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Many women undergoing fertility treatment make poor lifestyle choices that may affect treatment outcome

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STUDY QUESTION: What are the lifestyle choices and dietary aspects of women about to undergo fertility treatment in New Zealand?

SUMMARY ANSWER: A considerable proportion of women about to undergo fertility treatment make poor lifestyle choices, including the consumption of alcohol and caffeine.

WHAT IS KNOWN ALREADY: Women undergoing fertility treatment are highly motivated to achieve pregnancy, but there are relatively few published data on their lifestyle, lifestyle changes or dietary aspects.

STUDY DESIGN, SIZE, DURATION: This was a cross-sectional study of 250 women aged 20–43 years, taking place between March 2010 and August 2011.

PARTICIPANTS/MATERIALS, SETTING, METHODS: Women about to undergo IVF or ICSI treatment in two large fertility clinics in Auckland and Hamilton, New Zealand. Lifestyle and dietary intake questionnaires were individually administered once to each participant 35 days (SD = 22) prior to fertility treatment initiation. Outcome measures included incidence of smoking, consumption of alcohol and caffeinated beverages, BMI, detailed intake of dietary supplements and fertility treatment success. Consumption of certain nutrient supplements was compared with the general female New Zealand population.

MAIN RESULTS AND THE ROLE OF CHANCE: There were high rates of alcohol (50.8%) and caffeine (86.8%) consumption. Most women (82.8%) reported at least one lifestyle change in preparation for fertility treatment, but less than half of women who consumed alcohol regularly reduced their intake and 60% did not change consumption of caffeinated beverages. Similarly, the majority of women did not change their exercise levels (64.4%) or BMI (83.6%) ahead of fertility treatment. Coffee intake appeared unrelated to treatment outcome, but women who consumed caffeinated herbal tea (36.4% of the study population consumed green tea) had lower odds of becoming pregnant (odds ratio, OR 0.52; $P = 0.041$ versus those not consuming caffeinated herbal tea). Women who abstained from drinking or reduced alcohol intake had twice the odds of becoming pregnant than those who maintained their drinking habits prior to fertility treatment (OR 2.27; $P = 0.049$). While 93.2% of women took a folic acid supplement, 16.8% had an inadequate intake compared with the current New Zealand prenatal recommendation of 800 mcg/day. Women who held a university degree or higher qualification had twice the odds of becoming pregnant as women with lower levels of education (OR 2.08; $P = 0.017$), though this finding appeared to be unrelated to lifestyle or dietary habits.

LIMITATIONS, REASONS FOR CAUTION: The study involved self-reported behaviours that might have been misrepresented by respondents. In addition, our questionnaires covered the period following the first clinical assessment but ~5 weeks prior to fertility treatment initiation, so that we cannot ascertain whether dietary intakes and lifestyle choices persisted over the course of treatment itself.

WIDER IMPLICATIONS OF THE FINDINGS: Many women about to undergo fertility treatment make poor lifestyle choices that may negatively affect their chances of becoming pregnant. These findings may be more widely applicable to other women attempting to become pregnant. Specific advice for women regarding healthy lifestyle choices while undergoing fertility treatment is warranted.

STUDY FUNDING/COMPETING INTEREST(S): A.A.G. received financial support from Abbott Nutrition Research & Development Asia-Pacific Center; J.C.P. is a shareholder of Fertility Associates; the other authors have no financial or non-financial conflicts of interest to disclose.

Key words: fertility treatment / alcohol / caffeine / pregnancy / nutritional supplements

Introduction

Poor nutrition and lifestyle choices hold implications for general health, as well as potential effects on fertility. Importantly, most lifestyle and nutritional choices are modifiable behaviours. There is strong evidence that lifestyle has an effect on fertility, for both males and females (Homan *et al.*, 2007). Older female age (Lim and Tsakok, 1997; Nasseri and Grifo, 1998; Larsen and Yan, 2000; Baird *et al.*, 2005), smoking (Baird and Wilcox, 1985; Feichtinger *et al.*, 1997; Augood *et al.*, 1998; Hull *et al.*, 2000; Hassan and Killick, 2004; Waylen *et al.*, 2009), excessive body weight (Wang *et al.*, 2000; Nichols *et al.*, 2003; Hassan and Killick, 2004; Anderson *et al.*, 2010) and heavy alcohol use (Olsen *et al.*, 1997; Anderson *et al.*, 2010) have a detrimental effect on fertility and on the outcomes of fertility treatment. It is thought that light-to-moderate alcohol use, caffeine consumption, exercise, stress and pollutants may also negatively impact on fertility, but the evidence is currently inconclusive (Homan *et al.*, 2007).

