

1 **Title:** Women's dietary changes before and during pregnancy: a systematic review

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**17 Abstract****18 Background**

19 Dietary intake before and during pregnancy has significant health outcomes for both mother and  
20 child, including a healthy gestational weight gain. To ensure effective interventions are successfully  
21 developed to improve dietary intake during pregnancy, it is important to understand what dietary  
22 changes pregnant women make without intervention.

23

**24 Aims**

25 To systematically identify and review studies examining women's dietary changes before and during  
26 pregnancy and to identify characteristics of the women making these changes.

27

**28 Methods**

29 A systematic search strategy was employed using three databases (Web of Science, CINAHL and  
30 PubMed) in May 2016. Search terms included those relating to preconception, pregnancy and diet.  
31 All papers were quality assessed using the Scottish Intercollegiate Guidelines Network methodology  
32 checklist for cohort studies. The search revealed 898 articles narrowed to full-text review of 23  
33 studies. In total, 11 research articles were included in the review, describing nine different studies.  
34 The findings were narratively summarized in line with the aims of the review.

35

**36 Findings**

37 The included studies showed marked heterogeneity, which impacts on the findings. However, the  
38 majority report an increase in energy intake (kcal or kJ) during pregnancy. Of the studies that  
39 reported changes through food group comparisons, a majority reported a significant increase in fruit  
40 and vegetable consumption, a decrease in egg consumption, a decrease in fried and fast food  
41 consumption and a decrease in coffee and tea consumption from before to during pregnancy. The  
42 characteristics of the women participating in these studies, suggest that age, education and  
43 pregnancy intention are associated with healthier dietary changes; however these factors were only  
44 assessed in a small number of studies.

45

**46 Key conclusions**

47 The 11 included articles show varied results in dietary intake during pregnancy as compared to  
48 before. More research is needed regarding who makes these healthy changes, this includes  
49 consistency regarding measurement tools, outcomes and time points.

50

51 **Implications for practice**

52 Midwives as well as intervention developers need to be aware of the dietary changes women may  
53 spontaneously engage in when becoming pregnant, so that care and interventions can build on  
54 these.

55

56 **Keywords:** Pre-conception, pregnancy, dietary intake, caffeine, systematic review.

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57 Introduction

58 Pregnancy is a time when many women gain weight they subsequently retain post pregnancy.  
59 Almost 30% of pregnant women gain more weight than is recommended by the American Institute  
60 of Medicine guidelines (IOM, 2009) and previous evidence from a range of countries suggests a  
61 mean weight gain between 0.4kg to 3.8 Kg as a result of pregnancy up to 2.5 years postpartum  
62 (Linne et al., 2002). Increased weight post-natal was also found to be a strong indicator of being  
63 overweight 15 years later (Linne et al., 2004). The more weight gained during pregnancy, the more  
64 likely that it may be retained postpartum (Johnson et al., 2013) and women who enter a subsequent  
65 pregnancy overweight or obese also have a higher risk of adverse outcomes for themselves and/or  
66 their infants (Kuhlmann et al., 2008 and Marchi et al., 2015).

67  
68 Numerous interventions have targeted weight gain in pregnancy, including both physical activity and  
69 dietary components. A recent review suggests that interventions with dietary aspects may be most  
70 effective in helping women gain a healthy weight in pregnancy (Thangaratinam et al., 2012).  
71 Adequate nutritional intake during pregnancy is vitally important to ensure appropriate fetal growth  
72 both physically and mentally (Anderson et al., 2001) and poor maternal nutritional status is well  
73 reported to not only affect pregnancy outcomes (Osrin and de L Costello, 2000 and Keen et al.,  
74 2003), but may also be related to the risk of developing several non-communicable diseases in the  
75 adult child (Barker et al, 2013). As such dietary intake both before and during pregnancy is a major  
76 public health issue (Barker et al., 2013).

77  
78 Pregnancy is a period where women are particularly concerned with their dietary intake (Pinto et al.,  
79 2008) and are considered highly motivated for dietary improvements (Szwajcer et al., 2008 and  
80 Phelan, 2010). For example, when pregnant women have been asked for the behaviours they do to  
81 keep healthy in pregnancy, healthy eating is the most commonly mentioned health behaviour  
82 (Lewallen, 2004). To ensure appropriate and effective interventions are successfully developed to  
83 improve dietary intake during pregnancy, the dietary changes women make when they become  
84 pregnant are important to understand (Skreden et al., 2014). The primary aim of this systematic  
85 review was therefore to review the existing literature on dietary intake change before and during  
86 pregnancy. In addition to knowing *what* dietary changes women make when becoming pregnant, it  
87 is also important to understand *who* makes these changes. Thus, our secondary review aim was to  
88 identify the key characteristics of the women who report changing their dietary intake from before  
89 to during pregnancy.

90

91 Methods

92 A systematic literature review was conducted to identify the changes in women's dietary intake  
93 before and during pregnancy and to identify which women may make these changes. Three  
94 databases (Web of Science, CINAHL and PubMed) were systematically searched in May, 2016.  
95 Search terms included preconception, pre-pregnancy, pregnancy, gestation, dietary intake, food  
96 intake, beverages, caffeine, fruit and vegetables. Scopus was used for forward searching (May 2016).  
97 Studies were included if they measured women's dietary intake before and during pregnancy, either  
98 prospectively or retrospectively. For the purpose of this review, dietary intake included food groups  
99 as well as energy and macronutrients. Notably, drinking alcohol was not included in this review  
100 despite being part of a woman's energy intake. There are two reasons for omitting alcohol from this  
101 review, firstly not all women drink alcohol when not pregnant (Petherick et al., 2010). Secondly,  
102 drinking alcohol is consistently reported to decrease before and during to pregnancy (Crozier et al.,  
103 2009a; Aden et al., 2007; Pinto et al., 2008).

104

105 In addition, to be included studies had to use a within-participants design to limit the bias and  
106 individual variance associated with dietary intake. Lastly, to be included, articles had to be in English  
107 and in peer-reviewed journals. Screening of titles and abstracts and decision on final inclusion of  
108 articles was done by both authors.

109

110 *Analysis*

111 All papers were quality assessed using the Scottish Intercollegiate Guidelines Network methodology  
112 checklist for cohort studies (Scottish Intercollegiate Guidelines Network, 2016). This checklist was  
113 chosen as it differentiates between prospective and retrospective cohort studies, of which both  
114 were included in this review. Both authors scored the studies independently and scoring  
115 discrepancies were resolved via discussion. Inter-rater reliability was calculated using percentage  
116 agreement.

117

118 For all studies, study population, study design, diet measurement, type and timing of measurement  
119 and study findings were extracted. Due to the heterogeneity of the studies identified it was  
120 inappropriate to conduct a meta-analysis and a narrative method of synthesis analysis was  
121 conducted. This method has been used previously when the experimental studies included are not  
122 sufficiently similar for a meta-analysis to be appropriate (Mays et al., 2005) Ethical approval was not  
123 required for this systematic review.

124 Results

125 The literature search yielded 898 articles including one article found by a hand search, of which 468  
126 were screened by title and abstract and 23 were full text screened (see Figure 1). Details of study  
127 exclusion are detailed in Table 2 in supplementary material. Forward searching identified two  
128 additional articles (Aden et al., 2007 and Crozier et al., 2009a). In total, 11 research articles were  
129 included in the review, describing nine different studies.

130

### 131 *Study characteristics*

132 The included studies heralded from all over the world, published between 1998 and 2014 (see Table  
133 1). The majority of studies used a prospective design (n= 6) with three studies (reported in five  
134 articles) using a retrospective design. Study sample size varied from 10 (Kopp-Hoolihan et al., 1999)  
135 to 7174 (Hellerstedt et al., 1998). The included studies varied greatly regarding the information  
136 authors reported regarding participant characteristics in terms of age, ethnicity, parity and weight  
137 status (see Table 1). Variations in measurement time points were also noticed with the prospective  
138 studies measuring pre-conception dietary intake within a few months of a confirmed pregnancy. The  
139 retrospective studies measured dietary intake at different time points during pregnancy or  
140 postpartum to gather information of dietary intake before and during pregnancy. Dietary intake was  
141 either measured through interview (face-to-face or by phone) or self-administered questionnaire. In  
142 total, seven articles provided data on changes in food groups and three articles reported findings in  
143 terms of energy and macronutrients, with one reporting both methods. Four articles provided data  
144 on characteristics of the women who report changing their dietary intake before and during  
145 pregnancy.

