Promotion of folate for the prevention of neural tube defects: who benefits?

Carol Bower[a,b], Margaret Miller[a], Jan Payne[a] and Peta Serna[a]

[a]Centre for Child Health Research, The University of WA, Telethon Institute for Child Health Research, and [b]Birth Defects Registry of WA, Women's and Children's Health Service, Perth, WA, Australia

Correspondence:
Clinical Professor C Bower, Telethon Institute for Child Health Research, PO Box 855, West Perth WA 6872, Australia.
E-mail: carolb@ichr.uwa.edu.au

Summary

Since the publication of randomised trials showing firm evidence of prevention of neural tube defects with periconceptional folic acid, there have been population health promotion programmes to encourage women to take folic acid supplements, and the introduction of voluntary fortification of some foods with folic acid in Australia. In order to evaluate these two strategies, we collected data by self-administered questionnaire from a random sample of recently pregnant women in Western Australia between September 1997 and March 2000. Response to health promotion was measured in three ways: (1) knowledge of the association between periconceptional folate and prevention of spina bifida (the 'correct message'); (2) use of periconceptional vitamin supplements of folic acid daily in the periconceptional period; and (3) daily folate intake from fortified foods in the 6 months before pregnancy. We examined the relationship of maternal demographic and behavioural characteristics with these three measures.

Overall, 62.3% of women were aware of the correct message before pregnancy, 28.5% reported taking 200 μg or more of folic acid from supplements daily in the periconceptional period and 56.6% of women obtained 100 μg or more of folic acid from fortified foods. Women who first became aware of the correct message during pregnancy or who were unaware of the correct message before or during pregnancy were more likely than women aware before pregnancy to be younger, having their first pregnancy, be single or in a *de facto* relationship, have no tertiary education, and be a public patient. Similar associations were seen for women taking either no folic acid or <200 μg of folic acid in supplements daily in the periconceptional period. There were no significant associations between these demographic variables and amount of folate obtained from fortified foods. Women who were unaware of the correct message and did not take folic acid supplements were more likely to have smoked, not to have engaged in exercise, and not to have planned their pregnancy, whereas there was no association with these behavioural characteristics and intake of folate from fortified foods.

These results indicate that health promotion strategies have not reached all segments of the target population equally, but there is no such disparity with folate-fortified foods, and they suggest that mandatory fortification of a staple food is likely to reach all women regardless of demographic and behavioural characteristics, and hence provide improved opportunity for prevention of neural tube defects in Australia.

Introduction

Evidence from randomised controlled trials has shown that periconceptional folic acid supplementation reduces the incidence of neural tube defects (NTD) by 72%[1] and observational studies have shown that dietary folate is also protective.[2–6] There have been two main approaches to health promotion aimed at increasing folate intake to reduce the incidence of NTD. The first involves population health promotion programs to encourage women to take folic acid supplements periconceptionally and often also to increase dietary intake of folate rich foods. The second is the fortification of foods with folic acid. The former involves action on the part of individual women, the latter is an environmental strategy, and may involve legislative change.[7] Often, both approaches are used, as has been the case in Australia.

In Western Australia (WA), from 1992 to 1995, we ran a programme promoting folate to prevent NTD. The programme was based on the recommendations of the National Health and Medical Research Council of Australia,[8] and encouraged women of childbearing age to increase their dietary intake of folate and to take supplements of 500 μg folic acid daily for at least 1 month before pregnancy and for the first 3 months of pregnancy. Women with a close family history of NTD were advised to take 5 mg of folic acid daily. Information was distributed widely to health professionals (general practitioners, paediatricians, obstetricians, child health nurses, midwives, pharmacists) and women via posters, pamphlets, seminars, newsletters and the media.[9–11] Increases in knowledge and practice of women and health professionals occurred as a result of the programme.[9–12] Only 8% of women knew about the association between folate and spina bifida before the programme in 1992, while 67% were aware two and half years later. Over the same period, the proportion of women taking periconceptional folic acid supplements increased from 13% to 30%.[11,13] Since 1995, some promotion of periconceptional use of folic acid supplements has continued in WA and other states and some national promotion has been undertaken.[14]

Folate fortification of specified foods was approved for the first time in Australia in 1995 and, since then, there has been a gradual increase in the number of foods fortified. In 1999, over 100 foods were reported to be fortified with folate and available to consumers (mainly breakfast cereals, fruit juice, milk and special diet foods).[14] Since the introduction of these measures in WA, there has been a fall in NTD. The prevalence of NTD (births plus terminations) in WA was around two per 1000 births from 1980 until 1995, and fell by 30% from 1996.[15]

In order to evaluate the reach of the health promotion of folate in WA, we collected data from recently pregnant women in WA between September 1997 and March 2000.