Obesity reduces fecundity in both males and females (Hassan and Killick, 2004; Lim *et al.*, 2007). In males, overweight and obesity are associated with reduced ejaculate volume, sperm concentration and total sperm count (Eisenberg *et al.*, 2014). Among women, high BMI increases the risk of infertility, lengthens time taken to conceive and raises the risk of miscarriage and pregnancy complications (Norman *et al.*, 2008). Fertility treatment appears less successful in overweight and obese women, with decreased rates of pregnancy and live birth (Wang *et al.*, 2000; Nichols *et al.*, 2003; Fedorcsák *et al.*, 2004; Maheshwari *et al.*, 2007; Anderson *et al.*, 2010); however, these findings are not always consistent (Lashen *et al.*, 1999; Wittemer *et al.*, 2000). Underweight women (BMI < 20 kg/m^2) have similarly been shown to have decreased fecundability and pregnancy rates (Zaadstra *et al.*, 1993; Wang *et al.*, 2000; Nichols *et al.*, 2003), as well as increased risks of premature birth, low birthweight and intrauterine growth retardation (Neggers and Goldenberg, 2003).

Smoking significantly reduces the chances of success from assisted reproductive technologies, including IVF. A meta-analysis of 21 studies concluded that there are lower odds of live birth and clinical pregnancy per cycle, as well as increased odds of miscarriage and ectopic pregnancy in smokers (Waylen *et al.*, 2009). Smoking also increases both maternal and foetal health risks, such as the risk of miscarriage, premature labour, foetal growth restriction, low birthweight and sudden infant death syndrome (DiFranza and Lew, 1995; Castles *et al.*, 1999; Cnattingius, 2004; Anderson *et al.*, 2010).

A heavy alcohol intake decreases fertility in males and females, with more than eight alcoholic drinks per week linked with decreased fecundity in a large European-based multicentre study (Olsen *et al.*, 1997; Anderson *et al.*, 2010). Alcohol consumption during pregnancy also negatively affects maternal and foetal health and can have lifelong consequences for offspring in the form of foetal alcohol syndrome and foetal alcohol spectrum disorders (Windham *et al.*, 1992, 1995; Parazzini *et al.*, 2003; Mukherjee *et al.*, 2005).

The dietary intake of women during the periconceptional period can also have profound and lasting effects on the health of their children. Under-nutrition and over-nutrition around the time of conception have both been shown to increase the risk of obesity, cardiovascular and metabolic disorders in the offspring (Gluckman *et al.*, 2008; McMillen *et al.*, 2008). Folic acid supplementation of 400 mcg/day prior to and during the first trimester of pregnancy has been shown to reduce neural tube defects by up to 70% (Wald *et al.*, 1991; Rush, 1994). Despite this, rates of folic acid use by women planning a pregnancy or pregnant women are often low (Wild *et al.*, 1997; Rogers and Emmett, 1998; Forster *et al.*, 2009; Inskip *et al.*, 2009; Pinto *et al.*, 2009).

Animal studies have shown that maternal caffeine consumption has a range of long-term adverse effects in the offspring, including impaired glucose homeostasis (Sun *et al.*, 2014), neuromotor development (Souza *et al.*, 2015) and reproductive organ development (Dorostghoal *et al.*, 2012). In humans, epidemiological studies have shown that increased caffeine consumption during pregnancy is associated with impaired foetal growth (Klebanoff *et al.*, 2002; Bakker *et al.*, 2010). Further, a recent prospective study showed that *in utero* exposure to caffeine was associated with increased risk of childhood obesity (Li *et al.*, 2015).