146

### 147 *Quality assessment*

148 Inter-rater reliability, assessed through percentage agreement was 77.8%. Whilst the prospective  
149 studies were deemed marginally stronger compared to the retrospective studies, all articles were  
150 found to be of acceptable quality. See Table 1 in supplementary material for full breakdown of  
151 quality assessment.

152

153 The results of the review are presented under two headings, dietary intake changes and  
154 characteristics of women making dietary changes. Changes in dietary intake will be clustered using  
155 the sub-headings of food groups or energy and macronutrient intake to complement the individual  
156 study reporting and to allow comparisons between studies to be made more easily.

157

### 158 *Dietary intake change from preconception to pregnancy*

**159 Food Groups - Fruits and vegetables**

160 Six articles reported data on fruit and vegetable intake with inconsistent findings (Cuco et al., 2006a;  
161 Pinto et al., 2008; Crozier et al., 2009a; Crozier et al., 2009b; Paulik et al., 2009; Smedley et al.,  
162 2014). Paulik et al. (2009) reported an increase in the percentage of women consuming both fruits  
163 and vegetables (more than 4 times per week) in pregnancy (85.7% vs 94.8% fruit and 67.6% vs 75.4%  
164 vegetables). This is further supported by Smedley et al. (2014), who reports a significant increase in  
165 the number of women 'always' consuming fruit and vegetables during pregnancy (65% vs 78% fruit  
166 and 61% vs 77% vegetables). Crozier et al. (2009a) reports an increase in citrus fruit and fruit juice  
167 intake during pregnancy compared to before pregnancy (52% vs. 64%). In contrast, Pinto et al.  
168 (2008) reported no significant change in median daily vegetable consumption (grams) between  
169 preconception and pregnancy, but did report a significant increase in fruit consumption during  
170 pregnancy (+21.5 grams). This was also supported by Cuco et al. (2006a) who reports no significant  
171 differences in mean consumption of fruit or vegetable intakes. In addition, portions of fruit and  
172 vegetables per day did not significantly differ between pre-conception and during pregnancy (5.2 vs.  
173 5.35 portions) as reported by Crozier et al., (2009b).

174

**175 Dairy**

176 Three studies reported data on dairy intake and the results varied greatly between studies (Pinto et  
177 al., 2008; Crozier et al., 2009a; Smedley et al., 2014). Pinto et al. (2008) reported a significant  
178 increase in milk and dairy products between pre-conception and during pregnancy (387.5g vs  
179 691.8g), and a significant decrease in egg consumption between pre-conception and during  
180 pregnancy (22.2g vs 11.1g). In addition, Crozier et al. (2009a) reported an increased intake in a  
181 number of dairy products including cream and milk as well as reporting an increase in the  
182 consumption of cheese and cottage cheese during both early (3.0 portions) and late (4.5 portions)  
183 pregnancy when compare to pre-conception (1.8 portions). However Smedley et al. (2014) reported  
184 no significant difference in dairy intake in all categories between pre-conception and during  
185 pregnancy

186

**187 Meat and meat products**

188 Two studies reported data on meat and meat products and the results varied greatly between  
189 studies (Pinto et al., 2008; Crozier et al., 2009a). Crozier et al. (2009a) reported an increase in  
190 processed meat consumption during early and late pregnancy, but reported no change in red meat,  
191 chicken, turkey or fish consumption during pregnancy. Crozier et al. (2009a) also reported that the  
192 proportion of women consuming meat such as liver and kidneys was 48% during pre-conception,

193 and decreased to 22% in early pregnancy and 16% in late pregnancy. This contrasts with evidence  
194 reported by Pinto et al. (2008) who reported a significant decrease in red meat consumption during  
195 pregnancy (-4.7g) but who also found no significant difference in fish consumption.

196

### 197 **Starchy Carbohydrates (CHO)**

198 Two studies reported data on starchy carbohydrates and the results varied greatly between studies  
199 (Pinto et al., 2008, Crozier et al., 2009a). Pinto et al. (2008) reported a significant increase in bread  
200 consumption but a decrease in rice, pasta and potato consumption during pregnancy. Crozier et al.  
201 (2009a) reported that rice and pasta consumption was lower during early and late pregnancy with an  
202 increase in weekly consumption of breakfast cereals during late pregnancy (7 portions) compared to  
203 pre-conception (4.5 portions) and early pregnancy (4.5 portions) also reported. However Crozier et  
204 al. (2009a) also reported no changes in intake of wholemeal bread, quiche, pizza and pancakes.

205

### 206 **Sweet foods**

207 Three studies reported data on sweet foods and the results varied greatly between studies (Pinto et  
208 al., 2008; Crozier et al., 2009a; Smedley et al., 2014). Smedley et al. (2014) and Pinto et al. (2008)  
209 reported no change in sweet bakery food or sweets consumption between pre-conception and  
210 during pregnancy, whereas Crozier et al. (2009a) reported an increase in portion consumption of  
211 sweet spreads, confectionary, cakes and biscuits during both early and late pregnancy, whereas  
212 puddings only increased during late pregnancy.

213

### 214 **Fast and Fried Food**

215 Two articles reported data on fried and fast food (Pinto et al, 2008; Smedley et al, 2014). Fried food  
216 intake was not significantly different before and during pregnancy (Smedley et al., 2014). However  
217 fast food intake did decrease during pregnancy, with a greater number of women reporting that  
218 they 'never' consumed this food (56% vs 67%) (Smedley et al., 2014). Similarly, Pinto et al. (2008)  
219 reported a decrease in the consumption of fast food during pregnancy compared to pre-conception  
220 intake (25.1g vs 17.1g)

221

### 222 **Beverages**

223 Five articles reported data on beverage intake and the results varied greatly between studies  
224 (Hellerstedt et al., 1998; Cuco et al. 2006a; Pinto et al., 2008; Crozier et al., 2009b; Skreden et al.,  
225 2014). Coffee and tea was the most commonly reported beverage, and consumption was found to  
226 decrease from before to during pregnancy in four studies (Hellerstedt et al., 1998; Pinto et al., 2008;

227 Crozier et al., 2009b; Skreden et al., 2014). Paulik et al. (2009, n=349) reports a decrease in drinking  
228 one cup of coffee per day from 56.2% to 33.2%. Milk was assessed in three articles; Skreden et al.  
229 (2014) reported an increase in milk intake and Pinto et al. (2008) reported an increase in daily intake  
230 of milk and dairy products. Whereas Paulik et al. (2009) reported a decrease from 66.8% vs 60.2%.

231

232 Regarding sugar sweetened beverages and fruit juices, both Pinto et al. (2008) and Cuco et al.  
233 (2006a) reported no significant differences from before to during pregnancy, whilst Crozier et al.  
234 (2009a) and Skreden et al. (2014) found an increase in fruit juice consumption. Moreover, a decrease  
235 in sugar-sweetened beverages and artificially sweetened beverages was found in both studies  
236 (Crozier et al., 2009a and Skreden et al., 2014). Cuco et al. (2006a) also reported that participants  
237 who had high scores of sweetened beverages and sugar during both pre-conception and during  
238 pregnancy tended to consume less fresh fruit, vegetables, roots and tubers. Lastly, the percentage of  
239 women who reported at least daily consumption of water increased from before to during  
240 pregnancy (Skreden et al., 2014).