Methods

The data presented here relate to women who had a liveborn baby without birth defects in WA in 1997–2000. These women formed the control group of a larger case-control study, the methods of which have been reported elsewhere,[16,17] but are summarised again here.

A random sample of all liveborn infants in WA was selected using the Midwives' Notification System as a sampling frame. This is a statutory collection of data on all births over 20 weeks gestation in WA.[18] Sampling was conducted every month and based on births in the previous month, using a sampling fraction such that we would have a final sample size of about 700 eligible controls.

Mothers who did not speak English or were Aboriginal were ineligible for inclusion, as interpreters were not available, and the study methods were not culturally appropriate for Aboriginal people.

Data collection

A letter of invitation, with an information sheet about the study, a pregnancy questionnaire and a quantified food-frequency questionnaire, were sent to all eligible mothers 3–4 months after the birth of their child. Participating mothers returned completed questionnaires in the reply paid envelope provided.

Information collected included demographic and behavioural characteristics, knowledge of folate and the prevention of birth defects, use of vitamin supplements and consumption of 169 foods and beverages as well as any of a list of specific branded foods fortified with folic acid. An increasing number of folic acid-fortified foods came onto the market over the study period, and so the list of specific branded foods included in the questionnaire was updated at intervals (M. Lawrence, personal communication; NHMRC Scholar, Deakin University, and Australian and New Zealand Food Authority). Mothers were asked about

use of vitamin supplements taken in the month before and the first 3 months of pregnancy, and the total folic acid intake from supplements for each of the 4 months was obtained by summing over all the preparations a woman took in each of these months.

Follow-up of non-responders was by telephone or by post. A short questionnaire, covering knowledge of folate, and intake of vitamin supplements and fortified foods, and excluding the food frequency questionnaire, was offered to mothers who felt that they did not have time to complete the full questionnaires – 90 women completed only a short questionnaire.

Knowledge of folate and birth defects

Women were asked to choose the statement that came closest to their understanding of the main health message about folate and NTD from a list of six options (the correct option was '*Increased folate (or folic acid) taken by the mother before becoming pregnant and in the first three months of pregnancy helps to prevent birth defects such as spina bifida in her baby*'). They were also asked to note when they first became aware of the correct health message about folate (before, during or since completing their pregnancy). From this we identified whether women were aware of the correct message and, if so, when.

Folate intake from supplements

The amount of folic acid taken as supplements in the month before, and each of the first 3 months of pregnancy was expressed as an average of folic acid in micrograms (μg) per day for each of 4 months. Women consuming an average of 200 μg or more daily of folic acid from supplements in each of the four relevant time periods were considered to be adequately supplemented.[19]

Folate intake from fortified foods

Data on the folic acid content of fortified foods were obtained from the manufacturer. Total folate intake (in μg per day) from fortified food eaten in the 6 months before pregnancy was estimated by summing across all fortified food sources and categorised as none, <100 μg folate daily, and 100 μg or more daily.[16]

Response to health promotion was measured in three ways: (1) knowledge of the correct message; (2) use of periconceptional vitamin supplements containing folic acid; and (3) daily folate intake from fortified foods in the 6 months before pregnancy. We examined the relationship of maternal demographic and behavioural characteristics with these three measures. Demographic characteristics examined were: maternal age, number of previous pregnancies, marital status, maternal country of birth, maternal education, maternal residence at conception, and maternal health insurance status. Health behavioural characteristics were: pregnancy planning, gestational age when the pregnancy was first recognised, counselling about birth defects, periconceptional cigarette and alcohol consumption and exercise in early pregnancy.