Regular moderate exercise in pregnancy confers the same maternal benefits as for non-pregnant women (Artal and O'Toole, 2003), which may include weight control and improvement of cardiovascular and metabolic risk factors. There may also be a combined effect of poor lifestyle choices on fertility and neonatal health, where health risks are greater in the presence of several factors compared with the sum of the individual risk increases (ESHRE Task Force on Ethics and Law *et al.*, 2010).

Women undergoing fertility treatment are an ideal study cohort when researching the dietary intake and lifestyle habits of women planning a pregnancy. These women are undergoing frequent intensive medical intervention, and their motivation to achieve pregnancy is very high. However, there are relatively few published data on the lifestyle, lifestyle changes or dietary intake of women undergoing fertility treatment.

A prospective study of 118 women undergoing IVF treatment showed that despite lifestyle changes being advocated by clinic medical staff, many women still made poor lifestyle choices (Domar *et al.*, 2012). During their IVF cycle, 49% of the women consumed alcohol, 77% drank caffeinated beverages and 2% smoked (Domar *et al.*, 2012). Similarly, a 2010 study of 436 women undergoing their first ICSI cycle found that 32% of women had more than one coffee daily, 18% had at least one caffeinated soft drink per day and that alcohol was consumed more than five times per week by 5% of study participants (Ferreira *et al.*, 2010). A prospective controlled study of pregnant women from an ICSI cycle found that only 38% of subjects had taken folic acid prior to pregnancy and only 62% took iodine supplements at any stage during their pregnancy (Ludwig *et al.*, 2006).

While there is evidence to show that lifestyle factors have a detrimental effect on fertility, there are limited data examining the effects of lifestyle changes on fertility treatment outcome (Rooney and Domar, 2014). In this study, we aimed to evaluate the lifestyle choices and dietary aspects of women about to undergo fertility treatment in New Zealand. We hypothesized that women undergoing fertility treatment would be already following a healthy lifestyle in preparation for a planned pregnancy. We also hypothesized that these women would follow clinic recommendations and would be interested in making further lifestyle improvements prior to treatment.

Materials and Methods

Ethics approval was granted by the Northern Y Health and Disability Regional Ethics Committee. Written informed consent was obtained from all women participating in the study.

Recruited participants were women about to undergo IVF or ICSI treatment at Fertility Associates clinics in Auckland and Hamilton (New Zealand), between March 2010 and August 2011. Exclusion criteria were use of donor eggs, having a medically confirmed gastrointestinal or malabsorption disease, or taking non-IVF medication known to affect appetite and diet. In addition, to be eligible to participate in the study, women must not have commenced their fertility treatment cycle and needed to reside within 300 km of Auckland. The latter restriction was necessary so that the recruiter could travel to the participant and perform a lifestyle questionnaire on dietary and lifestyle habits face-to-face.

All women registered for fertility treatment underwent clinical assessments some weeks prior to treatment initiation. At the first medical consultation, all women were given verbal advice and comprehensive written information on how to optimize their lifestyle well before their fertility treatment. This advice included: (i) not to smoke, (ii) to reduce caffeine intake from tea, coffee and cola, (iii) that no alcohol should be drunk from the time of embryo transfer and (iv) that being overweight can reduce the response to fertility medication, and modest weight loss and some exercise can be beneficial.

For this study, women were interviewed following their initial clinic visit, prior to commencement of the first stage of fertility treatment (i.e. ovarian stimulation). The lifestyle questionnaires were individually administered once to each participant at a location of her choice. The questionnaire was based on the New Zealand Health Survey 2006/7 (Ministry of Health, 2008), with adaptations specific to this cohort and additional questions on specific dietary practices. The questionnaire comprised 13 main questions, which gathered information on modifiable lifestyle choices being made in the period immediately prior to beginning fertility treatment. The purpose of the questionnaire was to identify and quantify smoking and alcohol habits, caffeine intake, living situation, education level, medication and nutritional supplement use, and any dietary or lifestyle changes the women had made in anticipation of IVF treatment. Frequency and quantity of smoking, alcohol, caffeine, medications and nutritional supplements consumption was recorded. Women were asked whether they had made any lifestyle changes over the previous 3 months in anticipation of their upcoming fertility treatment cycle. The timing of any dietary or lifestyle changes made was also recorded. This was later used to determine when these changes were made prior to the treatment cycle starting (number of weeks prior to cycle). Closed questions were coded for yes or no, whereas responses to open-ended questions were grouped where possible.