241

#### 242 **Energy and Macronutrients**

243 Total energy intake (kcal, kJ or MJ) was measured in five studies (Koop-Hoolihan, 1999; Pinto et al.,  
244 2008; Cuco et al., 2006a and 2006b and Aden et al., 2007), with four studies (Koop-Hoolihan, 1999;  
245 Cuco et al., 2006a and 2006b and Aden et al., 2007) recording an increase in energy intake during  
246 pregnancy and one reporting no significant change (Pinto et al., 2008).

247

248 Kopp-Hoolihan et al. (1999) reported energy intake using three day food diaries from 10 women  
249 during pre-conception (T1) and three trimesters during pregnancy (T1, T2, and T3). The results show  
250 a 9% increase (775kJ/day) in total energy intake between T1 and T3. Similarly, Aden et al. (2007)  
251 reported an increase in energy intake between pre-conception ( $1852 \pm 751$  kcal/day) and during  
252 pregnancy ( $2104 \pm 583$  kcal/day) using a Food Frequency Questionnaire (FFQ) and a 24hr dietary  
253 recall, although there was no indication if this was a statistically significant increase. Cuco et al.  
254 (2006a and 2006b) reported changes in energy intake between pre-conception and four different  
255 weeks during pregnancy. The authors in both articles report an increase in energy intake between  
256 pre-conception and the 10<sup>th</sup> and 26<sup>th</sup> week of pregnancy but a decrease during the 6<sup>th</sup> and 38<sup>th</sup> week.  
257 However, Pinto et al. (2008) reported no significantly difference between pre-conception (2393  
258 kcal/day) and during pregnancy (2423 kcal/day).

259

260 Macronutrient intake was also reported in 3 studies (Cuco et al., 2006b; Aden et al., 2007 and Pinto  
261 et al., 2008), with no consistent changes in intake reported in studies. Cuco et al. (2006b) reported  
262 macronutrient intake using a 7 day consecutive food diary. Protein intake did not differ between  
263 pre-conception and during pregnancy; however the proportion of animal to vegetable protein  
264 increased in favour of vegetable protein during pregnancy compared to pre-conception. CHO and fat  
265 intake increased during the 10<sup>th</sup>, 26<sup>th</sup> and 38<sup>th</sup> week (182.2g preconception vs 199.4g; 206.7g; 191.8g  
266 respectively CHO and 91.6g preconception vs 98.0g, 97.3g, 92.9g respectively Fat). Cuco et al.  
267 (2006b) also reported changes in maternal consumption of protein, fat, CHO and suggests that an  
268 increase of only 1 gram of these during preconception, 6<sup>th</sup>, 10<sup>th</sup>, 26<sup>th</sup> and 38<sup>th</sup> week of pregnancy can  
269 cause significant changes in child birth weight (7.8 – 11.4 grams)

270

271 Aden et al. (2007) reported an increase in CHO and protein intake with a decrease in fat intake  
272 recorded during pregnancy. However, Pinto et al. (2008) reported no significant differences between  
273 CHO and total fat intake as a percentage of total energy intakes (%TEI) between pre-conception and  
274 during pregnancy. However the results do indicate a significant increase in %TEI saturated fat (SFA)  
275 and protein during pregnancy compared to pre-conception.

276

277 *Characteristics of the women who report changing their dietary intake from before to during*  
278 *pregnancy*

279 Four studies reported characteristics of the women who made dietary changes from before to  
280 during pregnancy. Crozier et al. (2009b) explored what variables may predict daily fruit and  
281 vegetable intake. They found that both at pre-conception and during pregnancy, younger women  
282 ate less than five portions of fruit and vegetables a day compared to older women. Cuco et al.  
283 (2006a) also reports a positive association between the consumption of vegetables and meat with  
284 age. Whilst Skreden et al. (2014) found that women over 25 years reported larger decreases in  
285 artificially sweetened beverages and increased their fruit juice consumption more compared to  
286 women less than 25 years old. The women over 25 years also reported a larger intake in milk  
287 compared to younger women from pre-conception to during pregnancy. The same study found no  
288 relationship between pre-pregnancy BMI (>25 vs. <25) and changes in drinking habits or beverage  
289 consumption. Skreden and colleagues (2014) also found that higher education was associated with  
290 more reduction in coffee consumption. Lastly, Hellerstedt et al. (1998) examined daily caffeine use  
291 and pregnancy intention. They found that women with intended pregnancies, compared to those  
292 who reported the pregnancy was unintended, were more likely to report decreased consumption of  
293 caffeine from before to during pregnancy.

294 Discussion

295 The aims of this review were to evaluate the evidence relating to what changes in dietary intake  
296 women make when becoming pregnant, and secondly identify any characteristics of the women  
297 making these changes. The included studies are heterogeneous, specifically in relation to outcome  
298 measures and time frames in which data collection occurred; as such the findings should be  
299 interpreted with caution. Overall, the review findings suggest that some changes regarding dietary  
300 intake are made during pregnancy and these are in line with studies that have compared dietary  
301 intake between pregnant women and non-pregnant women (Anderson et al, 1993; Verbeke et al,  
302 2007 and Inskip et al, 2009). The majority of studies report an increase in energy intake (kcal or kJ)  
303 during pregnancy, but failed to consistently report changes in different macronutrient intake (Cuco  
304 et al., 2006a and 2006b; Aden et al., 2007 and Pinto et al., 2008). Of the studies that reported  
305 changes through food group comparisons, a majority reported a significant increase in fruit and  
306 vegetable consumption, a decrease in egg consumption, a decrease in fried and fast food  
307 consumption and a decrease in coffee and tea consumption from pre-conception to during  
308 pregnancy (Helderstedt et al., 1998; Cuco et al., 2006a; Pinto et al., 2008; Crozier et al., 2009a and  
309 2009b; Paulik et al., 2009; Skreden et al., 2014; Smedley et al., 2014). There was no consistency in  
310 starch carbohydrate consumption, meat, fish or sweets/sweet food consumption. Regarding the  
311 characteristics of the women making these dietary changes, only three studies provided information  
312 and as such no conclusions can be drawn.

313

314 *Dietary intake change before and during pregnancy*

315 Changes in energy intake were found to vary considerably between studies, with several papers  
316 reporting a significant increase and others reporting no significant change. Despite the general trend  
317 towards an increase in overall energy intake there were no consistent differences reported in  
318 specific macronutrient intake from before and during pregnancy. However one author (Aden et al.,  
319 2007) did report a large range in energy intake between both stages, with pre-conception intake  
320 ranging between 1116 kcal/day to 6087 kcal/day and during pregnancy ranging between 945  
321 kcal/day and 3627 kcal/day. This indicates that although average intake may not change, there are  
322 likely to be large inter-individual variations in the overall energy and macronutrient intake between  
323 pregnant women which could have significant health and weight implications.

324

325 In terms of food group consumption, the most consistent findings are an increase in fruit and  
326 vegetable intake as well as an increase in dairy and a decrease in caffeine intake. An increase in fruit  
327 intake has also been reported in studies comparing pregnant to non-pregnant women (Anderson et

328 al, 1993; Verbeke et al, 2007), although one study found little difference between these groups  
329 (Inskip et al., 2009). Although fruit and vegetable intake was widely reported to increase during  
330 pregnancy, it cannot be assumed that all women adequately consumed the national  
331 recommendations for fruit and vegetable consumption per day. Smedley et al. (2014) reported that  
332 although fruit and vegetable consumption increased during pregnancy, only two thirds of  
333 participants reported consuming the recommend quantities of fruit and vegetable as suggested by  
334 the Australian public health guidelines (National Health and Medical Research Council, 2003). As  
335 fruit and vegetable intake is recommended as part of a healthy balanced diet, and their increased  
336 consumption is linked with a number of positive health outcomes (Slavin and Lloyd, 2012), the  
337 results indicate that more information should be provided to women before and during pregnancy  
338 on the importance of not only increased fruit and vegetable consumption but to ensure they reach  
339 the correct public health recommendations for their country.

