

# Effects of dietary counselling on micronutrient intakes in pregnant women in Finland

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## Abstract

The intake of some micronutrients is still a public health challenge for pregnant women in Finland. This study examined the effects of dietary counselling on micronutrient intakes among pregnant women at increased risk of gestational diabetes mellitus in Finland. This study utilised data from a cluster-randomised controlled trial ( $n = 399$ ), which aimed to prevent gestational diabetes. In the intervention group, the dietary counselling was carried out at four routine visits to maternity care and focused on dietary fat, fibre and saccharose intake. A validated 181-item food frequency questionnaire was used for evaluating the participants' food consumption and nutrient intakes. The differences in changes in micronutrient intakes from baseline (pre-pregnancy) to 36–37 weeks' gestation were compared between the intervention and the usual care groups using multilevel mixed-effects linear regression models, adjusted for confounders. Based on the multiple-adjusted model, the counselling increased the intake of niacin equivalent (coefficient 0.50, 95% confidence interval [CI] 0.03–0.97), vitamin D (0.24, CI 0.05–0.43), vitamin E (0.46, CI 0.26–0.66) and magnesium (5.05, CI 0.39–9.70) and maintained the intake of folate (6.50, CI 1.44–11.56), from early pregnancy to 36 to 37 weeks' gestation. Except for folate and vitamin D, the mean intake of the micronutrients from food was adequate in both groups at baseline and the follow-up. In conclusion, the dietary counselling improved the intake of several vitamins and minerals from food during pregnancy. Supplementation on folate and vitamin D is still needed during pregnancy.

## KEYWORDS

dietary counselling, Finland, micronutrient intake, pregnant women

## 1 | INTRODUCTION

The need for micronutrients increases remarkably during pregnancy, and maternal nutritional status is related to the health of both the mother and the growing fetus (Blumfield et al., 2013; Darnton-Hill

& Mkparu, 2015). A number of micronutrient insufficiencies and deficiencies are common among pregnant women globally (Blumfield et al., 2013; Bruins et al., 2018; Darnton-Hill & Mkparu, 2015). In Finland, the prevalence of different micronutrient deficiencies in pregnant women is not known. However, studies

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have shown that the median intakes of folic acid and vitamin D from food sources are lower than recommended in pregnant women (Arkkola et al., 2006; Meinila et al., 2015; Nordic Council of Ministers, 2014).

Micronutrient supplementation interventions are highly essential for preventing birth defects and may have effect also on some other outcomes (Black, 2001). Prevention of neural tube defects with folic acid, prevention of cretinism with iodine, reduction of risk of preterm birth with zinc and reduction of risk of low birth weight with iron are examples of successful supplementation with a single micronutrient before or during pregnancy (Gernand et al., 2016). Additionally, dietary counselling interventions, which focused on healthy dietary practices, have had some effect on reducing the odds of caesarean section, the mean gestational weight gain (The International Weight Management in Pregnancy [i-WIP] Collaborative Group, 2017) and the mean maternal systolic and diastolic blood pressure (Gresham et al., 2016) in studies conducted mostly in high-income countries. Many of the dietary counselling interventions that were included in these meta-analyses (Gresham et al., 2016; The International Weight Management in Pregnancy [i-WIP] Collaborative Group, 2017) have reported beneficial effects of the counselling on dietary practices, energy or macronutrient intakes (Guelinckx et al., 2010; Kinnunen et al., 2014; Poston et al., 2015; Rauh et al., 2013; Wolff et al., 2008). However, to our knowledge, only one such study has reported the effects of dietary counselling on the intake of micronutrients during pregnancy (Piirainen et al., 2006). The intervention had effect on the intake of folate, vitamin C and vitamin E among Finnish pregnant women (Piirainen et al., 2006). More information is needed on the effects of counselling pregnant women on healthy dietary practices on their intake of micronutrients to help to optimise the counselling practices further for the benefit of the mother and the growing fetus.

The aim of the present study was to examine the effects of dietary counselling on changes in the mean intake of vitamins and minerals from 8–12 to 36–37 weeks' gestation among pregnant women at increased risk for gestational diabetes mellitus (GDM) in Finland.

## 2 | METHODS

### 2.1 | Study design and participants

The data of the present study were obtained from the Neuvonta, Elintavat ja Liikunta neuvolassa (NELLI) cluster-randomised trial conducted in Pirkanmaa region in Finland in 2007–2009 (Luoto et al., 2010). The methods and the main results have been reported previously in detail (Kinnunen et al., 2014; Luoto et al., 2010, 2011). Briefly, the primary aim of the NELLI study was to prevent development of GDM by counselling women on diet, physical activity and gestational weight gain during pregnancy (Luoto et al., 2011). The study was conducted in the primary healthcare maternity clinics in 14 municipalities. The municipalities were randomised to the intervention and the usual care groups. The participants were pregnant women who had at least one risk factor of GDM (e.g. body mass index

### Key messages

- Intensified dietary counselling was carried out as part of the usual maternity care visits among pregnant women at increased risk for gestational diabetes mellitus.
- This paper adds to the previously published results on the effects of the counselling on dietary intake.
- The counselling had beneficial effects on the mean intake of niacin, folate, vitamin D, vitamin E and magnesium.
- Except for folate and vitamin D, the mean intake of the micronutrients from food was above the recommended level prior to the pregnancy and in late pregnancy in both groups.
- Supplementation with folic acid and vitamin D prior to and during pregnancy is still needed.