Data on age, height, weight and ethnicity are routinely collected by Fertility Associates, so were gathered from patient's medical files. Each woman's body weight was taken from the day of egg collection, though if treatment had stopped prior to egg collection, the most recent weight prior to the cycle was recorded instead. BMI was calculated, and the prevalence of overweight (BMI 25–29.99 kg/m^2) and obesity (BMI $\geq$ 30 kg/m^2) was calculated. The outcome of each woman's fertility treatment cycle was recorded; pregnancy was defined as a sac at the 7-week scan (with or without foetal heartbeat) or ongoing pregnancy.

Demographic characteristics of the study cohort were compared with the remainder of the female population undergoing fertility treatment at Fertility Associates' Auckland and Hamilton clinics over the same period, using one-way analysis of variance or the non-parametric Kruskal–Wallis test. Information on certain nutrient supplementation as reported by the study cohort was compared with the general female New Zealand population (University of Otago and Ministry of Health, 2011) using Fisher's exact tests.

Exploratory analyses were carried out using binary logistic regressions to assess the effects of lifestyle changes and dietary habits on the likelihood of women becoming pregnant. These were analyses for which the study was not originally designed or powered to address, but which provide valuable and interesting information. Regression models included as factors age, BMI, fertility treatment type (IVF or ICSI) and ethnicity. Data are provided as odds ratios (ORs) and associated 95% confidence intervals (CIs). Statistical analyses were carried out in Minitab (v.16, Pennsylvania State University, State College, PA, USA). All statistical tests were two-sided and a 5% significance level maintained throughout the analyses.

Results

Study population

There were 421 women undergoing fertility treatment (IVF or ICSI) at the Hamilton and Auckland clinics over the study period who met the inclusion criteria and were invited to participate; 164 declined so that 257 women were interviewed. Subsequently, data from seven women who did not start fertility treatment were excluded.

The studied cohort was demographically similar to the remainder of Fertility Associates clinics' population (Table I). The two groups had similar causes of infertility, except that a lower proportion of interviewed women had endometriosis as an underlying cause ($P = 0.010$; Table I). Our cohort consisted of well-educated women (with 60.3% holding a university degree or higher qualification). 4.4% of the study sample had a history of a previous eating disorder.

Interviews for this study were carried out 35 days (SD = 22) from fertility treatment initiation (median 32 days). However, 6 of the 250 women were interviewed >90 days prior to treatment.

Table I Characteristics of women recruited versus reference population.

	Study group	Reference population[a]	*P*-value[b]
N	250	1327	
Age (years)[c]	35.2 ± 0.3	36.0 ± 0.1	0.002
BMI (kg/m^2)[c]	24.8 ± 0.2	24.5 ± 0.1	0.13
Overweight	30.7%	26.9%	0.22
Obese	12.0%	13.6%	0.48
Ethnicity			0.91
European	81.6%	82.6%	
Maori and Pacific Islander	6.0%	4.9%	
Asian and Indian	10.0%	11.2%	
Previous pregnancy beyond 20 weeks	26.0%	27.5%	0.73
Cause of infertility			
Male factor	50.0%	46.5%	0.48
Endometriosis	16.4%	24.4%	0.010
Ovulation	10.9%	11.4%	0.87
Other female factors	36.5%	30.3%	0.14
Unexplained	14.6%	11.0%	0.19

Overweight: BMI = 25–29.9 kg/m^2; obese: BMI $\geq$ 30 kg/m^2.
[a]All patients undergoing fertility treatment at Fertility Associates clinics in Auckland and Hamilton, New Zealand, over the duration of the study.
[b]Data were compared between groups using one-way analysis of variance or Fisher's exact tests.
[c]Data are mean ± SEM.

