Dietary supplement use and iron, zinc and folate intake in pregnant women in London, Ontario

A. Roy, MSc (1,2); S. E. Evers, PhD (3); M. K. Campbell, PhD (1,4,5,6,7)

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Abstract

Introduction: We examined the dietary intake of iron, zinc and folate, estimated from both food and supplement sources, in 2019 pregnant women who participated in the Prenatal Health Project (PHP). The PHP recruited pregnant women from ultrasound clinics in London, Ontario, in the years 2002–2005.

Methods: Participants completed a telephone survey, which included a food frequency questionnaire and questions on dietary supplement use. Frequencies of use of dietary supplements were generated. Nutrient intake values were estimated from food and supplement sources, and summed to calculate total daily intake values.

Results: Most women took a multivitamin supplement, and many women took folic acid and iron supplements; however, one-fifth of the sample did not take any supplements providing any of the three micronutrients. Despite being of a higher socio-economic status overall, significant proportions of the cohort ranked below the recommended dietary allowance values for iron, zinc, and folate. This suggests there may be other barriers that impact dietary practices.

Conclusions: Further research is required on how to better promote supplement use and a healthy diet during pregnancy.

Keywords: iron, folate, zinc, dietary supplement, diet, nutrition, pregnancy

Introduction

Adequate amounts of nutrients during pregnancy are essential for maternal, fetal and child health. However, few population-based studies have examined dietary intake and use of dietary supplements among pregnant women in Canada. Of particular interest are iron, zinc and folate. Iron is integral to the structure and function of red blood cells, and its deficiency can result in anemia. Anemia and iron deficiency during pregnancy can cause pre-term birth and low birth weight.[1] In non-anemic mothers, iron supplementation may offer protection against low birth weight.[2] Iron is also involved in myelination, neuro-transmitter function, various cellular and oxidative processes, energy production and thyroid hormone metabolism.[1] Iron deficiency has been implicated in neurological and cognitive disorders in the mother; these include major depressive disorder, recognized to have health consequences on both the mother and child.[3,4] The 2009 Health Canada guidelines recommend a daily supplement of 16 to 20 mg of iron during pregnancy to ensure adequate iron intake.[5]

Zinc is integral to DNA synthesis and necessary for the structure and function of regulatory, structural and enzymatic proteins as well as cell membranes. It is involved in neurological function and proper immune function.[1,6,7] Various studies have implicated zinc deficiency in pre-term and low birth weight, although routine supplementation is not recommended unless there is an identified deficiency.[8] Zinc deficiency is also implicated in depressive disorders.[1,4] Folate is involved in the metabolism of nucleic acids and amino acids and in neurological functioning. While inadequate folate is implicated in various birth defects and poor pregnancy outcomes, its role in neural tube defects has received the most attention. In various countries, including Canada, women of child-bearing age are advised to take supplements. Food fortification policies are in effect in response to the strong evidence of the importance of folic acid intake in the very early stages of pregnancy.[9,10] Like iron and zinc, folate deficiency is implicated in depressive disorders.[1,4]

Health Canada has set out a Recommended Dietary Allowance (RDA) for a number of nutrients. The RDA is defined as the "average daily dietary intake level that is sufficient

Author references

1. Department of Epidemiology and Biostatistics, University of Western Ontario, London, Ontario, Canada
2. Department of Community Health Sciences, University of Calgary, Calgary, Alberta, Canada
3. Department of Family Relations and Applied Nutrition, University of Guelph, Guelph, Ontario, Canada
4. Department of Paediatrics, University of Western Ontario, London, Ontario, Canada
5. Department of Obstetrics and Gynecology, University of Western Ontario, London, Ontario, Canada
6. Children's Health Research Institute, London, Ontario, Canada
7. Lawson Health Research Institute, London, Ontario, Canada

Correspondence: Dr. M. Karen Campbell, Department of Epidemiology and Biostatistics, Kresge Building, Room K201A, University of Western Ontario, London, ON N6A 5C1; Tel.: (519) 661-2162; Fax: (519) 661-3766; Email: Karen.Campbell@schulich.uwo.ca

to meet the nutrient requirements of nearly all (97 to 98 percent) healthy individuals in a particular life-stage and gender group."[11] For pregnant women, the RDA of iron is 27 mg/day, of zinc is 11 mg/day and of folate, as dietary folate equivalents (DFE), is 600 µg/day.[11] In addition to the RDA, the Society of Obstetricians and Gynaecologists of Canada recommends a daily folic acid supplement of at least 400 µg (with higher amounts indicated based on risk status).[9]

In this paper, we examine the reported daily dietary intake of iron, zinc and folate estimated from both the food and dietary supplements of 2019 pregnant women in London, Ontario, who participated in the Prenatal Health Project (PHP). We also generate and examine rates of supplement use among the 2019 women and investigate the types of supplements taken among the entire PHP cohort (n = 2357). We present the results of analyses that explore possible sociodemographic determinants of dietary intake.