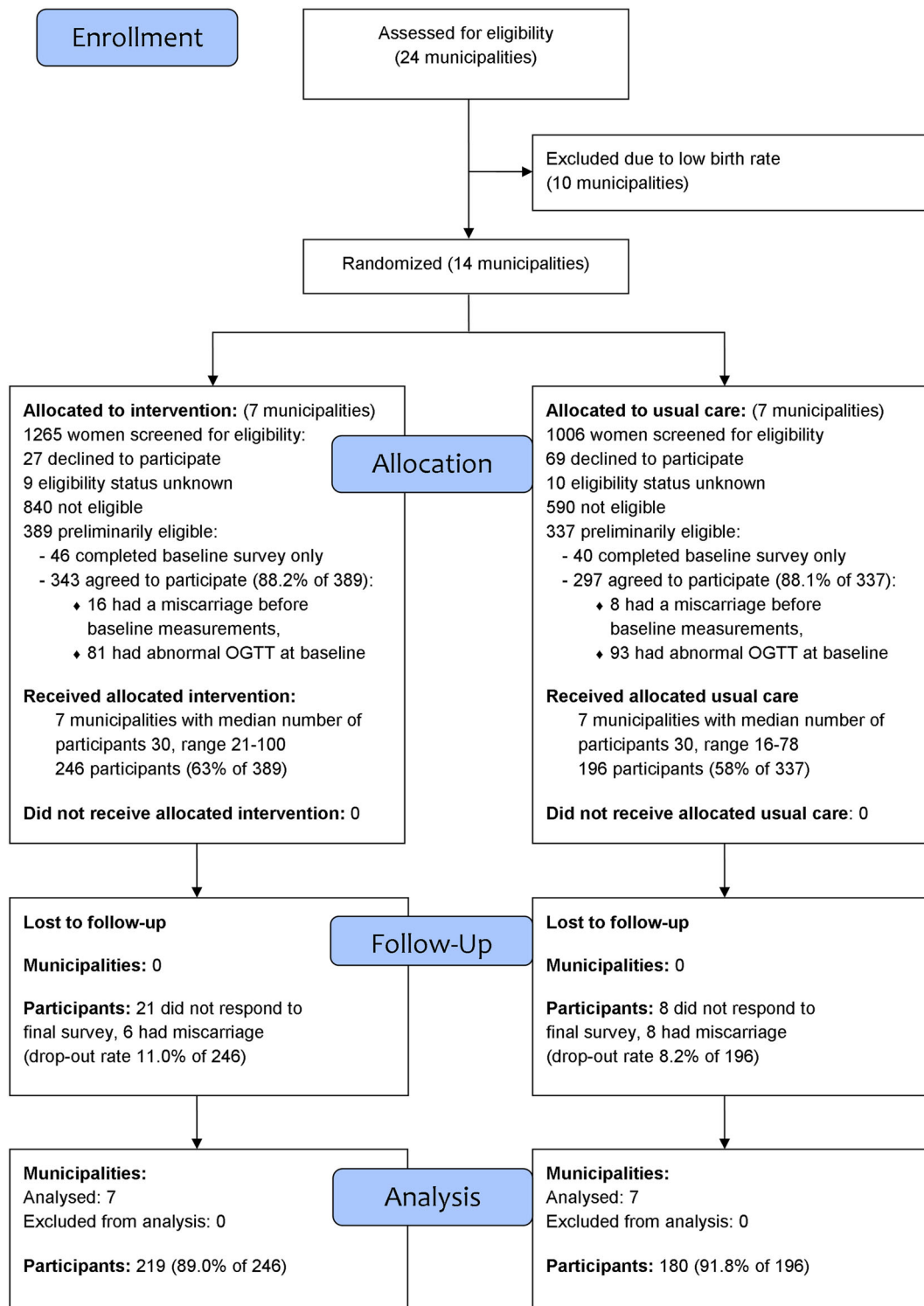
[BMI]  $\geq 25$  kg/m<sup>2</sup>, age  $\geq 40$  years, GDM or any sign of glucose intolerance or a macrosomic baby in any previous pregnancy or Type 1 or Type 2 diabetes in first- or second-grade relatives), but none of the exclusion criteria, such as having GDM or Type 1 or Type 2 diabetes at 8–12 weeks' gestation (Luoto et al., 2010).