Lifestyle and lifestyle changes

Most women (82.8%) stated that they had made at least one lifestyle change in preparation for their fertility treatment. These changes consisted mostly of eliminating or reducing alcohol and/or caffeinated beverage consumption (Table II).

Only a small minority of studied women smoked (2%; Table II). Half of the women (50.8%) drank alcohol regularly prior to fertility treatment, with 4.4% reporting binge drinking (defined as consuming more than four alcohol drinks in a single session) (Table III). Among women who consumed alcohol, less than half either reduced their intake (20.4%) or abstained (24.8%) for treatment (Table II). One participant reported the consumption of as many as 18.5 standard drinks per week.

The majority of women (86.8%) consumed caffeinated beverages before fertility treatment (Table II), with 36.4% of women drinking caffeinated herbal tea (regular green tea). Less than half reduced (21.6%) or abstained (18.0%) for treatment, so that 60.4% of women did not change their consumption of caffeinated beverages prior to fertility treatment (Table II).

Similarly, the majority of women did not make any lifestyle changes aimed at reducing BMI or exercise levels (83.6 and 64.4%, respectively) (Table II). No women reported increasing tobacco, alcohol or caffeinated beverage consumption (Table II). There were no associations between lifestyle changes and ethnic group or level of education (data not shown).

Use of medications, dietary supplements and alternative medicine

Approximately 25% of the study cohort took additional medications unrelated to fertility treatment, mainly asthma inhalers, antihistamines, metformin and thyroid medication. Almost all women were taking some form of dietary supplement (94.0%; Table III), which is considerably more than the percentage of women aged 31–50 years taking supplements in the general New Zealand population (University of Otago and Ministry of Health, 2011) (34.7%; $P < 0.0001$). The majority of participants were taking some form of folic acid (93.2%), although 16.8% were taking either no folic acid or an inadequate amount (Table III).

Overall, 52.0% of the study group used at least one nutritional supplement other than folic acid; the most common additional supplements were fish oil, vitamin C and iron, with nearly 12.0% of women also reporting the intake of botanical/herbal supplements (Table III).

Women about to undergo fertility treatment consumed more bee products (such as propolis and royal jelly) (3.2 versus 0.5%; $P = 0.003$), similar amounts of oil supplements (19.2 versus 17.9%; $P = 0.71$), but considerably less botanical/herbal products (12.0 versus 27.3%; $P < 0.0001$) than women in the general New Zealand population (University of Otago and Ministry of Health, 2011). Alternative therapists were seen by 36.8% of women in the 3 months prior to the recruitment interview, most commonly acupuncturists and naturopaths.

Treatment outcome

Exploratory analyses suggested that women who consumed caffeinated herbal tea had half the odds of becoming pregnant than women who did not consume it (OR: 0.52, 95% CI (0.28–0.97); $P = 0.041$). However, there was no significant association between coffee intake and treatment outcome. Among lifestyle changes, women who abstained from drinking or reduced alcohol intake had twice the odds of becoming pregnant than those who maintained their drinking habits prior to fertility treatment (OR: 2.27, 95% CI (1.01–5.15); $P = 0.049$). In addition, women who held a university degree or higher qualification had twice the odds of becoming pregnant as women with lower levels of education (OR 2.08, 95% CI (1.14–3.80); $P = 0.017$). There were no observed associations with other dietary and lifestyle habitats, including folic acid intake or smoking.

Discussion

This study shows that many women about to undergo fertility treatment make poor lifestyle choices. A large proportion of women did not follow current lifestyle recommendations for women planning a pregnancy and undergoing fertility treatment. This was particularly the case regarding alcohol and caffeine consumption, with the intake of alcohol and caffeinated herbal tea having a negative effect on fertility treatment outcome in our cohort. Although most women did make at least one lifestyle change in anticipation of fertility treatment, changes were generally insufficient to bring the women's behaviour in line with current recommendations. These findings are in agreement with a recent review that concluded that patients do not appear to follow recommendations for lifestyle behaviour modifications during fertility treatment (Rooney and Domar, 2014).

