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Abstract

Background

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

Aims

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

Methods

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

Findings

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

Key conclusions

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

Implications for practice

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

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

Introduction

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

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

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

Methods

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

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

Analysis

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

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

Results

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

Study characteristics

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

Quality assessment

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

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

Dietary intake change from preconception to pregnancy

Food Groups - Fruits and vegetables

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

Dairy

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

Meat and meat products

Two studies reported data on meat and meat products and the results varied greatly between studies (Pinto et al., 2008; Crozier et al., 2009a). Crozier et al. (2009a) reported an increase in processed meat consumption during early and late pregnancy, but reported no change in red meat, chicken, turkey or fish consumption during pregnancy. Crozier et al. (2009a) also reported that the proportion of women consuming meat such as liver and kidneys was 48% during pre-conception, and decreased to 22% in

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

Starchy Carbohydrates (CHO)

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

Sweet foods

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

Fast and Fried Food

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

Beverages

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

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

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

Energy and Macronutrients

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

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

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

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

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

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

Discussion

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

Dietary intake change before and during pregnancy

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

In terms of food group consumption, the most consistent findings are an increase in fruit and vegetable intake as well as an increase in dairy and a decrease in caffeine intake. An increase in fruit intake has also been reported in studies comparing pregnant to non-pregnant women (Anderson et al, 1993; Verbeke et al, 2007), although one study found little difference between these groups (Inskip

et al., 2009). Although fruit and vegetable intake was widely reported to increase during pregnancy, it cannot be assumed that all women adequately consumed the national recommendations for fruit and vegetable consumption per day. Smedley et al. (2014) reported that although fruit and vegetable consumption increased during pregnancy, only two thirds of participants reported consuming the recommend quantities of fruit and vegetable as suggested by the Australian public health guidelines (National Health and Medical Research Council, 2003). As fruit and vegetable intake is recommended as part of a healthy balanced diet, and their increased consumption is linked with a number of positive health outcomes (Slavin and Lloyd, 2012), the results indicate that more information should be provided to women before and during pregnancy on the importance of not only increased fruit and vegetable consumption but to ensure they reach the correct public health recommendations for their country.

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

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

In addition, the proportion of women consuming liver and kidneys was 48% pre-conception, 22% in early pregnancy and 16% in late pregnancy (Crozier et al., 2009a); this change in consumption is consistent with previous public health messages in pregnancy relating to the harmful effects of excess vitamin A consumption through liver consumption (NHS Choices, 2015), despite little scientific

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

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

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

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

Strengths and limitations

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

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

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

In addition, this review only included studies if they used a within-group study design. It must be acknowledged that studies using this design are subject to a number of limitations including practice effects and fatigue, with participants potentially becoming more attuned to detailing their dietary

intake practices, increasing the likelihood of miss-reporting. As such, this needs to be considered when interpreting the results. It must also be acknowledged that the review question could have been answered using other research designs such as comparisons between groups of pregnant and non-pregnant women. We have compared our review findings with evidence from such studies in the Discussion section, and shown that our findings are in line with these studies.

Implications and future directions

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

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

Conclusion

Dietary intake before and during pregnancy has significant implications for the mother and unborn child with a number of health outcomes related to poor dietary intake. The current literature available on women's change in dietary intake, using within-subject design, from before to during pregnancy is limited to a handful of studies using a variety of dietary intake recording methods on a wide range of dietary variables to collect data both prospectively and retrospectively and whose overall quality is acceptable or highly acceptable. The evidence suggests that a number of changes in dietary intake may take place during pregnancy (such as an increase in fruit and vegetable intake), but that a number of other key components relating to high energy dense foods are inconsistent which could have far

reaching implications in terms of energy balance and excess weight gain during pregnancy. Further research needs to be conducted investigating the changes in dietary intake before and during pregnancy prospectively, using this alongside records of weight gain and pregnancy outcomes in both mother and child to determine the longer term health implications of poor dietary intake.

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