The ethical committee of Pirkanmaa Hospital District gave the ethical statement for the study. All participants provided a written informed consent. The participation rate of preliminarily eligible women was 88% (Figure 1). The final number of participants in the analyses was 219 in the intervention group and 180 in the usual care group (89% and 92% of women receiving the allocated intervention in each group, respectively).

### 2.2 | Intervention

The intervention included individual face-to-face counselling on physical activity, diet and gestational weight gain on four to five routine visits to the maternity clinics. Public health nurses ( $n = 53$ ) carried out the counselling and facilitated the data collection (Kinnunen et al., 2014; Luoto et al., 2010). The primary dietary counselling session (20–30 min) took place at 16–18 weeks' gestation. Three booster sessions (10–15 min each) were arranged at 22–24, 32–34 and 36–37 weeks' gestation. The last booster session took place after completing the last follow-up questionnaire and therefore could not have effect on the outcomes.

The dietary counselling aimed at helping the participants to improve their diet towards the national recommendations (National Nutrition Council, 2005): saturated fat  $\leq 10\%$  of energy intake, polyunsaturated fat 5%–10% of energy intake, total fat 25%–30% of energy intake, saccharose  $< 10\%$  of energy intake and fibre 25–35 g/day. In practice, the participants were advised (1) to eat vegetables, fruits and berries, preferably at least five portions (a total of 400 g) a



**FIGURE 1** Flow diagram of the cluster-randomised trial (Kinnunen et al., 2014). OGTT, oral glucose tolerance test

day; (2) to select mostly high-fibre bread (>6 g fibre/100 g) and other whole-meal products; (3) to select mostly fat-free or low-fat milk and milk products and of meat and meat products; (4) to eat fish at least twice a week (excluding the fish species not recommended for pregnant women); (5) to use moderate amounts of soft vegetable spreads on bread, oil-based salad dressing in salad and oil in cooking and baking; (6) to use foods high in fat seldom and only in small portion sizes;

and (7) to use snacks containing lots of sugar and/or fat seldom and only in small portion sizes (Kinnunen et al., 2014).

The counselling procedure and the materials were described in detail by Luoto et al. (2010). During the counselling sessions, the participants set their individual plans for changing their dietary practices, wrote down the plans in their personal follow-up notebooks and kept record of their adherence to the plan until the next counselling

session when the plan was discussed and revised if needed. In the usual care clinics, the participants received the usual care including some dietary counselling.

## 2.3 | Data collection and study variables

The data on dietary practices were collected using a validated, self-administered, semi-quantitative 181-item food frequency questionnaire (FFQ) (Erkkola et al., 2001; Kinnunen et al., 2014). In the present study, we used FFQ data that were collected at 8–12 and 36–37 weeks' gestation. The baseline FFQ included questions on food intake during 1 month prior to the pregnancy, whereas the questions of the follow-up FFQ covered the previous month. For each food item, information on the frequency of use (per day, week, month or not at all) was collected. The portion size for each food item was defined in natural units, common household measures or portions. The participants also reported the use of any dietary supplements as a part of the FFQ. Data on the brand name of each supplement, dosage and frequency of use (per day, week or month) was elicited. Before calculating the food and nutrient intakes, the FFQ data were entered into a food database with the help of a software programme of the National Institute for Health and Welfare (THL) in Helsinki, Finland. The data were coded to daily food record form. The energy and nutrient intakes were calculated using the Finnish Food Composition Database Fineli (10th release, updated in 2009, <http://www.fineli.fi>) and an in-house software of the THL.

The primary outcome variables of the present study were the intakes of vitamins (vitamin A,  $\beta$ -carotene equivalent, vitamin B<sub>1</sub>, vitamin B<sub>2</sub>, niacin equivalent, folate, vitamin C, vitamin D, vitamin E and vitamin K) and minerals (calcium, iron, magnesium, sodium, potassium, selenium and zinc) per day from food. The total intake of the micronutrients from food and supplements is also reported. The daily intakes of the micronutrients were analysed as continuous variables.

Data on participants' background characteristics (e.g. age and parity) and anthropometric measurements were obtained from the standard maternity cards that were used in usual antenatal care. Data on pre-pregnancy BMI ( $\text{kg}/\text{m}^2$ ) was calculated based on pre-pregnancy weight (self-reported at 8–12 weeks' gestation) and height (measured at 8–12 weeks' gestation). The BMI was categorised to underweight (BMI < 18.5  $\text{kg}/\text{m}^2$ ), normal weight (BMI 18.5–24.9  $\text{kg}/\text{m}^2$ ), overweight (BMI 25.0–29.9  $\text{kg}/\text{m}^2$ ) and obesity (BMI  $\geq$  30  $\text{kg}/\text{m}^2$ ). Education was categorised to basic or secondary education, polytechnic education and university degree. The working status was categorised to working full time vs. not working full time. Smoking status was categorised to not smoking, smoking during the year before pregnancy and smoking during the year before pregnancy and during pregnancy.