Statistical analysis

Statistical comparisons were made using logistic regression in SPSS.[20] Odds ratios and 95% confidence intervals were calculated. The comparisons undertaken were:

1 First knowledge of the correct message during pregnancy, and no knowledge of the correct message before or during pregnancy, each compared with knowledge of the correct message before pregnancy (reference category);
2 Use of periconceptional vitamin supplements containing <200 μg folic acid daily (including no supplement intake of folic acid), compared with periconceptional vitamin supplements containing 200 μg or more of folic acid daily (reference category); and
3 1–100 μg folic acid from fortified foods daily and no folic acid from fortified foods, each compared with >100 μg folic acid from fortified foods daily (reference category).

Not all women answered all questions. Each analysis is based on all the available data for the variables involved.

Results

724 control mothers were eligible and invited to join the study, and 578 agreed (79.8%). Non-responders were significantly more likely to be younger, unmarried, a public patient, to smoke during pregnancy, and have either no previous births or more than two previous births, when compared with responders. There was no difference between responders and non-responders with respect to infant sex or plurality, or maternal place of residence.[16]

Table 1. Comparison of women who were unaware before pregnancy of the association between periconceptional folate intake and prevention of neural tube defects ('correct message') with those who were aware of the correct message before pregnancy, for parental demographic and maternal behavioural characteristics

	First aware of correct message before pregnancy[a]	First aware of correct message during pregnancy[a]	OR [95% CI]	Not aware of correct message before or during pregnancy[a]	OR [95% CI]
Parental demographic characteristics					
Maternal age group (years)					
<25	31 (8.6)	21 (32.8)	3.22 [1.62, 6.40]	42 (27.3)	3.60 [2.04, 6.35]
25–29	133 (36.9)	28 (43.8)	1.00 Reference	50 (32.5)	1.00 Reference
30–34	134 (37.2)	8 (12.5)	0.28 [0.12, 0.64]	44 (28.6)	0.87 [0.54, 1.40]
35+	62 (17.2)	7 (10.9)	0.54 [0.22, 1.29]	18 (11.7)	0.77 [0.42, 1.43]
Number of previous pregnancies					
0	77 (25.5)	31 (55.4)	5.99 [2.71, 13.24]	44 (36.1)	1.70 [1.03, 2.81]
1	91 (30.1)	16 (28.6)	2.62 [1.11, 6.18]	33 (27.0)	1.08 [0.64, 1.82]
2 or more	134 (44.4)	9 (16.1)	1.00 Reference	45 (36.9)	1.00 Reference
Marital status					
Married	271 (89.1)	31 (54.4)	1.00 Reference	72 (58.1)	1.00 Reference
De facto	28 (9.2)	19 (33.3)	5.93 [2.97, 11.84]	39 (31.5)	5.24 [3.02, 9.09]
Single, widowed, divorced or separated	5 (1.6)	7 (12.3)	12.24 [3.66, 40.89]	13 (10.5)	9.79 [3.38, 28.35]
Maternal birth place					
Australia, New Zealand	257 (84.5)	47 (82.5)	1.00 Reference	105 (85.4)	1.00 Reference
UK & Ireland	24 (7.9)	8 (14.0)	1.82 [0.77, 4.30]	10 (8.1)	1.02 [0.47, 2.21]
Other	23 (7.6)	2 (3.5)	0.48 [0.11, 2.08]	8 (6.5)	0.85 [0.37, 1.96]
Maternal education					
Tertiary	160 (52.6)	18 (31.6)	1.00 Reference	33 (26.6)	1.00 Reference
Trade or other qualification	32 (10.5)	8 (14.0)	2.22 [0.89, 5.55]	15 (12.1)	2.27 [1.11, 4.66]
High school only	112 (36.8)	31 (54.4)	2.46 [1.31, 4.61]	76 (61.3)	3.29 [2.05, 5.29]
Residence at conception					
Metropolitan WA	251 (70.7)	42 (66.7)	1.00 Reference	96 (66.2)	1.00 Reference
Rural WA	95 (26.8)	16 (25.4)	1.01 [0.54, 1.87]	43 (29.7)	1.18 [0.77, 1.82]
Interstate or overseas	9 (2.5)	5 (7.9)	3.32 [1.06, 10.39]	6 (4.1)	1.74 [0.80, 5.03]
Health insurance status					
Private	143 (41.8)	17 (27.0)	1.00 Reference	31 (20.9)	1.00 Reference
Public	199 (58.2)	46 (73.0)	1.94 [1.07, 3.53]	117 (79.1)	2.71 [1.73, 4.25]
Maternal health behavioural factors					
Planned pregnancy					
Yes, planned for 2+ months	154 (50.7)	15 (26.3)	1.00 Reference	39 (31.0)	1.00 Reference
Yes, planned for ≤1 month	56 (18.4)	9 (15.8)	1.65 [0.68, 3.98]	17 (13.5)	1.20 [0.63, 2.29]
No, not planned	94 (30.9)	33 (57.9)	3.60 [1.86, 6.99]	70 (55.6)	2.94 [1.84, 4.97]
When first recognised pregnancy (weeks)					
≤4	149 (49.0)	18 (31.6)	1.00 Reference	57 (46.0)	1.00 Reference
5–6	122 (40.1)	29 (50.9)	1.97 [1.04, 3.71]	42 (33.9)	0.90 [0.56, 1.43]
7+	33 (10.9)	10 (17.5)	2.51 [1.06, 5.93]	25 (20.2)	1.98 [1.08, 3.62]
Was counselled about birth defects					
Yes, before pregnancy	65 (21.9)	5 (9.6)	1.00 Reference	16 (13.0)	1.00 Reference
Yes, during pregnancy	80 (26.9)	16 (30.8)	2.60 [0.90, 7.47]	29 (23.6)	1.47 [0.74, 2.94]
No	152 (51.2)	31 (59.6)	2.65 [0.99, 7.12]	78 (63.4)	2.08 [1.13, 3.84]
Smoking in month before pregnancy					
No	233 (76.9)	34 (59.6)	1.00 Reference	71 (57.7)	1.00 Reference
Yes	70 (23.1)	23 (40.4)	2.25 [1.25, 4.07]	52 (42.3)	2.44 [1.56, 3.81]