Methods

Data for the Prenatal Health Project (PHP) were collected between 2002 and 2005 from pregnant women recruited at ultrasound clinics in London, Ontario. The PHP was designed to assess the psychosocial, nutritional, endocrine and infectious determinants of pre-term birth, and its methods have been discussed in more detail elsewhere.[12] Inclusion criteria were being aged 16 years or older, living in the Greater London Area, carrying a singleton pregnancy of between 10 and 22 weeks gestation, and speaking English. Women who met the inclusion criteria and who signed the consent form were eligible to participate. Those who were carrying a pregnancy with a known fetal anomaly were excluded.

The Ethics Review Board for Health Sciences Research Involving Human Subjects at The University of Western Ontario approved the study.

Trained interviewers collected dietary supplement intake data as part of the structured PHP telephone survey questionnaire. They asked respondents for the name, amount and frequency of consumption of all nutrient supplements currently used regularly. Nutrient amounts could be quantitatively estimated if the participant reported the brand and product name of a prenatal supplement or else the exact nutrient amounts. When brand or product information of prenatal supplements was missing (n = 930), we calculated the nutrient composition from the most commonly used prenatal multivitamin supplement, Centrum Materna. (Of the 643 women of the PHP core cohort who named a brand, most used Centrum Materna [n = 592], followed by Life Brand [n = 24], the composition of which is identical to that of Centrum Materna.) To generate average daily values, we assumed the standard dose of one tablet per day; if otherwise specified, we adjusted the intake values according to the reported frequency.

In contrast to prenatal multivitamin products, where the similar compositions justify assuming nutrient content, regular adult multivitamins on the market vary substantially. Thus, for those who reported taking such a supplement without specifying a brand name (n = 137), nutrient intake from supplements was declared missing. For the same reason, single-nutrient dietary supplements without specific amounts provided were also declared missing, with the exception of folic acid. Because there is less variation among folic acid supplements, a dose of 400 µg folic acid per day was assumed for those who did not specify their regular dose of folic acid supplement. This assumption is consistent with other studies that have measured folate supplement intake.[13] Based on the reported frequency of consumption, we calculated average daily intake values. A few respondents claimed to be taking a separate folic acid supplement that provided more than 1 mg (1000 µg) of folic acid per day; due to the possibility of inaccurate reporting, these were not quantified but were declared missing. Folate intake from supplement sources was converted to dietary folate equivalents (DFE) by multiplying by 1.7.[11]

Dietary intake from food was assessed with a food frequency questionnaire (FFQ). This was given to the study participants to complete before their scheduled telephone interview; they then reported their answers during the telephone interview. The FFQ is considered an acceptable method of assessing dietary intake in large surveys, including prenatal studies.[14] The major advantages of the FFQ, which make it more practical than dietary recalls or multiple food records, are the low respondent burden and the lower cost of data collection since it can be incorporated easily into the telephone interview itself. As there was no specific information on the dietary intake of pregnant Canadian women, we based the design of the FFQ on dietary data collected through 24-hour dietary recalls from 183 women who were breastfeeding at three months postpartum.[15] We compared the FFQ to one developed for a USA-based study of prenatal health[14] and subsequently added some more foods (e.g. broth). A pilot test of the FFQ for the PHP was conducted in London, and the instrument was validated with 3-day food records kept by 22 pregnant women. The correlation coefficients were as follows: folate 0.76 ($p < .001$), zinc 0.46 ($p < .05$) and iron 0.19 (not significant).