## 2.4 | Data analysis

The data were analysed according to the intention-to-treat principle, as far as the outcome data were available. Descriptive information on

the background characteristics and the absolute daily intake of the micronutrients (from food and in total) was reported as means (SD) for continuous variables and as frequencies (%) for categorical variables.

Because the intake of micronutrients is related to total energy intake, the daily intake of each micronutrient is reported per 1000 kcal in the following analyses to adjust for differences in energy intake (Willett, 2013). The between-group differences in changes in the micronutrient intakes from baseline (8–12 weeks' gestation) to the follow-up (36–37 weeks' gestation) were analysed using multilevel mixed-effects linear regression models, which enabled correction of the results for between-municipality, between-clinic and between-nurse variation. The outcome variable was the change in the intake of a micronutrient (per 1000 kcal) from baseline to the follow-up, and the model was adjusted for the baseline level of the variable in each model. The between-group differences in changes are reported as coefficients, 95% confidence intervals (CI) and *P*-values. The coefficients can be interpreted as the magnitude of the between-group differences in changes in the micronutrient intakes (as mg/1000 kcal or  $\mu\text{g}/1000$  kcal). In the multiple-adjusted models, the models were adjusted additionally for maternal age, BMI (both continuous variables), parity, level of education, smoking status and working status (all categorical variables).

STATA 35.0 software (Stata Corp., College Station, TX, USA) was used for the multilevel mixed-effects linear regression analyses and SPSS 25.0 software (IBM, Armonk, NY, USA) to describe the data. In the present study, *P* < 0.05 was considered statistically significant.

## 3 | RESULTS

### 3.1 | Background characteristics of the participants

The background characteristics of the participants are presented in Table 1. The mean age was 29.5 years in the intervention group and 30.0 years in the usual care group. Regarding parity, 47.0% of participants in the intervention group and 40.6% of the participants in the usual care group had no previous children. The mean pre-pregnancy BMI was similar in the two groups (26.2 vs. 26.4  $\text{kg}/\text{m}^2$ ). The percentage of participants with pre-pregnancy overweight or obesity (combined) was somewhat higher in the usual care group (62.2%) than in the intervention group (55.1%). The percentages of participants who had a university degree, who were working full time and who were non-smokers were higher in the intervention group than in the usual care group.

### 3.2 | The absolute daily intake of the micronutrients at baseline and at 36–37 weeks' gestation

Descriptive data on the absolute daily intake of energy and the micronutrients at baseline and at 36–37 weeks' gestation are shown for the

**TABLE 1** Background characteristics of the study participants at baseline, means (SD)<sup>a</sup> or numbers (%)

	Intervention group (n = 219) <sup>b</sup>	Usual care group (n = 180) <sup>c</sup>
Age, years	29.5 (4.8)	30.0 (4.7)
Parity, n (%)		
0	103 (47.0)	73 (40.6)
1	76 (34.7)	62 (34.4)
≥2	40 (18.3)	45 (25.0)
Pre-pregnancy BMI, (kg/m <sup>2</sup> )	26.2 (4.9)	26.4 (4.4)
Pre-pregnancy BMI categories, n (%)		
Underweight, <18.5 kg/m <sup>2</sup>	1 (0.5)	3 (1.7)
Normal weight, 18.5–24.9 kg/m <sup>2</sup>	97 (44.5)	65 (36.1)
Overweight, 25.0–29.9 kg/m <sup>2</sup>	83 (38.1)	72 (40.0)
Obese, ≥30.0 kg/m <sup>2</sup>	37 (17.0)	40 (22.2)
Education, n (%)		
Basic or secondary education	107 (49.5)	92 (52.6)
Polytechnic education	51 (23.6)	47 (26.9)
University degree	58 (26.9)	36 (20.6)
Working full time, n (%)	147 (67.1)	104 (57.8)
Smoking status, n (%)		
Non-smoker	169 (77.2)	128 (71.1)
Smoking during the year before pregnancy	36 (16.4)	41 (22.8)
Smoking during the year before pregnancy and during pregnancy	14 (6.4)	11 (6.1)

<sup>a</sup>Mean and standard deviation (SD) for age and pre-pregnancy BMI (continuous variables).

<sup>b</sup>Missing values in the intervention group: BMI, n = 1; education, n = 3.

