany. Being pregnant with the first child was a strong predictor for any supplement use in all countries. Higher education, low maternal age, BMI $\geq 25{\cdot}0\,kg/m^2$ and smoking during pregnancy were additional predictors but not consistently across all countries. The use of vitamin D-containing supplements was more common in countries with pertinent national recommendations.

Acknowledgements

Sources of funding: The TEDDY study was funded by grant numbers DK 63829, 63861, 63821, 63865, 63863, 63836, 63790 and UC4DK095300 and contract number HHSN267200700014C from the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), the National Institute of Allergy and Infectious Diseases (NIAID), the National Institute of Child Health and Human Development (NICHD), the National Institute of Environmental Health Sciences (NIEHS), the Juvenile Diabetes Research Foundation (JDRF) and the Centers for Disease Control and Prevention (CDC). *Conflicts of interest:* The authors declare no conflict of interest. *Authors' contributions:* C.A.A. wrote the manuscript and analysed the data; K.V. did the statistical analysis; J.Y. and U.U. assisted with drafting the manuscript and critically reviewed the manuscript; K.H., G.J. and A.R. critically reviewed the manuscript; L.B. was responsible for data handling; and S.V. and J.N. designed the study and critically reviewed the manuscript; J.M.N. and S.M.V. share last authorship. *Acknowledgements:* The participation of all families in the TEDDY study is gratefully acknowledged.

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Appendix 1

The TEDDY Study Group

Colorado Clinical Center

Marian Rewers, MD, PhD, Principal Investigator[1,4,6,10,11]; Katherine Barriga[12]; Kimberly Bautista[12]; Judith Baxter[9,12,15]; George Eisenbarth, MD, PhD; Nicole Frank[2]; Patricia Gesualdo[2,6,12,14,15]; Michelle Hoffman[12,13,14]; Lisa Ide; Rachel Karban[12]; Edwin Liu, MD[13]; Jill Norris, PhD[2,12]; Kathleen Waugh[7,12,15]; Adela Samper-Imaz; Andrea Steck, MD (University of Colorado, Anschutz Medical Campus, Barbara Davis Center for Childhood Diabetes).

Georgia/Florida Clinical Center

Jin-Xiong She, PhD, Principal Investigator[a,1,3,4,11]; Desmond Schatz, MD[b,4,5,7,8]; Diane Hopkins[a,12]; Leigh Steed[a,12,13,14,15]; Jamie Thomas[b,6,12]; Katherine Silvis[a,2]; Michael Haller, MD[b,14]; Meena Shankar[b,2]; Kim English[a]; Richard McIndoe, PhD[a]; Haitao Liu, MD[c]; John Nechtman[c]; Ashok Sharma[a]; Joshua Williams[a]; Gabriela Foghis[a]; Stephen W. Anderson, MD[d] ([a]Georgia Health Sciences University; [b]University of Florida; [c]Jinfiniti Biosciences LLC, Augusta, GA; [d]Pediatric Endocrine Associates, Atlanta, GA).

Germany Clinical Center

Anette G. Ziegler MD, Principal Investigator[a,1,3,4,11]; Alexandra Achenbach, PhD[b,12]; Andreas Beyerlein, PhD[a,2]; Ezio Bonifacio, PhD[b,5]; Nadine Bruckmeier[a]; Melanie Bunk[a]; Vanessa Dietrich[a]; Anna Huppert, MD[a]; Minna Harsunen, MD[a]; Lydia Henneberger[a,2,12]; Michael Hummel, MD[a,13]; Sandra Hummel, PhD[a,2]; Gesa Joslowski[c,2]; Mathilde Kersting, PhD[c,2]; Annette Knopff[a,7]; Nadja Kocher[a]; Sibylle Koletzko, MD[d,13]; Miriam Krasmann, MD[a]; Stephanie Krause[a]; Lorenz Lachmann[a]; Claudia Matzke[a]; Claudia Peplow[b,12]; Maren Pflüger, PhD[a,6]; Claudia Ramminger[a]; Christiane Ried[a]; Roswith Roth, PhD[a,9]; Julia Schenkel[a]; Marlon Scholz[a]; Joanna Stock[a]; Elisabeth Strauss[a]; Alexandra Thalmeier[a]; Katja Voit[a]; Katharina Warncke, MD[a,14]; Christiane Winkler, PhD[a,2,12,15];