Table 1. *Continued*

	First aware of correct message before pregnancy[a]	First aware of correct message during pregnancy[a]	OR [95% CI]	Not aware of correct message before or during pregnancy[a]	OR [95% CI]
Smoking in first 3 months of pregnancy					
No	253 (83.0)	40 (70.2)	1.00 Reference	81 (65.9)	1.00 Reference
Yes	52 (17.0)	17 (29.8)	2.07 [1.09, 3.93]	42 (34.1)	2.52 [1.56, 4.07]
Drank alcohol in first 3 months of pregnancy					
No	96 (32.4)	14 (25.0)	1.00 Reference	54 (45.4)	1.00 Reference
Yes	200 (67.6)	42 (75.0)	1.44 [0.75, 2.76]	65 (54.6)	0.58 [0.37, 0.89]
Drank more than usual amount of alcohol on any occasion in first 3 months of pregnancy					
No	193 (65.2)	29 (51.8)	1.00 Reference	88 (73.9)	1.00 Reference
Yes	103 (34.8)	27 (48.2)	1.75 [0.98, 3.10]	31 (26.1)	0.66 [0.41, 1.06]
Vigorous exercise in early pregnancy					
Yes	126 (44.5)	22 (43.1)	1.00 Reference	31 (27.2)	1.00 Reference
No	157 (55.5)	29 (56.9)	1.06 [0.58, 1.93]	83 (72.8)	2.15 [1.34, 3.45]
Less vigorous exercise in early pregnancy					
Yes	181 (66.8)	28 (56.0)	1.00 Reference	52 (45.6)	1.00 Reference
No	90 (33.2)	22 (44.0)	1.58 [0.86, 2.92]	62 (54.4)	2.40 [1.53, 3.75]
Took 200 μg or more of folic acid in supplements periconceptionally					
Yes	144 (40.0)	3 (4.7)	1.00 Reference	18 (11.7)	1.00 Reference
No	216 (60.0)	61 (95.3)	13.54 [4.17, 43.95]	136 (88.3)	5.04 [2.95, 8.60]

[a]In brackets are the column %s.

Overall, 62.3% of women were aware of the correct message of the association between folate and spina bifida before they became pregnant, 11.1% became aware during pregnancy and 26.7% were unaware of the association before or during pregnancy. 28.5% reported taking 200 μg or more of folic acid in supplements periconceptionally, and 56.6% were estimated to be consuming over 100 μg folic acid daily from fortified foods in the 6 months prior to pregnancy.