<sup>c</sup>Missing values in the usual care group: education, n = 5.

two groups as means (SD) in Table 2. The mean energy intake decreased slightly from baseline to 36–37 weeks' gestation in both groups and was somewhat lower in the intervention group than in the control group at both time points. Regarding vitamins, the absolute intake of vitamin A, niacin (in equivalents) and folate decreased in both groups from the baseline to 36–37 weeks' gestation. The absolute intake of the other vitamins increased or remained the same in the intervention group but decreased or remained the same in the usual care group during the same period. Regarding minerals, the absolute intakes decreased in both groups from baseline to 36–37 weeks' gestation, except for calcium intake in the intervention group. When including supplement intake, the total intake of the micronutrients was somewhat higher than the intake from food only for most of the micronutrients, especially at 36–37 weeks' gestation.

### 3.3 | Between-group differences in changes of energy-adjusted micronutrient intakes from baseline to 36–37 weeks' gestation

Table 3 presents differences in changes in the daily micronutrient intakes (per 1000 kcal) from baseline to 36–37 weeks' gestation between the groups. Regarding vitamins, the mean baseline-adjusted

intake of folate decreased by 5.78 µg/1000 kcal (95% CI 0.69–10.86) less in the intervention group compared with the usual care group. The mean baseline-adjusted intake of vitamin E increased by 0.47 mg/1000 kcal (95% CI 0.27–0.66) in intervention group compared with the usual care group. The between-group differences in changes in the intake of folate and vitamin E were statistically significant in the multiple-adjusted model. Additionally, the between-group difference in changes in the intake of niacin equivalent (0.50 mg/1000 kcal, 95% CI 0.03–0.97) and vitamin D (0.24 mg/1000 kcal, 95% CI 0.05–0.43) became statistically significant after adjusting for the other variables. No statistically significant differences were observed in changes in the intake of the other vitamins between the groups, although some were borderline significant. Regarding minerals, no statistically significant differences were observed between the groups in changes in the intake when adjusted for the baseline level of the variable (Table 3). In the multiple-adjusted model, the mean intake of magnesium was maintained in the intervention group, but it decreased in the usual care group from baseline to 36–37 weeks' gestation (between-group difference 5.05 mg/1000 kcal, 95% CI 0.39–9.70). The mean multiple-adjusted intake of potassium increased by 60.65 mg/1000 kcal (95% CI –0.68–121.98) in the intervention group compared with the usual care group, with borderline statistical significance. No statistically

**TABLE 2** The absolute daily intake of energy and micronutrients from food and from food and supplements (i.e. total) at baseline (pre-pregnancy) and 36–37 weeks' gestation in the intervention and the usual care groups, means (SD)

	Baseline			36–37 weeks gestation		Recommendation <sup>a</sup>