340

341 Two studies found an increase in milk and dairy consumption (Pinto et al. 2008 and Crozier et al.,  
342 2009a). This is in line with other research findings where pregnant women report higher dairy intake  
343 compared to non-pregnant women (Anderson et al, 1993; Verbeke et al, 2007). This increase is  
344 positive as the recommended intake of calcium increases during pregnancy and studies reporting  
345 micronutrient intake only indicate that calcium intake increases during pregnancy (Aden et al., 2007)  
346 which could further explain the reported increase in dairy consumption (Crozier et al., 2009a and  
347 Pinto et al., 2008). The increase in dairy consumption could also account for the increase in energy  
348 intake recorded (Koop-Hoolihan, 1999; Cuco et al., 2006a and 2006b and Aden et al., 2007),  
349 particularly as the types of products consumed may correspond to more energy-dense foods such as  
350 full-fat milk and cheese (Crozier et al., 2009a).

351

352 In terms of beverages, there was encouraging findings that women decrease their coffee intake  
353 when pregnant and increase their milk intake. A decrease in daily caffeine intake has also been  
354 found in women attempting pregnancy (Lum et al., 2011), this suggests it is a component of healthy  
355 eating some women are aware of. In terms of fruit juices and sugar-sweetened drinks, two studies  
356 reported inconsistent findings, and more research is needed. Fruit juices and sugar-sweetened  
357 drinks are both important to target for weight-management as they are often high in calories.

358

359 In addition, the proportion of women consuming liver and kidneys was 48% pre-conception, 22% in  
360 early pregnancy and 16% in late pregnancy (Crozier et al., 2009a); this change in consumption is  
361 consistent with previous public health messages in pregnancy relating to the harmful effects of

362 excess vitamin A consumption through liver consumption (NHS Choices, 2015), despite little  
363 scientific evidence to support this (Strobel et al., 2007). Similarly the decrease of consumption in fast  
364 food reported (Smedley et al., 2014) could be due to public health education programmes in  
365 Australia relating to foods not to eat to avoid Listeria (Anderson, 2001). Indeed, previous research  
366 has suggested that health education around effective weight management can affect weight gain  
367 during pregnancy (Wilkinson et al., 2009), with further evidence to suggest that pre-conception  
368 interventions can improve both the intention and self-efficacy of healthy eating behaviours during  
369 pregnancy (Hillemeier et al., 2008). There is also emerging evidence to suggest that women start  
370 eating healthily in preparation for pregnancy (Ramage et al, 2015).

371

372 The variation in dietary intake changes reported before and during pregnancy in the reviewed  
373 studies, may be due to the disparity of nutritional and lifestyle advice given by different countries  
374 (Shawe et al., 2015). A recent publication by Shawe et al. (2015) reviewed the pre-conception care  
375 policy, guidelines and recommendations of six European countries (Belgium, Denmark, Italy,  
376 Netherlands, Sweden and UK) and reported that there were large variations between countries  
377 particularly in relation to fish, caffeine and alcohol consumption. This could account for some of the  
378 inconsistent results reported by the current studies reviewed.

379

380 *Characteristics of the women who report changing their dietary intake from before to during*  
381 *pregnancy*

382 Only four studies reported characteristics of the women making dietary changes. Findings suggest  
383 that education and age may be linked to dietary intake (Crozier et al. 2009b; Cuco et al. 2006a;  
384 Skreden et al., 2014) where older and more educated women tend to make healthier dietary  
385 changes. Findings from one study suggest that pregnancy intention may be associated with coffee  
386 intake (Hellerstedt et al., 1998). Since our search, a recent study fitting the scope of our review has  
387 been published where older pregnant women were more likely to decrease their intake of processed  
388 foods compared to younger pregnant women (Alves-Santos et al, 2016). Thus, whilst it is  
389 disappointing that so few studies examined the demographic and pregnancy factors that may be  
390 associated with dietary changes, our findings suggest that age, education and pregnancy intention  
391 may be factors worthy further examination. For example, nutrition awareness has been found to be  
392 higher in women trying to conceive compared to those women not trying to conceive (Szwajcer et al,  
393 2012). This information is likely to be important for targeting the right population of women with  
394 interventions and support.

395

396 *Strengths and limitations*

397 There are a number of strengths and limitations relating to the evidence presented in this review.  
398 Quality assessment of the 11 studies included using the SIGN checklist, reported the studies to be  
399 acceptable or highly acceptable in quality (Scottish Intercollegiate Guidelines Network, 2016). This  
400 indicates that despite the relatively low number of articles meeting the inclusion criteria (n=11) they  
401 were overall of good quality. Another strength was the range of countries in which the data was  
402 collected from, showing consistency in dietary change across different cultures although only English  
403 language articles were included.

404  
405 One limitation of the literature included in the review is the different methods used to measure  
406 dietary intake. Ranging from food frequency questionnaires (FFQ), food diaries (FD; 3 and 7 day;  
407 weighed and unweighed) as well 24 hour dietary recall methods. Pinto et al. (2008) justified the use  
408 of an FFQ in their study as it allowed for retrospective estimation of dietary intake to be collected.  
409 However they also recorded intake with a 3 day food diary during pregnancy (Pinto et al., 2008) and  
410 reported that differences in intake recorded between the methods may be due to previous evidence  
411 indicating that the FFQ tends to overestimate intake whereas FD tends to underestimate (Cade et  
412 al., 2002). In addition, the longer the period of dietary recording, the greater likelihood of participant  
413 fatigue and therefore potential under or overestimation of dietary intake (Buzzard, 1998).

414  
415 Studies included in this review were both prospective and retrospective in nature. Retrospective  
416 studies are limited in quality as they are subject to participant recall bias and potentially the prior  
417 knowledge of pregnancy outcomes could have affected the outcome of dietary intake recall (Pinto et  
418 al., 2008). In addition, recall bias may have been greater in women who experienced nausea and  
419 vomiting in early pregnancy and this may have affected dietary intake patterns when comparing pre-  
420 conception to during pregnancy (Pinto et al., 2008). Furthermore, the diversity of time points used  
421 by researchers is problematic, as women may change their eating throughout pregnancy. That said,  
422 those studies that measured diet at different time points in pregnancy report inconsistent findings  
423 regarding whether diet changes or not (Pinto et al., 2008; Cuco et al., 2006a). Clearly more research  
424 is needed. Not all included papers in this review reported changes in dietary intake as a primary  
425 objective and thus not conducting significance testing. These papers were still included due the  
426 authors to wanting to include all identified evidence in the review.

427  
428 In addition, this review only included studies if they used a within-group study design. It must be  
429 acknowledged that studies using this design are subject to a number of limitations including practice

430 effects and fatigue, with participants potentially becoming more attuned to detailing their dietary  
431 intake practices, increasing the likelihood of miss-reporting. As such, this needs to be considered  
432 when interpreting the results. It must also be acknowledged that the review question could have  
433 been answered using other research designs such as comparisons between groups of pregnant and  
434 non-pregnant women. We have compared our review findings with evidence from such studies in  
435 the Discussion section, and shown that our findings are in line with these studies.

436

#### 437 *Implications and future directions*

438 This review provides implications for both healthcare professionals, such as midwives, and  
439 intervention developers. Women often report wanting information early in their pregnancy about  
440 healthy eating (Olander et al., 2012). Healthcare professionals are consistently identified as the key  
441 source of information regarding healthy diet in pregnancy (Olander et al., 2012 and Smedley et al.,  
442 2014) and thus it is important for midwives and others to be aware of the dietary changes women  
443 may make when becoming pregnant, so that positive changes can be supported and built upon. It is  
444 also important to be mindful that a planned pregnancy may not necessarily mean women are  
445 healthier in preconception, and thus are likely to need the same advice as those women who have  
446 an unplanned pregnancy.

447

448 For intervention developers, these review findings are important to consider when targeting dietary  
449 intake in pregnancy. This review has identified food groups and characteristics of women that may  
450 confound intervention results. The review identifies that future studies should develop an agreed  
451 set of measures (timeframes, dietary recording techniques) for use across studies on this topic to  
452 reduce the problem of heterogeneity in this area. A successful intervention must be able to identify  
453 what behaviours women may change spontaneously when becoming pregnant and what behaviours  
454 they need support with.