Demographic characteristics

Compared with women who were aware of the correct message before becoming pregnant, women who were first aware only during pregnancy or who were unaware of the correct message before or during pregnancy were significantly more likely to be <25 years of age, be having their first pregnancy, be single or in a *de facto* relationship, have no tertiary education, and not to have private health insurance (Table 1). Similar associations were seen when women who took either no folic acid supplement or <200 μg folic acid daily periconceptionally were compared with women who took 200 μg or more of folic acid in the recommended period (Table 2). There was no significant association of either of these outcome measures with maternal country of birth or rural WA residence at the time of conception. Women resident interstate or overseas at the time of conception were more likely to be unaware of the correct message before pregnancy, but there was no association with use of folic acid supplements.

In contrast, there was no significant association between maternal age, number of previous pregnancies, maternal place of birth, education or health insurance status and amount of folate obtained from fortified food. Rural women and women who were interstate or overseas at the time of conception were more likely to have obtained little or no folic acid from the fortified foods listed in the questionnaire (Table 3).

Maternal health behavioural characteristics

Women unaware of the correct message before pregnancy and those not taking folic acid supplements were more likely not to have planned their pregnancy, first recognised they were pregnant later, not to have been counselled about birth defects before pregnancy, to be smokers and not to engage in exercise in early pregnancy (Tables 1 and 2). Women unaware of the correct message before or during pregnancy were less

Table 2. Comparison of women who took either no folic acid or <200 μg folic acid daily from supplements in the periconceptional period with those who took ≥200 μg folic acid from supplements daily, for parental demographic and maternal behavioural characteristics

	≥200 μg folic acid daily in supplements[a]	No folic acid or <200 μg folic acid daily in supplements[a]	OR [95% CI]
Parental demographic characteristics			
Maternal age group (years)			
<25	14 (8.5)	80 (19.4)	2.43 [1.28, 4.61]
25–29	63 (38.2)	148 (35.8)	1.00 Reference
30–34	59 (35.8)	127 (30.8)	0.92 [0.60, 1.40]
35+	29 (17.6)	58 (14.0)	0.85 [0.50, 1.45]
Number of previous pregnancies			
0	41 (28.3)	111 (33.1)	1.24 [0.77, 1.99]
1	45 (31.0)	95 (28.4)	0.97 [0.60, 1.55]
2 or more	59 (40.7)	129 (38.5)	1.00 Reference
Marital status			
Married	134 (91.8)	240 (70.8)	1.00 Reference
De facto	11 (7.5)	75 (22.1)	3.81 [1.95, 7.42]
Single, widowed, divorced or separated	1 (0.7)	24 (7.1)	13.34 [1.79, 99.27]
Maternal birth place			
Australia, New Zealand	127 (87.0)	282 (83.4)	1.00 Reference
UK & Ireland	9 (6.2)	33 (9.8)	1.65 [0.77, 3.55]
Other	10 (6.8)	23 (6.8)	1.04 [0.48, 2.24]
Maternal education			
Tertiary	83 (56.8)	128 (37.8)	1.00 Reference
Trade or other qualification	14 (9.6)	41 (12.1)	1.90 [0.98, 3.70]
High school only	49 (33.6)	170 (50.1)	2.25 [1.48, 3.43]
Residence at conception			
Metropolitan WA	117 (70.9)	272 (68.3)	1.00 Reference
Rural WA	41 (24.8)	113 (28.4)	1.19 [0.78, 1.80]
Interstate or overseas	7 (4.2)	13 (3.3)	0.80 [0.31, 2.05]
Health insurance status			
Private	76 (49.0)	115 (28.9)	1.00 Reference
Public	79 (51.0)	283 (71.1)	2.37 [1.62, 3.47]
Maternal health behavioural factors			
Planned pregnancy			
Yes, planned for 2+ months	87 (60.0)	121 (35.4)	1.00 Reference
Yes, planned for ≤1 month	31 (21.4)	51 (14.9)	1.18 [0.70, 2.00]
No, not planned	27 (18.6)	170 (49.7)	4.52 [2.77, 7.39]
When first recognised pregnancy (weeks)			
≤4	73 (50.3)	151 (44.4)	1.00 Reference
5–6	60 (41.4)	133 (39.1)	1.07 [0.71, 1.62]
7+	12 (8.3)	56 (16.5)	2.26 [1.14, 4.47]
Was counselled about birth defects			
Yes, before pregnancy	40 (28.4)	46 (13.9)	1.00 Reference
Yes, during pregnancy	32 (22.7)	93 (28.1)	2.53 [1.41, 4.53]
No	69 (48.9)	192 (58.0)	2.42 [1.46, 4.01]
Smoking in month before pregnancy			
No	111 (76.0)	227 (67.4)	1.00 Reference
Yes	35 (24.0)	110 (32.6)	1.54 [0.99, 2.39]
Smoking in first 3 months of pregnancy			
No	119 (81.5)	255 (75.2)	1.00 Reference
Yes	27 (18.5)	84 (24.8)	1.45 [0.89, 2.36]