	Source	Intervention group (n = 219)	Usual care group (n = 178)	Intervention group (n = 181)	Usual care group (n = 155)	During pregnancy
Total energy intake (kcal/day)	Food	2263 (571)	2458 (713)	2215 (570)	2341 (736)	<sup>b</sup>
<b>Vitamins</b>						
Vitamin A (µg)	Food	1152.01 (655.18)	1221.64 (817.54)	866.02 (415.15)	943.40 (472.73)	800
	Total	1192.13 (675.25)	1246.30 (824.99)	890.18 (443.14)	959.38 (482.64)	
β-Carotene equivalent (µg)	Food	4695.40 (2938.62)	5066.74 (3923.64)	5146.41(4080.64)	4537.23 (2910.13)	-
	Total	4722.80 (2940.07)	5066.74 (3923.64)	5171.27 (4097.38)	4601.74 (2950.12)	
Vitamin B <sub>1</sub> (mg)	Food	1.67 (0.51)	1.83 (0.63)	1.65 (0.49)	1.73 (0.59)	1.5
	Total	3.66 (6.75)	3.25 (3.13)	3.47 (2.24)	3.94 (2.64)	
Vitamin B <sub>2</sub> (mg)	Food	2.49 (0.80)	2.65 (0.90)	2.50 (0.77)	2.58 (0.88)	1.6
	Total	4.34 (4.77)	4.23 (3.68)	4.34 (2.49)	4.89 (2.98)	
Niacin equivalent (mg)	Food	41.00 (10.86)	43.80 (12.27)	39.17 (10.32)	39.85 (11.86)	17
	Total	48.82 (18.65)	51.55 (20.87)	48.00 (15.06)	50.39 (19.84)	
Folate (µg)	Food	340.66 (107.79)	361.31 (124.77)	314.66 (94.20)	315.07 (100.45)	500
	Total	428.31 (196.06)	432.70 (182.28)	458.11 (183.19)	473.92 (184.08)	
Vitamin C (mg)	Food	156.00 (88.23)	173.84 (96.52)	157.73 (78.13)	158.50 (89.15)	85
	Total	210.06 (163.13)	228.01 (161.90)	241.01 (175.73)	250.10 (164.78)	
Vitamin D (µg)	Food	6.54 (2.95)	7.06 (3.03)	6.81 (2.70)	6.63 (2.41)	10
	Total	8.69 (4.87)	9.12 (4.72)	11.52 (5.33)	11.39 (5.20)	
Vitamin E (mg)	Food	10.40 (3.28)	11.26 (3.83)	10.84 (3.70)	10.41 (3.80)	10
	Total	12.78 (5.87)	13.60 (6.13)	17.12 (8.10)	17.19 (8.53)	
Vitamin K (µg)	Food	131.34 (46.25)	142.83 (54.35)	132.74 (46.75)	132.90 (51.33)	-
	Total	132.21 (47.03)	143.25 (55.44)	135.12 (48.81)	134.40 (52.19)	
<b>Minerals</b>						
Calcium (mg)	Food	1559.72 (564.85)	1715.25 (692.07)	1559.73 (574.62)	1673.22 (647.61)	900
	Total	1615.05 (568.78)	1787.83 (684.57)	1750.61 (606.10)	1905.54 (669.69)	
Iron (mg)	Food	14.25 (4.12)	14.98 (4.44)	13.93 (4.05)	14.08 (4.72)	-
	Total	17.56 (15.01)	18.68 (15.72)	57.46 (57.17)	72.04 (59.91)	
Magnesium (mg)	Food	427.50 (114.66)	450.97 (122.57)	414.36 (109.73)	417.11 (117.23)	280
	Total	467.25 (164.63)	473.95 (134.87)	518.55 (196.72)	510.94 (160.83)	
Sodium (mg)	Food	3657.31 (989.95)	3929.30 (1091.46)	3518.51 (975.81)	3600.90 (1024.42)	2400
	Total	4749.14 (1374.91)	5083.22 (1421.26)	4659.14 (1248.63)	4745.03 (1342.60)	
Potassium (mg)	Food	4749.09 (1374.94)	5082.89 (1421.22)	4659.09 (1248.64)	4744.53 (1342.58)	3100
	Total <sup>c</sup>	4749.09 (1374.94)	5082.89 (1421.22)	4659.09 (1248.64)	4744.53 (1342.58)	
Selenium (µg)	Food	89.98 (25.34)	96.41 (28.25)	85.45 (23.66)	89.78 (29.14)	60
	Total	99.92 (32.95)	105.78 (33.45)	104.07 (32.76)	110.46 (36.91)	
Zinc (mg)	Food	14.74 (3.99)	15.79 (4.58)	14.30 (3.89)	14.75 (4.46)	9
	Total	18.25 (7.60)	18.98 (7.07)	19.81 (7.51)	20.84 (7.82)	