The FFQ assessed the usual frequency of consumption of 106 foods over the month prior to the interview date. Frequency of consumption of each item was categorized as never, once per day, 2 to 3 times per day, 4 or more times per day, once per week, 2 to 4 times per week, 5 to 6 times per week, or 1 to 3 times per month. CANDAT Nutrient Calculation System software[16] was used to convert responses to metric estimates of energy and nutrient intake per day, based on the 2006 Canadian Nutrient File.[17] Nutrient intake values from supplements were added to those from food to yield total daily dietary intakes.

Of 3656 women approached at ultrasound clinics to participate in the PHP, 2747 agreed to participate and 2421 (66%) completed the survey. Of these 2421 respondents, 38 were eliminated from the "core" longitudinal cohort due to perinatal data not being available or not being applicable (for such reasons as loss to follow-up, miscarriage, abortion or neonatal death). Additionally, 26 women had been recruited into the study twice, for two different pregnancies; for each of these participants, a single set of data was randomly excluded. This yielded 2357 PHP participants in the core longitudinal cohort, with 2019 included in the intake analyses reported in this paper. Those included had completed the FFQ, reported an energy consumption amount within two standard deviations from the sample mean (as outside that plausible range is indicative of possible inaccurate reporting), had plausible FFQ-derived intake values for the nutrients of interest, and did not have any missing values for the nutrient supplement intake values for the nutrients of interest.

Statistical analyses

For the sample of 2019 eligible study participants, we calculated descriptive analyses of the estimated mean daily intake values of iron, zinc and folate from food, from supplements and from total dietary intake. To explore the contribution of supplement use in this regard, stratum-specific mean intakes for each micronutrient were also calculated, based on whether a supplement containing the micronutrient was being taken; Student's t tests were conducted to see if the differences between strata of supplement use were statistically significant. A correlation matrix between the total intakes of the three micronutrients was also generated to see whether intakes were linked. To assess possible predictors of diet, we explored associations between diet and four categorical sociodemographic variables: age, marital status, education and household income. To this end, we used ANOVA to explore associations between the four categorical sociodemographic variables and total dietary iron, zinc and folate intake separately. In addition, we ran χ^2 tests between each of the sociodemographic variables and dichotomized supplement use to assess any possible associations. Finally, we determined the frequencies of the types of dietary supplements taken by the full core PHP cohort (n = 2357). The statistical package SAS version 9.1 (SAS Institute Inc.)[18] was used to conduct data management and statistical analyses.

Results

Table 1 shows the characteristics of the eligible survey participants (n = 2019). Most women were aged between 22 and 34 years (with mean age of 30 years), were married, had completed college or university and had household incomes of between $30,000 and $79,999. Most women reported taking one or more dietary supplements; however, 29.6% did not receive any zinc from supplement sources, 28.4% did not receive any iron from supplement sources and 20.3% did not receive any folic acid from supplement sources. Approximately one-fifth of the sample did not take any regular or prenatal multivitamin products or single-nutrient supplements that contained any zinc, iron or folic acid.

Table 2 shows the descriptive analyses of each of the three micronutrients. Included are estimates of mean daily intake from food, from dietary supplements and from both sources together. Also indicated is the proportion ranking below the RDA, based on the total dietary intake estimates. Because of the inherent limitations of the

TABLE 1
Characteristics of Prenatal Health Project (PHP) dietary intake analysis participants (n = 2019)

Categorical variables	Participants	
	Number, n	Percentage, %
Age group, years		
< 22	85	4.2
22–34	1578	78.2
35+	355	17.6
Marital status		
Married	1544	76.5
Common-law	310	15.4
Single/separated/divorced	163	8.1
Education[a]		
Completed college diploma/university degree	1431	71.3
Other	575	28.7
Household income[a], $		
< 30,000	224	11.9
30,000–79,999	941	50.0
80,000+	716	38.1
Using one or more dietary supplement(s)[b]		
Yes	1613	79.9
No	406	20.1
Taking a supplement containing iron		
Yes	1446	71.6
No	573	28.4
Taking a supplement containing zinc		
Yes	1422	70.4
No	597	29.6
Taking a supplement containing folic acid		
Yes	1610	79.7
No	409	20.3
Measured variables	**Mean**	**(SD)**
Age, years	30.4	(5.0)
Energy consumption, kcal/day	1982	(545)

Abbreviation: SD, standard deviation.

[a] Sample size is less than 2019 due to missing values.

[b] Containing any amount of folic acid, iron or zinc; therefore, those assigned a "no" to this variable were not taking any of the multivitamin products or single-nutrient products listed in Table 4.