Table 2. *Continued*

	≥200 μg folic acid daily in supplements[a]	No folic acid or <200 μg folic acid daily in supplements[a]	OR [95% CI]
Drank alcohol in first 3 months of pregnancy			
No	52 (36.6)	112 (34.0)	1.00 Reference
Yes	90 (63.4)	217 (66.0)	1.12 [0.74, 1.67]
Drank more than usual amount of alcohol on any occasion in first 3 months of pregnancy			
No	104 (73.2)	206 (62.6)	1.00 Reference
Yes	38 (26.8)	123 (37.4)	1.63 [1.06, 2.52]
Vigorous exercise in early pregnancy			
Yes	63 (45.7)	116 (37.4)	1.00 Reference
No	75 (54.3)	194 (62.6)	1.41 [0.94, 2.11]
Less vigorous exercise in early pregnancy			
Yes	91 (68.4)	170 (56.3)	1.00 Reference
No	42 (31.6)	132 (43.7)	1.68 [1.09, 2.59]

[a]In brackets are the column %s.

likely to have consumed alcohol in early pregnancy. Women who were first aware only during pregnancy were more likely to have consumed alcohol early in pregnancy (Table 1), and there was a significant increase in odds in relation to one or more occasions of alcohol excess for women not taking folic acid supplements (Table 2).

Women who were unaware of the correct message or only became aware during pregnancy were significantly more likely not to take supplements containing 200 μg or more of folic acid, when compared with women who were aware before pregnancy (Table 1).

There was a significant reduction in odds for alcohol excess for women who consumed no folate-fortified foods (Table 3). There were no significant associations between any other behavioural factors and the intake of fortified foods.

Discussion

The relatively high rate of knowledge (over 60%) of the association between folate and neural tube defects found in this study concurs with that seen in other Australian studies.[11,21] The proportion of women taking periconceptional folic acid supplements (28.5%) falls within the range found in other studies in Australia[21,22] and elsewhere,[23] supporting the belief that, even with extensive health promotion activities, folic acid supplementation alone is unlikely to achieve maximal levels of prevention of neural tube defects.[23] We found that better educated, older and married women, women with private health insurance cover and women who engaged in other health-promoting behaviours (not smoking, taking exercise, planning pregnancy) were more likely to know about the preventive effect of folate and to have taken periconceptional folic acid supplementation. Others have found similar associations with maternal age, education, marital status, health insurance status, smoking, and pregnancy planning.[23] Of concern, the health promotion messages and strategies used to promote folate to date have failed to have as much impact on the less well-educated, lower socio-economic status members of our population, and yet, there is a well-documented socio-economic gradient for NTD.[24]

Importantly and in contrast, we have shown that there are no such gradients for the intake of foods voluntarily fortified with folic acid. This is in spite of voluntary fortification being limited mainly to breakfast cereals in Australia.[14] We are unaware of studies from other places with voluntary fortification (for example the UK) that have investigated this issue. This finding underlines the value of fortification in reaching all women in the target group, and the potential for a greater level of prevention with mandatory fortification. The Australia and New Zealand Food Regulation Ministerial Council agreed, in May 2004, that mandatory fortification with folate should be considered as a priority for Australia and New Zealand.[25]

The increased odds of low amounts of folate from fortified sources for women not resident in WA at the time of conception is probably because the fortified foods listed on the questionnaire were those available in WA and were not relevant to them. Although not