Abbreviation: SD, standard deviation.

<sup>a</sup>Nordic Council of Ministers (2014).<sup>b</sup>The supplements did not contain any potassium and therefore the total intake is the same as the intake from food.<sup>c</sup>The energy requirement depends on the physical activity level.

TABLE 3 Between-group differences in changes in the energy-adjusted micronutrient intakes from food from baseline (pre-pregnancy) to 36–37 weeks' gestation, means (SD)

	Baseline		36–37 weeks' gestation		Baseline-adjusted difference in change <sup>a</sup>		Multiple-adjusted difference in change <sup>b</sup>	
	Intervention group (n = 219)	Usual care group (n = 178)	Intervention group (n = 181)	Usual care group (n = 155)	Coefficient (95% CI)	P	Coefficient (95% CI)	P
<b>Vitamins</b>								
Vitamin A (µg/1000 kcal)	509.89 (253.39)	500.56 (299.08)	395.34 (198.60)	411.86 (194.97)	-15.25 (-56.96 to 26.45)	0.47	-10.74 (-57.62 to 36.15)	0.65
β-Carotene equivalent (µg/1000 kcal)	2074.83 (1199.54)	2111.89 (1570.81)	2389.27 (2272.59)	2072.64 (1557.00)	378.42 (-3.82 to 760.65)	0.05	353.03 (-32.23 to 738.29)	0.07
Vitamin B <sub>1</sub> (mg/1000 kcal)	0.74 (0.14)	0.75 (0.15)	0.75 (0.13)	0.75 (0.17)	0.003 (-0.026 to 0.031)	0.86	0.0042 (-0.02 to 0.03)	0.77
Vitamin B <sub>2</sub> (mg/1000 kcal)	1.10 (0.22)	1.09 (0.25)	1.13 (0.23)	1.12 (0.28)	0.006 (-0.038 to 0.051)	0.78	0.014 (-0.03 to 0.06)	0.55
Niacin equivalent (mg/1000 kcal)	18.24 (2.45)	18.02 (2.38)	17.84 (2.60)	17.29 (2.67)	0.42 (-0.060 to 0.89)	0.09	0.50 (0.03 to 0.97)	0.04
Folate (µg/1000 kcal)	150.54 (28.51)	148.37 (36.04)	142.88 (27.72)	136.82 (28.04)	5.78 (0.69 to 10.86)	0.03	6.50 (1.44 to 11.56)	0.01
Vitamin C (mg/1000 kcal)	68.24 (32.08)	71.12 (33.37)	72.01 (30.89)	67.93 (30.37)	5.03 (-1.23 to 11.29)	0.12	5.52 (-0.79 to 11.83)	0.09
Vitamin D (µg/1000 kcal)	2.88 (0.98)	2.93 (1.15)	3.08 (1.02)	2.91 (0.95)	0.19 (-0.006 to 0.39)	0.06	0.24 (0.05 to 0.43)	0.01
Vitamin E (mg/1000 kcal)	4.59 (0.84)	4.62 (1.00)	4.90 (1.14)	4.46 (0.93)	0.47 (0.27 to 0.66)	<0.001	0.46 (0.26 to 0.66)	<0.001
Vitamin K (µg/1000 kcal)	58.16 (14.70)	58.89 (17.58)	60.80 (20.67)	58.56 (22.07)	3.60 (-0.33 to 7.54)	0.07	3.56 (-0.38 to 7.50)	0.08
<b>Minerals</b>								
Calcium (mg/1000 kcal)	686.07 (167.93)	697.19 (199.62)	703.06 (184.97)	721.93 (194.24)	-8.47 (-42.27 to 25.33)	0.62	-8.13 (-42.15 to 25.90)	0.64
Iron (mg/1000 kcal)	6.31 (0.95)	6.15 (0.97)	6.33 (1.10)	6.08 (1.18)	0.15 (-0.07 to 0.37)	0.18	0.19 (-0.03 to 0.41)	0.09
Magnesium (mg/1000 kcal)	189.38 (22.74)	185.47 (22.93)	188.11 (24.60)	181.64 (30.56)	3.85 (-0.75 to 8.46)	0.10	5.05 (0.39 to 9.70)	0.03
Sodium (mg/1000 kcal)	1621.41 (194.22)	1615.39 (208.59)	1594.78 (205.39)	1566.17 (229.58)	24.91 (-15.72 to 65.54)	0.23	33.16 (-6.85 to 73.17)	0.10
Potassium (mg/1000 kcal)	2102.86 (317.72)	2093.33 (323.23)	2119.37 (319.72)	2071.78 (395.63)	46.94 (-14.58 to 108.46)	0.14	60.65 (-0.68 to 121.98)	0.05
Selenium (µg/1000 kcal)	39.93 (5.76)	39.52 (5.69)	38.77 (5.40)	38.71 (6.33)	-0.09 (-1.40 to 1.22)	0.90	0.05 (-1.22 to 1.33)	0.93
Zinc (mg/1000 kcal)	6.53 (0.74)	6.46 (0.78)	6.48 (0.81)	6.37 (0.86)	0.07 (-0.08 to 0.22)	0.37	0.09 (-0.06 to 0.24)	0.24

Abbreviation: CI, confidence interval; SD, standard deviation.

<sup>a</sup>Multilevel mixed-effects linear regression models, adjusted for the baseline level of the variables.<sup>b</sup>Multilevel mixed-effects linear regression models, adjusted additionally for maternal age, parity, body mass index, level of education, smoking history and working status.

significant differences were observed in changes in the intake of the other minerals between the groups.

## 4 | DISCUSSION

In this study, the intensified dietary counselling increased the intake of a few vitamins (niacin equivalent, vitamin D and vitamin E) and one mineral (magnesium) from the baseline to 36–37 weeks' gestation in the multiple-adjusted model. In addition, the counselling helped the participants to maintain the intake of folate during the same time period. The counselling may also have increased the intake of  $\beta$ -carotene equivalent and potassium, as the differences in change were close to statistical significance.

The earlier results of the NELLI study indicated that the counselling had beneficial effects on total intake of vegetables, fruits and berries, the percentage of high-fibre bread of all bread, the percentage of low-fat cheese of all cheese and the percentage of vegetable fats of all dietary fat by 36–37 week's gestation (Kinnunen et al., 2014). These effects were partly reflected on changes in the micronutrient intakes. Vegetables, fruits and berries are among the main food sources for vitamin A (including  $\beta$ -carotene), folate, vitamin E, magnesium and potassium, in the average diet of Finnish women (Valsta et al., 2018). In addition, cereal products are also among the main sources of niacin, folate, vitamin E and magnesium among Finnish women. Fat spreads and other vegetable fats provide vitamin E and fat spreads also vitamin D. However, in contrary to our expectations, the counselling had no effect on the intake of vitamin B<sub>1</sub>, vitamin C or vitamin K although vegetables are among their main sources in the average Finnish diet.