Anja Wosch[a] ([a]Forschergruppe Diabetes eV at Helmholtz Zentrum München; [b]Center for Regenerative Therapies, TU Dresden; [c]Research Institute for Child Nutrition, Dortmund; [d]Dr. von Hauner Children's Hospital, Department of Gastroenterology, Ludwig Maximillians University Munich).

Finland Clinical Center

Olli G. Simell, MD, PhD, Principal Investigator[a,b,1,4,11,13]; Heikki Hyöty, MD, PhD[c,d,6]; Jorma Ilonen, MD, PhD[a,e,3]; Mikael Knip, MD, PhD[c,d]; Maria Lonnrot, MD, PhD[c,d,6]; Elina Mantymaki[a,b]; Juha Mykkänen, PhD[a,b,3]; Kirsti Nanto-Salonen, MD, PhD[a,b,12]; Tiina Niininen[c,d]; Mia Nyblom[c,d]; Anne Riikonen[c,d,2]; Minna Romo[a,b]; Barbara Simell[a,b,12,15]; Tuula Simell, PhD[a,b,9,12]; Ville Simell[a,b,13]; Maija Sjöberg[a,b,12,14]; Aino Stenius[f,g]; Eeva Varjonen[a,b]; Riitta Veijola, MD, PhD[f,g]; Suvi M. Virtanen, MD, PhD[c,d,h,2] ([a]University of Turku; [b]Turku University Hospital; [c]University of Tampere; [d]Tampere University Hospital; [e]University of Kuopio; [f]University of Oulu; [g]Oulu University Hospital; [h]National Institute for Health and Welfare, Finland).

Sweden Clinical Center

Åke Lernmark, PhD, Principal Investigator[1,3,4,8,10,11,15]; Daniel Agardh, MD, PhD[13]; Peter Almgren; Eva Andersson; Carin Andrén-Aronsson[2,13]; Maria Ask; Ulla-Marie Karlsson; Corrado Cilio, MD, PhD[5]; Jenny Bremer; Emilie Ericson-Hallström; Thomas Gard; Joanna Gerardsson; Gertie Hansson[12,14]; Monica Hansen; Susanne Hyberg; Rasmus Håkansson; Fredrik Johansen; Linda Jonsson; Helena Larsson, MD, PhD[14]; Barbro Lernmark, PhD[9,12]; Maria Markan; Theodosia Massadakis; Jessica Melin; Maria Månsson-Martinez; Anita Nilsson; Kobra Rahmati; Monica Sedig Järvirova; Sara Sibthorpe; Birgitta Sjöberg; Carina Törn, PhD[3,15]; Anne Wallin; Åsa Wimar; Sofie Åberg (Lund University).

Washington Clinical Center

William A. Hagopian, MD, PhD, Principal Investigator[1,3,4,5,6,7,11,13,14]; Xiang Yan, MD; Michael Killian[6,7,12,13]; Claire Cowen Crouch[12,14,15]; Kristen M. Hay[2]; Stephen Ayres; Carissa Adams; Brandi Bratrude; David Coughlin; Greer Fowler; Czarina Franco; Carla Hammar; Diana Heaney; Patrick Marcus; Arlene Meyer; Denise Mulenga; Elizabeth Scott; Jennifer Skidmore; Joshua Stabbert; Viktoria Stepitova; Nancy Williams (Pacific Northwest Diabetes Research Institute).

Pennsylvania Satellite Center

Dorothy Becker, MD; Margaret Franciscus[12]; MaryEllen Dalmagro-Elias[2]; Ashi Daftary, MD (Children's Hospital of Pittsburgh, University of Pittsburgh Medical Center).