TABLE 2
Intake from food and dietary supplements of iron, zinc and folate by pregnant women (n = 2019)

Micronutrient	RDA for pregnant women	Estimated mean daily intake, weight per day (SD)			Proportion of sample below RDA, %
		From food alone	From dietary supplements alone	Total	
Iron (mg/day)	27	13 (4)	19 (12)	32 (13)	31
Zinc (mg/day)	11	10 (3)	5 (3)	16 (5)	18
Folate (µg/day DFE)	600	473 (155)	1338[a] (763)	1811 (772)	16

Abbreviations: DFE, Dietary Folate Equivalent; RDA, Recommended Dietary Allowance; SD, standard deviation.

[a] In addition to the RDA from food, the Society of Obstetricians and Gynaecologists of Canada recommends that pregnant women take a 400 µg folic acid supplement (400 µg folic acid = approximately 680 DFE).[9]

FFQ method of dietary assessment, it is not considered appropriate to use the estimates of nutrient intake to assess nutrient adequacy. However, FFQ estimates may be used to rank nutrient intakes in a population based on the RDA.[19] In this case, a relatively high proportion of the sample fell below the specified RDA for all three micronutrients: iron (31%), zinc (18%) and folate (16%). A correlation matrix between the total intakes of the three micronutrients showed high correlation.

Table 3 shows stratum-specific mean estimates of total dietary intake, according to whether a supplement containing the particular micronutrient was being taken. The corresponding Student's *t* tests indicate statistically significant differences in mean intakes for all three micronutrients. Figure 1 shows histograms depicting the distributions of the three micronutrients. While total zinc intake follows a reasonably normal distribution, the distributions for total iron intake and total folate (DFE) intake are bimodal, each showing two distinct peaks. For both micronutrients, one peak was below the RDA level while the other was above. The peaks correspond to the stratum-specific mean estimates in Table 3; in other words, the bimodal distributions are a function of dietary supplement use.

Table 4 shows the types of nutrient supplement product used; that is, multi-vitamin products as well as single-nutrient supplements featuring iron, zinc or folate. To show the complete range of products used, the numbers are based on the full PHP core cohort of 2357 women. Therefore, the table includes entries that could not be quantified. Of the specified prenatal multivitamin supplements, the most commonly used product was Centrum Materna (n = 592). In the case of supplements of specific micronutrients (i.e. single-nutrient supplements, or products containing a small complex of nutrients), the most common were folic acid supplements (n = 354), followed by iron supplements (n = 98).

ANOVA tests were run to examine whether there were associations between the four categorical sociodemographic variables and each of total dietary iron, zinc and folate intakes. None was statistically significant. Similarly, of the χ^2 tests conducted between each of the sociodemographic variables and dichotomized dietary supplement use, none was statistically significant. In other words, age, marital status, education, and household income were not associated with either total dietary intake or supplement use in this group of women.

Discussion

London is a city in southwestern Ontario. In 2006, its population was just over 350 000.[20] The reported median family income in 2005 was $67,018—only slightly higher than the median family income for Canada ($63,866) and only slightly lower than that for Ontario ($69,156).[20] The results of this study may thus be informative for other Canadian cities with similar characteristics.