A previous Finnish randomised controlled trial reported partly similar findings (Piiirainen et al., 2006). The participants ( $n = 209$ ) were healthy pregnant women (including women with atopic diseases) who participated in dietary counselling (carried out by a nutritionist) on three visits during pregnancy. The participants were also given food products with healthy fat and fibre contents. The intervention had effect not only on the mean intake of folate and vitamin E but also on mean vitamin C intake. No effects were observed on the intake of the other vitamins, calcium, iron or zinc. To our knowledge, other respective dietary counselling intervention studies from high-income countries have not reported the effects of the intervention on micronutrient intake in pregnant women.

The micronutrient intake levels of the participants of the present study are not directly comparable with those of the previous Finnish observational studies from years 1997 to 2004 (Arkkola et al., 2006; Prasad et al., 2010) due to differences in the characteristics of the study populations, the timing of the data collection or the dietary recommendations that were used as the reference. Baseline data from a randomised controlled trial ( $n = 234$ ) showed that the median intakes of folate, vitamin A and vitamin D from food were below the recommended level among a sample of pregnant women with obesity or history of GDM in Finland (Meinila et al., 2015). Piiirainen et al. (2006) also reported lower mean intakes of folate and vitamin D from food

than recommended. These findings are in accordance with the results of the present study, where the mean intakes of folate and vitamin D from food were below the recommended level. In high-income countries, the median intakes of folate, vitamin D and iron among pregnant women have generally been lower than the national recommendations based on a systematic review and meta-analysis (Blumfield et al., 2013). Therefore, vitamin D and folic acid supplements are generally recommended for pregnant women, for example, in the Nordic countries (Nordic Council of Ministers, 2014). Folate supplementation should be started already before pregnancy to reduce the risk of neural tube defect in the fetus, but data from Norway show that it is uncommon to start folate supplementation before pregnancy (Nilsen et al., 2006), especially among women from ethnic minority groups (Kinnunen et al., 2017).

Future studies that examine the impact of counselling on dietary intake should give attention to micronutrient intake, as well as energy and macronutrient intake, to give a broader picture of the effects of the counselling on dietary intake. This will help to tailor the contents of the dietary counselling to optimise the intake of micronutrients, in addition to improving the other outcomes.

This study has several strengths. Firstly, the dietary counselling was carried out by public health nurses as part of the routine maternity care visits, which improves the applicability of the dietary counselling methods in usual care, and no extra visits or personnel were required (Kinnunen et al., 2014). Secondly, the present study had a high participation rate and a low dropout rate among eligible women (Figure 1). Finally, the validated FFQ is a useful tool for categorising pregnant women according to their dietary intake and has an acceptable reproducibility (Erkkola et al., 2001). In the present study, the FFQ was modified to evaluate the previous month's diet in the follow-up. Therefore, the participants may have recalled their diet more accurately than participants in the study by Erkkola et al. where the FFQ was completed 1–3 months after pregnancy to recall the diet during the eighth month of pregnancy.

There were also limitations in the present study. The FFQ method tends to overestimate the absolute food intake of the participants (Willett, 2013), especially among pregnant women (Erkkola et al., 2001). Therefore, the absolute amounts and the energy-adjusted amounts of micronutrient intakes should be interpreted with caution. For the same reason and because the nutrition recommendations are meant for population groups rather than for individuals, we did not compare the percentages of participants with adequate micronutrient intakes between the groups. The participants were pregnant women with at least one risk factor for GDM. Although those risk factors are common in the Finnish population, the results might not be generalisable to pregnant women without any risk factors or for example, women who do not speak Finnish as they were not included in the study. The sample size calculations were made for the primary outcome of the trial (gestational diabetes) only (Luoto et al., 2010). The power of the study was adequate for the micronutrient outcomes for which we observed statistically significant differences between the groups. However, the power was slightly too low for the outcomes for which we observed border-line significant differences



between the groups ( $\beta$ -carotene equivalent, vitamin C, vitamin K, iron, sodium and potassium). Finally, even though the loss to follow-up was generally low, we cannot exclude the possibility that a selective loss to follow-up might have biased the results. Based on our earlier dropout analyses (Kinnunen et al., 2014), it is possible that the some of the observed between-group differences in changes in diet were actually slightly smaller.

## 5 | CONCLUSIONS

The present study showed that dietary counselling, which aimed to improve the quality of diet in general, had also statistically significant effects on the energy-adjusted intake of several vitamins (niacin equivalent, folate, vitamin D, vitamin E) and one mineral (magnesium) in pregnant women. The mean actual intake of the micronutrients was above the recommended level, except for vitamin D and folate. Supplementation with vitamin D and folate prior to and during pregnancy is still needed.

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## CONFLICTS OF INTEREST

The authors have no conflicts of interest.

## AUTHOR CONTRIBUTIONS

TIK and YL contributed equally to this paper. TIK, RL and SMV designed the research; TIK and RL conducted the research; SMV was responsible for the FFQ method and the dietary calculations; YL and AMK performed the statistical analyses; YL and TIK interpreted the results and wrote the paper. All authors read, commented and approved the final manuscript.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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