Surprisingly, ~1 month before commencing fertility treatment, half of our study group was still drinking alcohol. However, this issue is not unique to our cohort, and the use of alcohol by women undergoing IVF treatment was also high in another population (73% drinking alcohol in the month prior to IVF treatment, dropping to 49% during their cycle) (Domar *et al.*, 2012). Alcohol has a detrimental effect on

Table II Reported active changes in lifestyle among studied women ($n = 250$) about to undergo fertility treatment.

	Behaviour at the time of the interview		Behavioural change due to upcoming fertility treatment			
	Yes	No	Abstained	Reduced	Increased	No change
Smoking	2.0%	98.0%	2.8%	0.4%	0%	96.8%
Alcohol	50.8%	49.2%	24.8%	20.4%	0%	54.8%
Caffeinated beverages	86.8%	13.2%	18.0%	21.6%	0%	60.4%
BMI	–	–	–	13.2%	3.2%	83.6%
Exercise levels	–	–	0%	7.2%	28.4%	64.4%

Table III Lifestyle and dietary supplementation among recruited women about to undergo fertility treatment ($n = 250$).

Smoking	2.0%
Alcohol	
Any intake	50.8%
Binge drinkers	4.4%
Caffeinated beverages	86.8%
Any supplement	94.0%
Folic acid supplement	
Any intake	93.2%
Adequate intake (≥800 mcg/day)	83.2%
Folic acid-only	47.6%
Folic acid in combined prenatal supplement	54.0%
Any supplement besides folic acid	52.0%
Multivitamin and multi-mineral	23.6%
Fish oil/prenatal fish oil	14.4%
Vitamin C supplement (single vitamin)	13.2%
Botanical/herbal supplement (including spirulina)	12.0%
Iron ± vitamin C	6.8%
Iodine (as single mineral supplement)	4.4%

Multivitamin and multi-mineral supplements include those specific for pregnancy, as well as supplements consisting of a mix of specific vitamins and minerals.

female fertility (Hakim *et al.*, 1998; Jensen *et al.*, 1998; Klonoff-Cohen *et al.*, 2003; Homan *et al.*, 2007). Importantly, we showed that women who reduced alcohol consumption or abstained from it prior to treatment had greater odds of becoming pregnant. This finding is in accordance with previous evidence showing that a moderate-to-heavy alcohol intake decreases fertility, increases the time taken to conceive, increases the risk of miscarriage and negatively impacts on the success of IVF treatment (Hakim *et al.*, 1998; Jensen *et al.*, 1998; Klonoff-Cohen *et al.*, 2003; Homan *et al.*, 2007). Consumption of seven or more standard drinks per week during pregnancy is associated with increased risk of lifelong negative effects on development and cognition in the offspring (Stade *et al.*, 2009), and it is unclear whether any level of alcohol can be consumed safely during pregnancy. Thus, the current recommendation is for women to abstain from alcohol when planning a pregnancy (Ministry of Health, 2006).

Caffeine consumption also appears to have adverse effects on female fertility (Wilcox *et al.*, 1988). Caffeine intake may also increase the risk of spontaneous abortion and decrease the chance of a live birth after IVF treatment (Klonoff-Cohen *et al.*, 2002). In our study, the majority of women still consumed caffeinated beverages prior to fertility treatment, and similarly high rates of caffeinated beverage consumption have also been reported in other IVF populations (Ferreira *et al.*, 2010; Domar *et al.*, 2012). We observed that the consumption of caffeinated herbal tea was associated with lower odds of a successful pregnancy, but did not see an association with coffee consumption. Not all studies looking at coffee consumption have found an effect on fertility, presumably because the effect of diet on fertility will be the sum of many potentially causal elements and their interactions. Women who drink green tea may have diets and lifestyles that differ in other ways from women who drink coffee. The relatively high proportion of women drinking green tea in our population (36%) may be why we found an association that has not been reported previously. In addition, it is possible that bioactive factors other than caffeine in green tea may contribute; there are a large number of papers reporting biological effects of polyphenols and catechins in green tea on non-fertility aspects of human health (Cabrera *et al.*, 2006; de Bock *et al.*, 2012).