455

#### 456 Conclusion

457 Dietary intake before and during pregnancy has significant implications for the mother and unborn  
458 child with a number of health outcomes related to poor dietary intake. The current literature  
459 available on women's change in dietary intake, using within-subject design, from before to during  
460 pregnancy is limited to a handful of studies using a variety of dietary intake recording methods on a  
461 wide range of dietary variables to collect data both prospectively and retrospectively and whose  
462 overall quality is acceptable or highly acceptable. The evidence suggests that a number of changes in  
463 dietary intake may take place during pregnancy (such as an increase in fruit and vegetable intake),

464 but that a number of other key components relating to high energy dense foods are inconsistent  
465 which could have far reaching implications in terms of energy balance and excess weight gain during  
466 pregnancy. Further research needs to be conducted investigating the changes in dietary intake  
467 before and during pregnancy prospectively, using this alongside records of weight gain and  
468 pregnancy outcomes in both mother and child to determine the longer term health implications of  
469 poor dietary intake.

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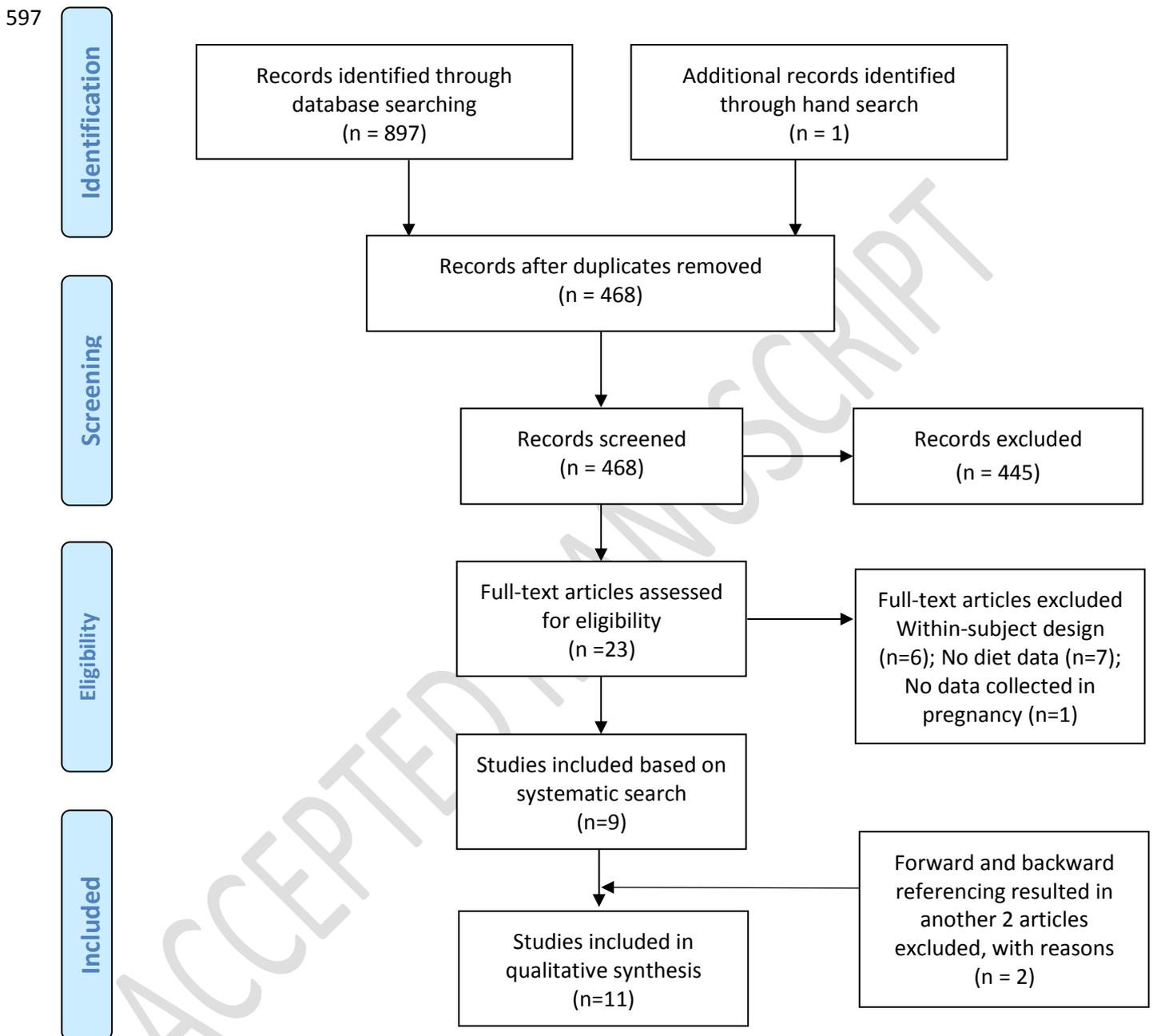
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595 **Figure 1.** Flowchart describing the number of articles retrieved, and included and excluded at each  
596 stage of the review process



598 **Table 1.** Summary of studies included in review.

Study authors, year (country)	Sample characteristics	Study design (prospective / retrospective)	When was diet measured?	What was measured?	How was diet measured?	Change in diet	Women's characteristics
Aden et al, 2007 (Sweden)	<p><b>Sample size:</b> 50</p> <p><b>Age:</b> 30 years (SD 4.6; range 18-40 years)</p> <p><b>Gestation weeks:</b> 18.1 (SD 1.1; range 15-21) weeks</p> <p><b>Weight category:</b> Pre-pregnant BMI mean 23.2 (SD3.1, 17.1-32.4)</p> <p><b>SES or similar:</b> Before pregnancy FT working 52% Student 20% PT working 16% Unemployed/sick leave 4% Other 8%</p> <p><b>Education:</b> Not reported</p> <p><b>Ethnicity:</b> Swedish 92% Asian 6%, Persian 2%</p> <p><b>Smoking:</b> Pre-pregnancy 16%, during pregnancy 6%</p> <p><b>NCD's:</b> Not reported</p> <p><b>Parity:</b> 62% first time mothers 38% one or more children</p>	Retrospective	18 weeks gestation	Energy and nutrient intake	Self-administered, validated FFQ (84 items)	<p>Intake mean (no p-values reported)</p> <p><b>Energy (kcal)</b> Pre-pregnancy 1852 (SD 751) Pregnancy 2104 (SD 583)</p> <p><b>Energy (MJ)</b> Pre-pregnancy 7.75 (SD 3.14) Pregnancy 8.81 (SD 2.44)</p> <p><b>Carbohydrates (E%)</b> Pre-pregnancy 48.1 (SD 5.3) Pregnancy 51.1 (SD 6.6)</p> <p><b>Protein (E%)</b> Pre-pregnancy 14.6 (SD 2.1) Pregnancy 16.8 (SD 2.4)</p> <p><b>Fat (E%)</b> Pre-pregnancy 35.9 (5.4) Pregnancy 32.1 (SD 6.4)</p>	None Reported.
Crozier et al, 2009a (United Kingdom)	<p><b>Sample size:</b> 2057</p> <p><b>Age:</b> Not reported</p> <p><b>Gestation weeks:</b> N/A</p> <p><b>Weight category:</b> Not reported</p> <p><b>SES or similar:</b> Not reported</p> <p><b>Education:</b> Not reported</p> <p><b>Ethnicity:</b> Not reported</p>	Prospective	Pre-pregnancy, 11 and 34 weeks gestation. Conception was on average 1.8 years after pre-pregnancy data collection	White bread, breakfast cereals, cakes and biscuits, processed meat, crisps, fruit and fruit juices, dried fruit, sweet	Validated interviewer-administered FFQ	<p>Intake of white bread, breakfast cereals, cakes and biscuits, processed meat, crisps, fruit and fruit juices, dried fruit, sweet spreads, confectionery, and hot chocolate drinks increased from pre-pregnancy to pregnancy (all p&lt;0.0001).</p> <p>Consumption of breakfast cereals, cakes</p>	None Reported.