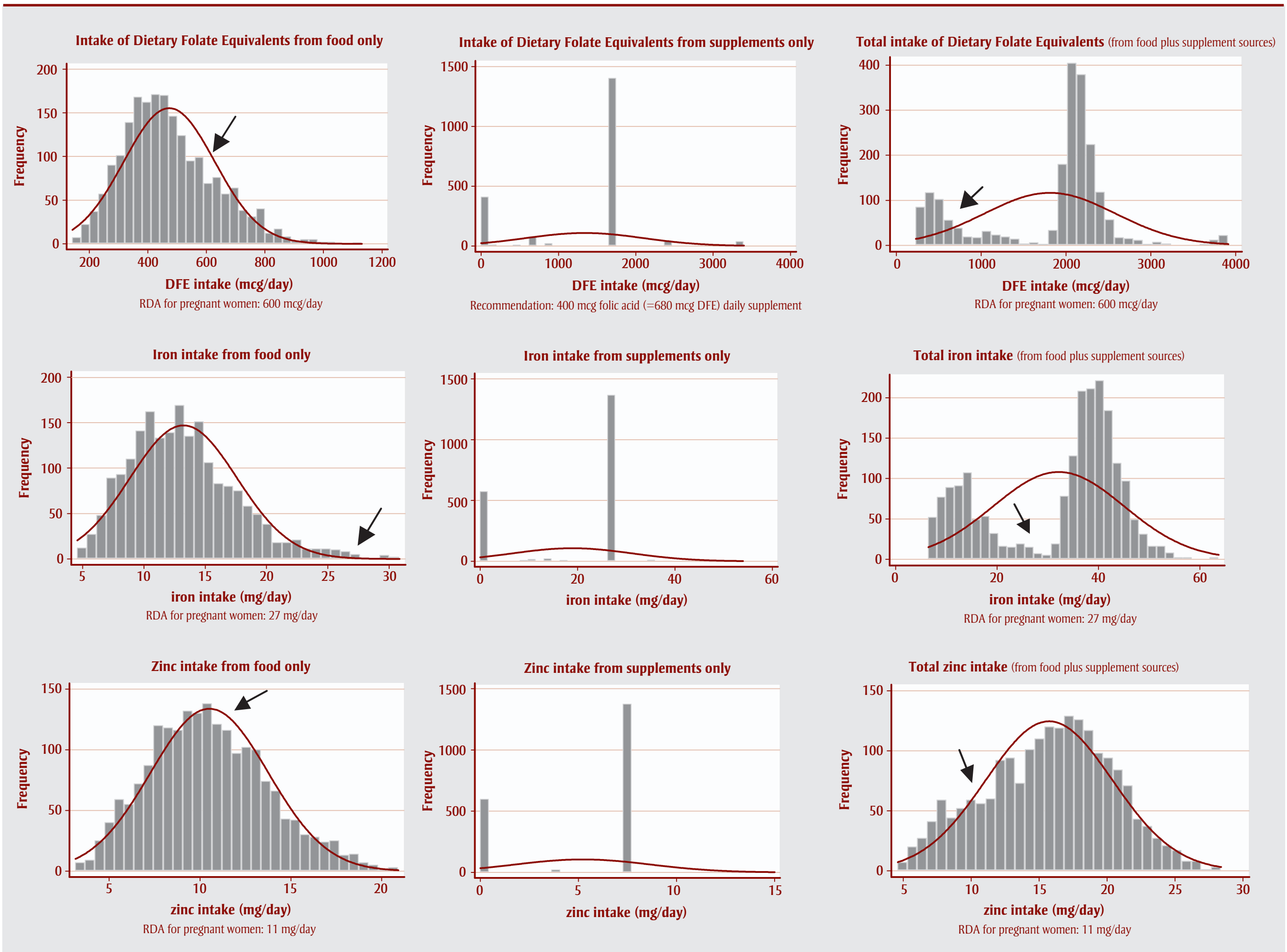
TABLE 3
Total dietary iron, zinc and folate intake by pregnant women, stratified by supplement use (n = 2019)

Micronutrient	RDA for pregnant women	Estimated mean daily intake, weight per day (SD) [n]		Student's *t* test*
		Participants obtaining micronutrient only from food	Participants obtaining micronutrient from both food and supplement sources	
Iron (mg/day)	27	13 (4) [n = 573]	40 (6) [n = 1446]	−100.0
Zinc (mg/day)	11	11 (3) [n = 597]	18 (3) [n = 1422]	−44.7
Folate (µg/day DFE)	600	482 (157) [n = 409]	2148 (422) [n = 1610]	−78.4

Abbreviations: DFE, Dietary Folate Equivalent; *p*, p-value; SD, Standard deviation.

* $p < .001$

FIGURE 1
Estimated dietary intake of dietary folate equivalents, iron and zinc from both food and supplement sources (separately and totalled) by Prenatal Health Project (PHP) survey participants (n = 2019)



Abbreviations: DFE, Dietary Folate Equivalent; RDA, Recommended Dietary Allowance.

Note: The arrows approximately indicate the RDA for each nutrient.