Table 3. Comparison of women who consumed 1–100 μg of folic acid daily or no folic acid daily from fortified food with those who consumed >100 μg folic acid daily from fortified food, for parental demographic and maternal behavioural characteristics

	>100 μg folate daily from fortified food[a]	1–100 μg folate daily from fortified food[a]	OR [95% CI]	No daily folate from fortified foods[a]	OR [95% CI]
Parental demographic characteristics					
Maternal age group (years)					
<25	54 (16.6)	29 (15.1)	0.98 [0.57, 1.68]	11 (19.0)	1.49 [0.65, 3.38]
25–29	124 (38.0)	68 (35.4)	1.00 Reference	17 (29.3)	1.00 Reference
30–34	100 (30.7)	68 (35.4)	1.24 [0.81, 1.90]	18 (31.0)	1.31 [0.64, 2.68]
35+	48 (14.7)	27 (14.1)	1.03 [0.59, 1.79]	12 (20.7)	1.82 [0.81, 4.10]
Number of previous pregnancies					
0	90 (33.8)	48 (28.7)	0.86 [0.54, 1.37]	13 (28.9)	0.96 [0.44, 2.10]
1	70 (26.3)	53 (31.7)	1.22 [0.76, 1.95]	16 (35.6)	1.51 [0.71, 3.23]
2 or more	106 (39.8)	66 (39.5)	1.00 Reference	16 (35.6)	1.00 Reference
Marital status					
Married	211 (79.3)	127 (74.7)	1.00 Reference	35 (74.5)	1.00 Reference
De facto	39 (14.7)	36 (21.2)	1.53 [0.93, 2.54]	10 (21.3)	1.55 [0.71, 3.38]
Single, widowed, divorced or separated	16 (6.0)	7 (4.1)	0.73 [0.29, 1.12]	2 (4.3)	0.75 [0.17, 3.42]
Maternal birth place					
Australia, New Zealand	226 (85.0)	143 (84.1)	1.00 Reference	39 (84.8)	1.00 Reference
UK & Ireland	23 (8.6)	15 (8.8)	1.03 [0.52, 2.04]	3 (6.5)	0.76 [0.22, 2.64]
Other	17 (6.4)	12 (7.1)	1.12 [0.52, 2.41]	4 (8.7)	1.36 [0.44, 4.27]
Maternal education					
Tertiary	119 (44.7)	68 (40.0)	1.00 Reference	23 (48.9)	1.00 Reference
Trade or other qualification	32 (12.0)	17 (10.0)	0.93 [0.48, 1.80]	6 (12.8)	0.97 [0.36, 2.58]
High school only	115 (43.2)	85 (50.0)	1.29 [0.86, 1.95]	18 (38.3)	0.81 [0.41, 1.58]
Residence at conception					
Metropolitan WA	232 (73.0)	121 (64.4)	1.00 Reference	34 (61.8)	1.00 Reference
Rural WA	79 (24.8)	59 (31.4)	1.43 [0.96, 2.14]	16 (29.1)	1.38 [0.72, 2.64]
Interstate or overseas	7 (2.2)	8 (4.3)	2.19 [0.78, 6.19]	5 (9.1)	4.87 [1.46, 16.23]
Health insurance status					
Private	110 (35.4)	65 (35.1)	1.00 Reference	15 (27.3)	1.00 Reference
Public	201 (64.6)	120 (64.9)	1.01 [0.69, 1.48]	40 (72.7)	1.46 [0.77, 2.76)]
Maternal health behavioural factors					
Planned pregnancy					
Yes, planned for 2+ months	110 (41.2)	77 (45.0)	1.00 Reference	20 (42.6)	1.00 Reference
Yes, planned for ≤1 month	45 (16.9)	29 (17.0)	0.92 [0.53, 1.60]	8 (17.0)	0.98 [0.40, 2.38]
No, not planned	112 (41.9)	65 (38.0)	0.83 [0.54, 1.27]	19 (40.4)	0.93 [0.47, 1.84]
When first recognised pregnancy (weeks)					
≤4	122 (45.5)	79 (47.0)	1.00 Reference	22 (46.8)	1.00 Reference
5–6	107 (39.9)	66 (39.3)	0.95 [0.63, 1.45]	19 (40.4)	0.99 [0.51, 1.92]
7+	39 (14.6)	23 (13.7)	0.91 [0.51, 1.64]	6 (12.8)	0.85 [0.32, 2.26]
Was counselled about birth defects					
Yes, before pregnancy	49 (18.9)	25 (14.9)	1.00 Reference	11 (25.6)	1.00 Reference
Yes, during pregnancy	72 (27.8)	39 (23.2)	1.06 [0.57, 1.97]	14 (32.6)	0.86 [0.36, 2.07]
No	138 (53.3)	104 (61.9)	1.48 [0.86, 2.55]	18 (41.9)	0.58 [0.26, 1.32]
Smoking in month before pregnancy					
No	190 (71.7)	113 (66.9)	1.00 Reference	35 (74.5)	1.00 Reference
Yes	75 (28.3)	56 (33.1)	1.25 [0.83, 1.90]	12 (25.5)	0.87 [0.43, 1.76]
Smoking in first 3 months of pregnancy					
No	209 (78.6)	128 (75.3)	1.00 Reference	36 (76.6)	1.00 Reference
Yes	57 (21.4)	42 (24.7)	1.20 [0.76, 1.90]	11 (23.4)	1.12 [0.54, 2.34]