Data Coordinating Center

Jeffrey P. Krischer, PhD, Principal Investigator[1,4,5,10,11]; Michael Abbondondolo; Lori Ballard[3,9,14,15]; Rasheedah Brown[12,15]; Brant Burkhardt, PhD[5,6]; David Cuthbertson; Christopher Eberhard; Steven Fiske; Veena Gowda; David Hadley, PhD[3,13]; Hye-Seung Lee, PhD[3,6,13,15]; Shu Liu; Kristian Lynch, PhD[9]; Jamie Malloy; Cristina McCarthy[12,15]; Wendy McLeod[2,5,6,13,15]; Laura Smith, PhD[9]; Susan Smith[12,15]; Ulla Uusitalo, PhD[2,15]; Kendra Vehik, PhD[4,5,9,14,15]; Earnest Washington; Jimin Yang, PhD, RD[2,15] (University of South Florida).

Project Scientist

Beena Akolkar, PhD[1,3,4,5,7,10,11] (National Institutes of Diabetes and Digestive and Kidney Diseases).

Other contributors

Kasia Bourcier, PhD[a,5]; Thomas Briese, PhD[b,6,15]; Henry Erlich, PhD[c,3]; Suzanne Bennett Johnson, PhD[d,9,12]; Steve Oberste, PhD[e,6] ([a]National Institutes of Allergy and Infectious Diseases; [b]Columbia University; [c]Children's Hospital Oakland Research Institute; [d]Florida State University; [e]Centers for Disease Control and Prevention).

Committees

[1]Ancillary Studies; [2]Diet; [3]Genetics; [4]Human Subjects/Publicity/Publications; [5]Immune Markers; [6]Infectious Agents; [7]Laboratory Implementation; [8]Maternal Studies; [9]Psychosocial; [10]Quality Assurance; [11]Steering; [12]Study Coordinators; [13]Celiac Disease; [14]Clinical Implementation; [15]Quality Assurance Subcommittee on Data Quality.

Appendix 2

Coding of dietary supplements in The Environmental Determinants of Diabetes in the Young (TEDDY) study

Single vitamins and minerals

- Vitamin D
- Vitamin C
- Probiotic
- Single fatty acid (e.g. DHA, EPA, γ-linolenic acid, dihomo-γ-linolenic acid, arachidonic acid)
- Calcium
- Vitamin B_6
- Vitamin B_{12}
- Folic acid
- Vitamin A
- Vitamin E
- Iron
- Niacin
- Zinc
- Magnesium
- Potassium
- Choline
- Vitamin B_1
- Vitamin B_2

- Biotin
- Pantothenic acid
- Selenium
- Chromium
- Fluorine
- β-Carotene
- Iodine
- Copper
- Antioxidants (non-vitamin/mineral; e.g. lycopene, coenzyme Q_{10})

Multivitamins/minerals

- Multivitamins/minerals with probiotic (no vitamin D, no fish oil/fatty acids)
- Multivitamins/minerals containing vitamin D (no probiotic, no fish oil/fatty acids)
- Multivitamins/minerals (no vitamin D, no probiotic, no fish oil/fatty acids)
- Multivitamins/minerals with fish oil/fatty acids (no vitamin D, no probiotic)
- Multivitamins/minerals with fish oil/fatty acids containing vitamin D (no probiotic)
- Multivitamins/minerals with probiotic and fish oil/fatty acids and containing vitamin D
- Multivitamins/minerals with probiotic containing vitamin D (no fish oil/fatty acids)
- Multivitamins/minerals with probiotic and fish oil/fatty acids (no vitamin D)
- Antioxidants (products with several non-vitamin/mineral antioxidants, e.g. combination of lycopene, coenzyme Q_{10}, etc.)
- Mixture of fatty acids without vitamin/mineral (no probiotic, no vitamin D)