There was greater use of nutritional supplements in this cohort than the general adult female population in New Zealand (University of Otago and Ministry of Health, 2011). Importantly, there was a much higher intake of folic acid in our cohort (93%) compared with a group of women undergoing ICSI treatment in Germany (38%; $P < 0.0001$) (Ludwig *et al.*, 2006) or to 588 women in Australia prior to pregnancy (23%; $P < 0.0001$) (Forster *et al.*, 2009). Our results are similar to another Australian study where 100% of a small infertile female population were taking folic acid prior to fertility treatment (Homan *et al.*, 2012). Nonetheless, ~20% of women who became pregnant in our study were not taking adequate folic acid as per Ministry of Health recommendations. This is of relevance in New Zealand, since foods are not required to be fortified with folic acid as is the case in many other countries. Our interviews indicated that most women taking an inadequate amount of folic acid had been given incorrect advice, most commonly by alternative practitioners or retail pharmacy staff. Inadequate folic acid intake during the periconceptional period is linked with a higher incidence of neural tube defects (Wald *et al.*, 1991; Rush, 1994), so foetal health is at risk. Babies of obese women (BMI of over 30 kg/m^2) have an increased risk of neural tube defects, and the UK has increased the folic acid amount recommendation for obese women to 5000 mcg/day (Modder and Fitzsimons, 2010). Considering that 12% of women in our cohort were obese and that we used the New Zealand Ministry of Health folic acid recommendation of 800 mcg as our level of adequacy, inadequate folic acid intake in our study might have been somewhat underestimated.

In regard to iodine, current recommendations for women in New Zealand who are pregnant, breastfeeding or planning a pregnancy are to take a 150 mcg of supplement daily. Since July 2010, this supplement has been fully funded for all New Zealand women who are pregnant, breastfeeding or planning a pregnancy. Although recruitment to this study began 3 months before this funding was made available, uptake and dissemination of iodine recommendations to women in our cohort was poor with only 4% of women taking the funded supplement. However, a number of other women were taking some iodine as part of multi-mineral supplements.

This study cohort was generally well-educated and very motivated to become pregnant compared with the general female New Zealand population. Interestingly, we observed that higher levels of education were associated with greater odds of a successful pregnancy following fertility treatment. This corroborates the findings of a 2011 study in which having at least a college degree was independently associated with higher odds of pregnancy after fertility treatment (OR 1.9) (Smith *et al.*, 2011). The authors speculated that higher-educated females have greater access to and knowledge of health-care options and better health overall, which may have influenced fertility treatment success (Smith *et al.*, 2011). Additionally, we speculate that women with higher educational qualifications are potentially more compliant with the complex medication and testing regimens of assisted

reproductive technology, thereby increasing their likelihood of treatment success. The observed association between education and fertility treatment success warrants further investigation.

There was a willingness among participants to make lifestyle changes to try and increase the chances of fertility treatment success. As a result, many participants made changes to their lifestyle prior to their fertility treatment, such as reducing alcohol, caffeine and increasing exercise levels. One other study looked at how women had changed their lifestyle from the last 5 years to the month prior to fertility treatment, also observing a decrease in alcohol consumption, smoking and an increase in physical activity levels (Domar *et al.*, 2012). However, despite many study participants making healthier lifestyle changes, there remained a high proportion of women who did not adhere to the fertility clinic's recommendation to reduce alcohol and caffeine consumption and body weight (if overweight or obese). Additionally, among our study participants, there was a range of misinformed behaviours initiated with the declared intent of increasing fertility. These included initiating detoxification or highly-restrictive diets, and consuming multiple nutritional/herbal supplements.