Table 3. *Continued*

	>100 μg folate daily from fortified food[a]	1–100 μg folate daily from fortified food[a]	OR [95% CI]	No daily folate from fortified foods[a]	OR [95% CI]
Drank alcohol in first 3 months of pregnancy					
No	95 (37.1)	55 (32.9)	1.00 Reference	13 (28.3)	1.00 Reference
Yes	161 (62.9)	112 (67.1)	1.2 [0.80, .81]	33 (71.7)	1.50 [0.75, 2.99]
Drank more than usual amount of alcohol on any occasion in first 3 months of pregnancy					
No	166 (64.8)	105 (62.9)	1.00 Reference	38 (82.6)	1.00 Reference
Yes	90 (35.2)	62 (37.1)	1.09 [0.73, 1.63]	8 (17.4)	0.39 [0.17, 0.88]
Vigorous exercise in early pregnancy					
Yes	98 (40.3)	66 (41.0)	1.00 Reference	14 (33.3)	1.00 Reference
No	145 (59.7)	95 (59.0)	0.97 [0.65, 1.46]	28 (66.7)	1.35 [0.68, 2.70]
Less vigorous exercise in early pregnancy					
Yes	181 (66.8)	97 (64.7)	1.00 Reference	20 (44.4)	1.00 Reference
No	90 (33.2)	53 (35.3)	0.82 [0.54, 1.26]	25 (55.6)	1.88 [0.99, 3.58]
Took 200 μg or more of folic acid in supplements periconceptionally					
Yes	98 (30.1)	49 (25.5)	1.00 Reference	17 (29.3)	1.00 Reference
No	228 (69.9)	143 (74.5)	1.25 [0.84, 1.87]	41 (70.7)	1.04 [0.56, 1.91]

[a]In brackets are the column %s.

significant, there was also an increased odds for women in rural areas, which may relate to reduced availability of, or less reliance on, manufactured foods generally.

The reason for the inconsistent findings in relation to alcohol is not obvious, but may relate to differential reporting of alcohol consumption.

There are limitations in this study. Although there was high participation in the study (79%), non-responders were more likely to be young, unmarried, not to have private health insurance, to smoke during pregnancy, and have either had no previous births or more than two previous births. With the exception of women with two or more previous births, all these characteristics were associated with a greater risk of not knowing the correct message and not taking periconceptional folic acid supplements. Also, Aboriginal mothers were excluded from this study. However, Aboriginal infants are known to be at higher risk of neural tube defects, with no change in rates over time compared with non-Aboriginal infants.[26] Thus, the proportion of the population unaware of the correct message and not taking supplements is likely to be greater than this study indicates.

This study has shown that efforts to increase folate intake through health promotion strategies aimed at changing individual behaviour did not reach all women equally, whereas the structural health promotion strategy of folate-fortified foods did not have the same unequal distribution in the target group. However, folate fortification in Australia is currently voluntary, and hence only about half the women (56.6%) were getting over 100 μg daily from fortified foods. Mandatory fortification of a staple food is likely to reach all women regardless of demographic characteristics and health-related behaviours.

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