Few Canadian studies have examined dietary intake and supplement use during pregnancy. Of those that have, most focus on folic acid supplement use.[21-25] In terms of nutrient intake from food among Canadian pregnant women, a 2005 paper by Pick et al.[26] reported on the nutrient intake levels of a small sample of non-pregnant and pregnant women in Edmonton, Alberta. Because they were reporting findings from a pilot study, the sample size was relatively small (n = 52 pregnant women), which they acknowledge as a limitation.[26] In contrast, our study uses a very large sample size and a pre-piloted, validated instrument to capture dietary intake. Additionally, Pick et al. did not factor in nutrient values from dietary supplements,[26] while we were able to incorporate nutrient values from supplements to generate total intake estimates. Thus, our study offers a valuable glimpse into the nutritional status of a pregnant Canadian population, thereby contributing meaningfully to the literature in the area.

We found that a significant proportion of women had dietary intakes of iron, zinc and folate that ranked below the RDA values. Nutrient intake from food alone was particularly low (see Figure 1), supporting other Canadian studies that suggested that it is difficult for pregnant women to meet recommendations for key micronutrients from food alone.[26,27] Additionally, one-fifth of women did not take any supplements containing any of the three micronutrients. Given the importance of these micronutrients for maternal and fetal health, this is of concern.

Clinical practice guidelines emphasize the importance of folic acid supplementation during pregnancy[9] and recommend iron supplementation.[5] Thus it is not surprising that these two micronutrients were the most common among single-micronutrient products. The bimodal distributions associated with both micronutrients are a function of dietary supplement use, as shown in Table 3; women who used supplements for these nutrients were well above the RDAs for them and constituted the higher-valued peaks, whereas women who did not use dietary supplements did not achieve the RDAs for them and constituted the lower-valued peaks. Thus, dietary supplement use is clearly integral to the attainment of the micronutrient intake levels required during pregnancy.

Even with folic acid fortification of foods in Canada and the United States, most women appear to require a separate folic acid supplement in order to achieve the red blood folate concentrations required to prevent neural tube defects.[25,27] While the exact mechanism by which folic acid prevents neural tube defects is unknown, it seems that folic acid supplements (rather than natural food folates) may be key to the preventive effect.[25] As such, it is of concern that 20% of women in this sample were not taking a dietary supplement containing folic acid.

As mentioned in the Results section, the intake values for the three micronutrients were highly correlated overall. This finding is likely a reflection of the fact that individuals tend to be deficient in multiple micronutrients due to poor overall dietary practices; along the same vein, it may also be a reflection of multivitamin supplement use, through which individuals receive the micronutrients together as a "package."

Age, marital status, education and household income were not associated with either total dietary intake of micronutrients or supplement use. As part of a separate analysis involving PHP data, we used multivariable regression to evaluate predictors of dietary zinc intake more thoroughly. Those findings, done in the context of a research question on the predictors of prenatal depression, have been reported in detail elsewhere;[28] none of the sociodemographic variables or psychosocial stress were shown to be predictors of dietary zinc intake in this cohort.[28] The cohort as a whole is of higher socio-economic status than the general population of the city of London.[20,28] Thus, other factors may account for the variation in dietary intake. Further investigation to uncover these factors would be pertinent from a public-health policy perspective. Certainly, the link between socio-economic status and dietary intake is well-established.[29-33] In that light, it is somewhat intriguing that notable proportions of a more socially advantaged cohort also show indications of inadequate dietary intake and a lack of supplement use. Such findings may flag the existence of additional barriers in Canadian women's lives, not captured by typical socio-economic status indicators. It has been suggested in the folic acid supplement literature, for example, that there may be barriers at the health care provider and public-health policy levels.[24,25] There has been increasing focus on the social determinants of population health and on health promotion as a function of public health;[34-36] both of these frameworks may be useful to understand the determinants of dietary intake and supplement use among Canadian women of childbearing age. Further research and action is warranted to help effectively promote healthy dietary practices across all segments of the Canadian population.

TABLE 4
Self-reported multivitamin supplements and single-nutrient supplements featuring iron, zinc or folate, taken by the full cohort of Prenatal Health Project (PHP) participants (n = 2357 women)

Source	Number of self-reported entries, n		
	Total	Quantified	Missing
Regular multivitamin supplement			
Product specified[a]	37	37	0
Product not specified	137	0	137[b]
Prenatal multivitamin supplement			
Product specified: Centrum Materna	592	592	0
Product specified: other[c]	51	51	0
Product not specified	930	930[d]	0
Iron			
Single-nutrient iron supplement	95	31	64[e]
Iron in a supplement with one other micronutrient	3	2	1[e]
Zinc			
Single-nutrient zinc supplement	2	2	0
Zinc with selected (few) other micronutrients	1	0	1[e]
Folate			
Single-nutrient folic acid supplement	347	315	32
Folic acid in a supplement with a few selected other micronutrients	7	3	4