Nonetheless, the high uptake of alternative medicines and practices (despite advice to the contrary) illustrates the desire of patients to have control over their life. Lifestyle information given to patients by the fertility clinic is understandably cautious, in light of the limited data on their effects on fertility treatment outcomes. One could argue that for lifestyle recommendations known to be generally advantageous for overall health, the burden of proof underpinning the advice could be lower. While unhealthy lifestyle choices, such as alcohol intake and smoking, were lower in our study than the general New Zealand female population, they were still higher than might be expected given our participants' high levels of motivation to become pregnant.

We speculate that a number of factors contributed to many women not following the basic healthy lifestyle advice from the fertility clinic and Ministry of Health. Clinic staff have limited time with patients but provide them with written and verbal information on healthy lifestyle changes. However, the key messages may be diluted among the large amount of complex information that needs to be conveyed about the medications, tests and procedures involved in fertility treatment. A lack of knowledge might have led women to substitute green tea for regular tea and coffee, in the mistaken belief that green tea does not contain caffeine. Women undergoing fertility treatment require further advice and support with making healthy lifestyle choices prior to and while undergoing treatment.

There needs to be honest discussion around the current lifestyle habits of the patient, and clear recommendations for potential improvements should be given in both verbal and written forms. Given the time constraints of clinical appointments, fertility clinics may benefit from having a designated staff member to have these discussions with patients, offering motivation and support on an ongoing basis throughout their treatment.

Further studies are necessary to identify the reasons why women adopt certain lifestyle practices and not others while undergoing fertility treatment. These studies could lead to more effective communication with patients to prompt positive behavioural changes. It is possible that more marked lifestyle changes could be observed if recommendations focused on optimising the patient's health for the physiological demands of pregnancy and the health of the developing baby. Lastly, it is important to further evaluate the effects of lifestyle changes prior to and during fertility treatment on pregnancy success.

A limitation of this study was the highly detailed dietary intake survey, which might have attracted more motivated and potentially healthier participants, possibly limiting applicability of our findings to the wider population of women undergoing fertility treatment. The study data also involved self-reported behaviours that might have been misrepresented by respondents, but we aimed to elicit consistent responses by the use of a structured questionnaire administered by two trained researchers. In addition, our questionnaires covered the period following the first clinical assessment but ~5 weeks prior to fertility treatment initiation, so that we cannot ascertain whether dietary intakes and lifestyle choices persisted over the course of treatment itself.

Conclusion

We showed that a considerable proportion of women about to undergo fertility treatment make poor lifestyle choices, including the consumption of alcohol and caffeine. Importantly, alcohol and caffeinated herbal tea appeared to negatively affect the chances of these women becoming pregnant. A proportion of women (17%) still failed to take adequate supplementary folic acid, which was surprising considering the strength of scientific evidence for foetal benefit, and the high motivation of the participants to achieve pregnancy. Although we observed no association between changes in exercise levels or BMI with treatment outcome, these observations are inconclusive in the light of the small numbers of women making these changes in our study. Further research is needed to confirm the current findings and to look at the associations between lifestyle factors and fertility treatment success in more detail. There may also be a cumulative effect of lifestyle habits on the outcome of fertility treatment, which should be investigated in future research. Nonetheless, our findings indicate that all women undergoing fertility treatment need specific education on appropriate lifestyle choices for conception and optimal foetal health, ideally provided by staff at the fertility clinic. Finding the most effective method of educating and motivating patients to make healthy lifestyle changes needs further investigation. Fertility patients should also be made aware of evidence-based information sources or registered professionals to consult if they would like additional advice and support in making lifestyle improvements.

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Authors' roles

A.A.G., W.S.C., J.C.P. and P.D.G. conceived and designed the study. A.A.G. and N.L.Y. recruited and performed the study. A.A.G. collected and compiled the data. J.G.B.D. carried out the statistical analyses. A.A.G. and J.G.B.D. wrote the manuscript with input from other authors. All authors have approved the submission of the final version of this manuscript.

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Conflict of interest

J.G.B.D., P.D.G., N.L.Y. and W.S.C. have nothing to disclose. The funders had no role in study design, data collection and analysis, decision to publish or preparation of the manuscript.

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