	<p><b>Smoking:</b> Not reported  <b>NCD's:</b> Not reported  <b>Parity:</b> Not reported</p>			<p>spreads, confectionery, and hot chocolate drinks, fruit, sweet spreads, puddings, cream, milk, cheese, full-fat spread, cooking fats and salad oils, red meat, soft drinks, rice and pasta, liver and kidney, vegetables, vegetable dishes, nuts, tea, coffee, boiled potatoes, crackers.</p>		<p>and biscuits, processed meat, non-citrus fruit, sweet spreads, and hot chocolate drinks increased further in late pregnancy (all <math>p &lt; 0.0001</math>).</p> <p>Puddings, cream, milk, cheese, full-fat spread, cooking fats and salad oils, red meat, and soft drinks did not change in early pregnancy, they increased in late pregnancy (all <math>p &lt; 0.001</math>).</p> <p>Intakes of 10 foods or food groups decreased in pregnancy. These were consumption of rice and pasta, liver and kidney, salad vegetables, other vegetables, vegetable dishes, nuts, diet cola, tea, and coffee were lower in pregnancy than before pregnancy (all <math>p &lt; 0.0001</math>).</p> <p>Compared to early pregnancy, consumption of rice, pasta, liver, and kidney were lower again in late pregnancy (<math>p &lt; 0.001</math>).</p> <p>Consumption of green vegetables, boiled potatoes, and crackers did not change in early pregnancy but decreased in late pregnancy.</p>	
<p>Crozier et al, 2009b (United Kingdom)</p>	<p><b>Sample size:</b> 1490  <b>Age:</b> 28.2 years  <b>Gestation weeks:</b> N/A  <b>Weight category:</b> Non-pregnant BMI mean 24.3  <b>SES or similar:</b></p>	<p>Prospective</p>	<p>Pre-pregnancy, 11 and 34 weeks gestation</p>	<p>Portions of fruit and vegetables per day  Caffeinated drinks/day (i.e. coffee,</p>	<p>Interviewer-administered 100-item food frequency questionnaire</p>	<p>Fruit and vegetable median scores 5.2 (IQR 3.7-7.0) pre-pregnancy, 5.3 (IQR 3.7-7.0) 11 weeks gestation, 5.4 (IQR 3.9-7.2) 34 weeks gestation.</p> <p>Eating &lt;5 portions of fruit and</p>	<p>None Reported.</p>

	<p><b>Education:</b> None 2.3% GCSE grade D or below 10.3% GCSE graded C or above 28.4% A level or equivalent 29.3% HND or equivalent 7.8% Degree 21.9%</p> <p><b>Ethnicity:</b> 96.2% White 3.8% Non-white</p> <p><b>Smoking:</b> 26.6% yes pre-pregnancy</p> <p><b>NCD's:</b> Not reported</p> <p><b>Parity:</b> Not reported</p>			caffeinated tea and cola)		<p>vegetables a day: 47% pre-pregnancy, 46% 11 weeks gestation, 44% 34 weeks gestation (NS change btw time points)</p> <p>Caffeinated drinks median scores: 4.1 (IQR 2-6) pre-pregnancy, 2.0 (IQR 0.6-4.1) 11 weeks gestation, 2.3 (IQR 0.9-4.3) 34 weeks gestation.</p> <p>Drinking &gt;300mg of caffeine in drinks per day: 39% before pregnancy, 16% 11 weeks gestation, 20% 34 weeks gestation. All changes significant. P &lt; 0.05</p>	
Cuco et al, 2006a (Spain)	<p><b>Sample size:</b> 80</p> <p><b>Age:</b> 29 years (24-35 years)</p> <p><b>Gestation weeks:</b> Not reported</p> <p><b>Weight category:</b> 6.3% below BMI 20 70% BMI 20-25 20% BMI 25-30 3.8% above 30 BMI</p> <p><b>SES or similar:</b> Not reported</p> <p><b>Education:</b> Only primary education 22.5% Secondary education and vocational training 40% University education 37.5%</p> <p><b>Ethnicity:</b> Not reported</p> <p><b>Smoking:</b> Not reported</p> <p><b>NCD's:</b> Not reported</p> <p><b>Parity:</b> Not reported</p>	Prospective	Pre-pregnancy, 6, 10, 26 and 38 weeks gestation and 6 months postpartum	Energy intake (kcal)	7 consecutive day dietary record	<p>Data reported as 50<sup>th</sup> percentile (25<sup>th</sup>-75<sup>th</sup> percentile) No p-values reported.</p> <p><b>Energy intake (kcal)</b> Preconception 1910 (1730-2237) 6 weeks 1896 (1664-2076) 10 weeks 2017 (1743-2231) 26 weeks 2032 (1794-2251) 38 weeks 1899 (1680-2157) 6 months postpartum 1767 (1536-1957)</p>	None Reported.
Cuco et al, 2006b(Spain)	<p><b>Sample size:</b> 77</p> <p><b>Age:</b> 27.3% 24-27 years 50.6% 28-31 years</p>	Prospective	Pre-pregnancy, 6, 10, 26 and 38 weeks gestation	Energy intake (kcal), protein (g), carbohydrates	7 consecutive day dietary record	<p>Data reported as 50<sup>th</sup> percentile (25<sup>th</sup>-75<sup>th</sup> percentile) No p-values reported.</p> <p><b>Energy intake (kcal)</b></p>	None Reported.

	<p>22.1% ≥32 years  <b>Gestation weeks:</b> N/A  <b>Weight category:</b> pre-pregnancy: 6.5% &lt;BMI 20  71.4% BMI 20-25  18.2% BMI &gt;25-30  3.9% BMI &gt;30  <b>SES or similar:</b> Not reported  <b>Education:</b> Not reported  <b>Ethnicity:</b> Not reported  <b>Smoking:</b> 48.1% never 14.3% ex-smokers 13% pre-pregnancy  <b>NCD's:</b> Not reported  <b>Parity:</b> 67.5% primiparae</p>			(g), fats (g), animal proteins (g) vegetable proteins (g)		<p>Preconception 1940 (1743-2311)  6 weeks 1908 (1667-2084)  10 weeks 2037 (1742-2258)  26 weeks 2035 (1813-2299)  38 weeks 1904 (1688-2169)  <b>Proteins (g)</b>  Preconception 80 (71.5-91.9)  6 weeks 76.4 (68.8-86)  10 weeks 79.9 (67.3-87.6)  26 weeks 80.5 (70.6-93)  38 weeks 79.9 (68.4-87.5)  <b>Carbohydrates (g)</b>  Preconception 182.2 (157.3-226.4)  6 weeks 182.9 (163.1-212)  10 weeks 199.4 (178.9-230.2)  26 weeks 206.7 (175-239.9)  38 weeks 191.8 (165-223.4)  <b>Fats (g)</b>  Preconception 91.6 (82-118.2)  6 weeks 91.9 (79.8-103.6)  10 weeks 98 (79.8-110.1)  26 weeks 97.3 (83.8-111)  38 weeks 92.9 (75.6-104.6)  <b>Animal proteins (g)</b>  Preconception 54.7 (46.7-62.8)  6 weeks 51.7 (43.6-58.7)  10 weeks 48.5 (40.6-58.2)  26 weeks 50.9 (42.9-64.3)  38 weeks 52.9 (43.6-65.1)  <b>Vegetables proteins (g)</b>  Preconception 17.7 (14.6-22.9)  6 weeks 19.1 (15.5-22.7)  10 weeks 21.3 (16.6-25.5)  26 weeks 20.5 (17.4-24.9)  38 weeks 18.6 (15.9-22.2)</p>	
Hellerstedt et	<b>Sample size:</b> 8827 (7174)	Retrospective	1-20 weeks	Daily Caffeine	Telephone	Caffeine:	Pregnancy intention:

al, 1997 (USA)	<b>Age:</b> 18-48yr <b>Gestation weeks:</b> Mean 8 weeks (1-20 weeks) <b>Weight category:</b> Not reported <b>SES or similar:</b> Employed - (82.7, 79.1, 68.8%) <b>Education:</b> 37% college degrees 12% graduate education <b>Ethnicity:</b> White – (89.1, 82.6, 77.7%) <b>Smoking:</b> Not reported <b>NCD's:</b> Not reported <b>Parity:</b> 65.5-94.9%		gestation		survey (yes/no, categorical questions)	<i>Preconception</i> (67.5, 69.8, 73.8) <i>Pregnancy</i> (26.0,28.6, 38.7) All changes are P <.01.	Women with intended pregnancies, compared to those who reported the pregnancy was unintended, were more likely to report decreased consumption of caffeine in pregnancy.
Kopp-Hoolihan et al, 1999 (USA)	<b>Sample size:</b> 10 <b>Age:</b> 29.1 ± 5 (21-36 yrs) <b>Gestation weeks:</b> n/a <b>Weight category:</b> 23.1 ± 2.1 (19-26 kg/m <sup>2</sup> ) <b>SES or similar:</b> Not stated <b>Education:</b> Not stated <b>Ethnicity:</b> Not reported <b>Smoking:</b> Not reported <b>NCD's:</b> Not reported <b>Parity:</b> 2 <sup>nd</sup> or 3 <sup>rd</sup> child	Prospective	T0 - Preconception (within 3months of pregnancy) T1, 2, 3 – Wk 8-10, 24-26, 34-36) TPost- 4-6 wk postpartum	RMR, DIT, TEE (active EE), EI and Body composition	3 day weighed food diary at each time point EI and Macronutrient content estimated at each time point from the 3d averaged values	<b>Energy intake only:</b> 9% increase from T0 – T3 T0 – 8569 ± 1842 T1 – 8488 ± 1624 T2 – 8496 ± 1654 T3 – 9344 ± 2170 TPost – 8367 ± 2624 Large inter-individual variation	None reported

Paulik et al, 2009 (Hungary)	<b>Sample size:</b> 349 <b>Age:</b> 16-45 years Mean = 29.94 years <b>Gestation weeks:</b> 28.7 ± 0.7 weeks <b>Weight category:</b> not stated <b>SES or similar:</b> 7.4% Single <b>Education:</b> 37.5% secondary education 37.2% higher education <b>Ethnicity:</b> Not reported <b>Smoking:</b> Not reported <b>NCD's:</b> 78.7% in good or very good health <b>Parity:</b> 56.4% primiparae	Retrospective	During pregnancy (average 28.7 weeks gestation)	Fruit, vegetables, milk, coffee	Questionnaire	P-values not reported <b>Fruit</b> (85.7% vs 94.8%) <b>Vegetables</b> (67.6% vs 75.4%) <b>Milk</b> (66.8% vs 60.2%) <b>Coffee</b> (56.2% vs 33.2%)	None Reported
Pinto et al, 2008  Portugal	<b>Sample size:</b> 249 <b>Age:</b> 29 years (SD5.8) <b>Gestation weeks:</b> First trimester <b>Weight category:</b> 57% normal weight before pregnancy Pre-Preg BMI <18.5 = 3.4% 18.5-24 = 57.4% 25-30 = 28.4% >30 = 10.5% <b>SES or similar:</b> Employment- Student = 19.8%; employed = 59.5%; unemployed = 20.7%	Prospective	FFQ1 – first antenatal visit in trimester 1 (preconception) FFQ2 – After delivery (for whole pregnancy)	Energy (kcal) CHO (%TEI) Fat (%TEI) SFA (%TEI) Protein (%TEI) Caffeine (mg)	Semi-Quantitative FFQ with pre-specified portion sizes	<b>Preconception vs pregnancy</b> Energy (kcal) 2393 vs 2423 CHO (%TEI) 49.5% vs 50.3% Fat (%TEI) 31% vs 30.6% SFA (%TEI) 10% vs 10.5 Protein (%TEI) 17.6% vs 18.4% Caffeine (mg) 64.8 vs 34.4	None reported

	<p><b>Education:</b>          &lt;6yr = 31.7%          7-9yr = 29.3%          10-12yr = 26.1%          &gt;12 = 12.9%</p> <p><b>Ethnicity:</b>          Not stated</p> <p><b>Smoking:</b> (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> tri)          (25%, 15.3%, 13.4%)</p> <p><b>NCD's:</b>          Not reported</p> <p><b>Parity:</b>          0 = 62.7%; +1 = 37.3%)</p>						
Skreden et al, 2014 (Norway)	<p><b>Sample size:</b> 575  <b>Age:</b> 28.1 years (SD 4.35)  <b>Gestation weeks:</b> 15 weeks gestation (range 5-20 weeks)  <b>Weight category:</b> healthy weight (70.2%), overweight category (21.9%), obese category (7.5%)  <b>Mean BMI:</b> 23.9 (SD 3.83)  <b>SES or similar:</b> Not reported  <b>Education:</b>          7-10 years 1.6%          10-12 years 12.9%          Completed high school 16.9%          &lt; 4 years university/college 33.1%          ≥ 4 yeayrs, 35.5%  <b>Ethnicity:</b> Not reported  <b>Smoking:</b> Not reported  <b>NCD's:</b> Not reported  <b>Parity:</b> Not reported</p>	Retrospective	15 weeks gestation (range 5-20 weeks) And 'before they got pregnant'	Milk, water, coffee, sugar-sweetened beverages (SSB), artificially sweetened beverages (ASB), fruit juice	Food frequency questionnaire (0-never, 10-several times daily)	<p>From pre-pregnancy to early pregnancy: the percentage of women drinking coffee decreased (38 % v. 10%, p&lt;0.001), SSB decreased (10 % v. 6%, p=0.011) and ASB (12 % v. 9%, P =0.001) decreased of those reporting drinking it daily.</p> <p>Percentage of women who reported at least daily consumption of water (85 % v. 92%, P&lt;0.001), fruit juice (14 % v. 20%, P=0.001) and milk (37 % v. 42%, P=0.001) increased.</p>	<p><b>Education:</b> Women with higher educational attainment reduced their frequency of at least daily coffee consumption (46% v. 12%) more than women with lower educational attainment (31% v. 9%; interaction timexeducation, P=0.005).</p> <p><b>Age (≥25 yrs vs &lt;25yrs):</b> Older women reported a larger decrease in at least daily consumption of artificially sweetened beverages (17% v. 11%) compared with younger women (7% v. 7 %; interaction timexage, (P=0.045).</p>

							<p>Older women increased their frequency of at least daily consumption of fruit juice (17 % v. 27%) and daily intake of milk (35% v. 43%) from pre-pregnancy to early pregnancy more than younger women (fruit juice: 11% v. 13%; interaction time×age, P=0.029; milk; (39 % v. 40%; interaction time×age, P=0.041).</p> <p><b>BMI:</b> No significant interactions found between BMI and changes in drinking habits from prepregnancy to pregnancy.</p>
<p>Smedley et al, 2014 (Australia)</p>	<p><b>Sample size:</b> 100 <b>Age:</b> 18 – 24 years = 11 &gt;25 years = 89 <b>Gestation weeks:</b> Postnatal (up to 12 months) <b>Weight category:</b> BMI: 18.5-25 = 69 25-30 = 20 30+ = 11 <b>SES or similar:</b></p>	<p>Retrospective</p>	<p>12 months post birth (retrospective pre-conception and during pregnancy)</p>	<p>Dietary intake</p>	<p>Self-complete questionnaire (5-point Likert scale)</p>	<p><b>Fruit (p 0.002)</b> Never (10 v 5) Sometimes (25 v 17) Always (65 v 78) <b>Veg (p 0.001)</b> Never (10 v 5) Sometimes (29 v 18) Always (61 v 77) <b>Fibre (p 0.001)</b> Never (22 v 8) Sometimes (23 v 16)</p>	<p>None reported</p>