Note: This table shows the frequencies of self-reporting of types of supplements. To show the full range of products used, the table is based on the core PHP cohort, including those participants who were excluded from the other analyses in this paper. Please note that some women may have been taking multiple types of supplements; as such, there may be multiple entries for a single participant. Similarly, as discussed in the paper and displayed in Table 1, a notable proportion of women did not take any supplements; there are no entries for these participants.

a Specified regular multivitamin brands: Centrum (regular), Centrum Forte, Centrum Protegra, Flintstones (children's multivitamins), Nutrilite Double X, Life Daily One for Women, Life Spectrum, Life Spectrum Forte, One A Day, One A Day – Women's.

b Declared missing because, in contrast to prenatal multivitamins, the nutrient composition of regular adult multivitamins varies substantially and therefore cannot be inferred from other brands.

c Specified prenatal multivitamin brands (apart from Centrum Materna): Equate, Fem, GNC, Jamieson, Life, Natural Factors (MultiStart), Orifer F, PregVit, Rexall, Thorne Research, Truly.

d Assumed to be identical to Materna since nutrient compositions of different prenatal multivitamin products are very similar.

e Declared missing because nutrient composition of single-nutrient dietary supplements (aside from folic acid) varies substantially and therefore cannot be inferred from other brands.

Study strengths and limitations

The FFQ method of assessing dietary intake offers only an estimate of nutrient values, and individual-level adequacy status cannot be determined with certainty.

However, for large survey studies such as this one, it is an acceptable and useful method, and still offers insight relevant for the purposes of public health. As noted in the Methods section, the correlation coefficient for the validation of iron intake is low (0.19). Since the estimate of iron intake from FFQ data was lower than that obtained from the 3-day records in the pilot test, our findings are likely conservative. However, this issue is unlikely to account for the very stark difference in total iron intake between those taking and not taking an iron-containing supplement. In other words, it likely does not alter the conclusion that supplement use is important in achieving the RDA for iron during pregnancy.

As described in the Methods section, we assumed that unspecified prenatal dietary supplements were of the same composition as Centrum Materna. This assumption, however, is reasonable given the similarities between popular prenatal multivitamin products on the market. Additionally, for those who did not specify the amount of their folic acid supplement, we assumed a daily dose of 400 µg of folic acid, though folic acid supplements do come in higher doses. Other studies that measured folic acid supplementation used a similar approach. The difference in mean DFE estimates is quite stark between those taking and those not taking folic acid supplements; as such, potentially underestimating folic acid intake for some participants as a result of this assumption would not alter our conclusions about the importance of supplementing with folic acid to achieve the RDA for folate.

The strengths of this study include the large sample size, the community-based sample, and the comprehensive assessment of both food and supplement sources in estimating dietary intake. Weaknesses of the study are the potential for selection bias and response bias. These are inevitable to some degree, although steps were taken to minimize their occurrence. Response bias was minimized by having trained telephone interviewers guide participants through all components of the questionnaire, including the FFQ. Selection bias was minimized by recruiting from ultrasound clinics in a variety of locations in London, where it is routine practice for pregnant women to get ultrasounds. A potential limitation is the fact that only English-speaking women could be recruited. However, as less than 2% of women in London, Ontario, cannot speak English,[20] the impact is likely negligible. The PHP cohort is of somewhat higher socio-economic status than the general population of the city of London, Ontario,[20] which may indicate selection bias; however, it also allowed for intriguing findings to come to light regarding dietary intake and supplement use in more socially advantaged segments of the population, as discussed above.

Conclusions

While the general importance of prenatal multivitamin supplement use is recognized in clinical practice guidelines,[9] zinc is not highlighted as a specific micronutrient of interest. While folic acid and iron supplementation are formally recommended, the data from this study suggest that, at the population level, dietary adequacy and supplement use may still be a concern. Notable proportions of this cohort showed lower dietary intake levels for all three micronutrients, as well as a lack of supplement use, despite being of a higher socio-economic status overall. Further research is warranted to evaluate both the comprehensiveness and the success of population-level implementation of current supplementation recommendations during pregnancy.

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