	Employed = 91 Unemployed = 9 <b>Education:</b> High school = 20 Tech college = 22 University = 58 <b>Ethnicity: n/a</b> Country of Birth Oz = 70 Other = 30 <b>Smoking:</b> Non= 68 Ex = 18 Current = 4 <b>NCD's:</b> Not reported None <b>Parity:</b> 1 child = 88 1 + = 12					Always (55 v 76) <b>Fried Food (NS)</b> Never (56 v 67) Sometimes (34 v 28) Always (10 v 5) <b>Fast Food (P0.017)</b> Never (56 v 67) Sometimes (34 v 28) Always (10 v 5) <b>Sweet Bakery (NS)</b> Never (38 v 40) Sometimes (47 v 40) Always (10 v 20) <b>Sweet Dairy (NS)</b> Never (25 v 27) Sometimes (41 v 32) Always (34 v 41)	
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600 (SD=standard deviation, FFQ=food frequency questionnaire, NCD=Non-communicable diseases, RMR=Resting Metabolic Rate, DIT=Diet Induced Thermogenesis, TEE=Total

601 Energy Expenditure, EI= Energy intake

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602 **Supplementary Table 1:** Quality assessment of included studies

Author (year) / Checklist item	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.11	1.12	1.13	1.14	2.1
Aden et al, 2007	Yes	DNA	Yes	DNA	DNA	DNA	Yes	DNA	Can't Say	Yes	Yes	DNA	No	Yes	Acceptable
Crozier et al, 2009a	Yes	DNA	Yes	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Can't Say	No	Acceptable
Crozier et al, 2009b	Yes	DNA	Yes	No	DNA	DNA	Yes	No	No	Yes	Yes	Yes	Can't Say	Yes	High quality
Cuco et al, 2006a	Yes	DNA	Yes	DNA	DNA	DNA	Yes	No	Can't Say	Yes	Can't Say	Yes	Yes	Yes	Acceptable
Cuco et al, 2005b	Yes	DNA	Yes	DNA	DNA	DNA	Yes	No	Can't Say	Yes	Can't Say	Yes	Yes	Yes	Acceptable
Hellerstedt et al, 1997	Yes	DNA	Yes	DNA	DNA	DNA	Yes	DNA	Can't Say	Yes	No	No	No	Yes	Acceptable
Kopp-Hoolihan et al, 1999	Yes	DNA	Yes	DNA	DNA	DNA	Yes	No	No	Yes	Can't say	Yes	Can't Say	No	Acceptable
Paulik et al, 2009	Yes	DNA	Yes	DNA	DNA	DNA	Can't Say	DNA	Can't Say	Can't Say	No	Yes	No	No	Acceptable
Pinto et al, 2009	Yes	DNA	Yes	DNA	DNA	DNA	Yes	DNA	Can't Say	Yes	Can't Say	DNA	No	Yes	Acceptable
Skreden et al, 2015	Yes	DNA	Yes	DNA	DNA	DNA	Yes	DNA	No	Yes	Can't say	DNA	Can't Say	Yes	Acceptable
Smedley et al, 2014	Yes	DNA	Yes	DNA	DNA	DNA	Yes	DNA	No	Can't Say	Can't Say	DNA	Can't Say	No	Acceptable

603 DNA – does not apply

604

605 **Checklist items**606 **1.1** The study addresses an appropriate and clearly focused question607 **1.2** The two groups being studied are selected from source populations that are comparable in all respects other than the factor under investigation.

608 (Deemed not applicable in this review)

609 **1.3** The study indicates how many of the people asked to take part did so, in each of the groups being studied610 **1.4** The likelihood that some eligible subjects might have the outcome at the time of enrolment is assessed and taken into account in the analysis.611 **1.5** What percentage of individuals or clusters recruited into each arm of the study dropped out before the study was completed? (Applies to prospective  
612 studies only)613 **1.6** Comparison is made between full participants and those lost to follow up, by exposure status. (Applies to prospective studies only)614 **1.7** The outcomes are clearly defined.615 **1.8** The assessment of outcome is made blind to exposure status. If the study is retrospective this may not be applicable.616 **1.9** Where blinding was not possible, there is some recognition that knowledge of exposure status could have influenced the assessment of outcome617 **1.10** The method of assessment of exposure is reliable618 **1.11** Evidence from other sources is used to demonstrate that the method of outcome assessment is valid and reliable619 **1.12** Exposure level or prognostic factor is assessed more than once (In this review – has dietary intake been assessed more than once in  
620 pregnancy/postpartum?)621 **1.13** The main potential confounders are identified and taken into account in the design and analysis.622 **1.14** Have confidence intervals been provided?623 **2.1** How well has the study done to minimise the risk of bias or confounding?

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625 **Supplementary Table 2:** Details of studies excluded from systematic review and reason for exclusion.

Author	Year	Title and Journal	Reason for exclusion
Ådén et al.	2007	Energy and nutrients in self-reported diet before and at week 18-22 of pregnancy. <i>Scandinavian Journal of Food and Nutrition</i> 51(2): 67-73.	No diet data
Anderson et al.	2006	Prevalence of risk factors for adverse pregnancy outcomes during pregnancy and the preconception period -- United States, 2002-2004. <i>Maternal &amp; Child Health Journal</i> 10(5): S101-106 101p.	No diet data
Arija et al.	2004	Food consumption, dietary habits and nutritional status of the population of Reus: Follow-up from preconception throughout pregnancy and after birth." <i>Medicina Clinica</i> 123(1): 5-11.	Manuscript not in English
Backhausen et al.	2014	Pregnancy planning and lifestyle prior to conception and during early pregnancy among Danish women. <i>European Journal of Contraception &amp; Reproductive Health Care</i> 2014; <b>19</b> (1): 57-65.	No diet data
Bussell & Marlow	2000	The dietary beliefs and attitudes of women who have had a low-birthweight baby: a retrospective preconception study. <i>Journal of Human Nutrition &amp; Dietetics</i> 13(1): 29-39 11p.	Between subject design
Clark & Ogden	1999	The impact of pregnancy on eating behaviour and aspects of weight concern. <i>International Journal of Obesity</i> . 23, 18±24	Between subject design
D'Angelo et al.	2007	Preconception and interconception health status of women who recently gave birth to a live-born infant -- Pregnancy Risk Assessment Monitoring System (PRAMS), United States, 26 Reporting Areas, 2004." <i>MMWR: Morbidity &amp; Mortality Weekly Report</i> 56(SS-10): 1-35 35p.	No diet data
Grieger et al.	2016	"Asthma control in pregnancy is associated with pre-conception dietary patterns." <i>Public Health Nutrition</i> 19(2): 332-338 337p.	Between subject design
Harris et al.	2015	"Impact of rurality on maternal and infant health indicators and outcomes in Maine." <i>Rural &amp; Remote Health</i> 15(3): 1-17 17p.	No diet data
Inskip et al.	2009	Women's compliance with nutrition and lifestyle recommendations before pregnancy: general population cohort study. <i>British Medical Journal</i> . 338:b481	Between subject design
Jedrychowski et al.	2007	Pre-pregnancy dietary vitamin A intake may alleviate the adverse birth outcomes associated with prenatal pollutant exposure: epidemiologic cohort study in Poland." <i>International Journal of Occupational &amp; Environmental Health</i> 13(2): 175-180 176p.	No diet data
Kingsley et al	2012	Preconception health indicators among women - Texas, 2002-2010. <i>MMWR: Morbidity &amp; Mortality Weekly Report</i> 61(29): 550-555 556p.	Between subject design

Oza-Frank et al.	2015	Provision of specific preconception care messages and associated maternal health behaviors before and during pregnancy." <i>American Journal of Obstetrics &amp; Gynecology</i> 212(3): 372.e371-378 371p.	No diet data
Ramage et al.	2015	"Assessment of Pre-Pregnancy Dietary Intake with a Food Frequency Questionnaire in Alberta Women." <i>Nutrients</i> 7(8): 6155-6166 6112p.	Between subject design

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