Maternal & Child Nutrition

DOI: 10.1111/mcn.12158

Review Article

A systematic review of behavioural interventions to increase maternal calcium intake

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Abstract

Pregnancy and lactation are a time when adequate calcium consumption is essential for the development of the fetus and to ensure the health of the mother. Over 50% of Canadian women of childbearing and rearing age fail to meet the recommended daily intake of calcium. Identification of effective behavioural intervention strategies for increasing calcium intake is needed within this specific population. This paper brings together all published behavioural interventions designed to increase calcium consumption in pregnant, lactating or post-partum mothers in a systematic review. Relevant studies were obtained through searches of MEDLINE, EMBASE, PsycINFO, CINAHL and the Cochrane Library with no date restrictions. Studies were evaluated using previously published criteria for evaluating calcium behaviour change interventions. This systematic literature review identified five behavioural calcium interventions conducted within this population. Three interventions aimed to improve overall dietary behaviours, the fourth aimed to promote breastfeeding (including increasing calcium consumption) and the fifth aimed to increase daily servings of yoghurt. Only one of the five interventions yielded large effect sizes, with a mean change of 954 mg of calcium per day post-intervention. The number of behavioural change techniques did not appear to be related to intervention efficacy. Only one study used a theoretical framework to guide the intervention. This review highlights the lack of research examining behaviour change interventions aimed at increasing calcium consumption in pregnant, lactating and post-partum women and provides practical suggestions for researchers wishing to intervene with this population in the future.

Keywords: calcium interventions, pregnant, lactating, dairy, behaviour change, self-efficacy.

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Introduction

Pregnancy and lactation represent critical calcium consumption periods to ensure healthy development of the fetus and to maintain the health of the mother (Prentice 2000). Calcium is required for fetal skeletal growth during pregnancy, with an estimated calcium transfer of 250 mg per day by the third trimester (Oliveri *et al*. 2004). During lactation, approximately 300 mg of calcium is required each day in order to produce adequate breast milk (Kovacs 2001). The current Canadian and US guidelines recommend 1300 mg of calcium per day for women under 19 years of age during pregnancy and lactation. This recommended daily intake (RDI) drops to 1000 mg per day for women over 19, in line with the general Canadian and US population calcium RDI (Ross 2011). The most recent Canadian statistics suggest that over 50%

of women between 19 and 50 years of age are failing to consume the RDI of calcium (1000 mg; Health Canada, Statistics Canada 2009). Statistics from the United States tell a similar story, with only 41% of women aged between 19 and 50 consuming the RDI of calcium, even with the use of calcium supplementation (Bailey *et al.* 2010). While rates of underconsumption in pregnant and lactating women are not available, it is reasonable to assume that they are underconsuming at comparable rates to the national average.

Dairy products are considered more advantageous over non-dairy calcium-rich foods as a source of calcium because of the high calcium content and the bioavailability of calcium within these products. Furthermore, dairy products provide both protein and essential nutrients that the mother and fetus require to ensure efficient bodily function and development (Ortega 2001). Alarmingly, it has been reported that women are actively avoiding consumption of dairy products during pregnancy and lactation based on the belief that dairy products will promote allergies in newborns (Chandra 2000). In contrast to popular beliefs about associations of dairy with allergies, consuming dairy products during pregnancy has recently been linked to a decrease in child eczema and wheeze (Miyake *et al.* 2010), as well as reduced dental decay in children (Tanaka *et al.* 2010). Furthermore, failure to consume the minimum RDI of calcium during pregnancy has been associated with lower bone mineral content of infants (Koo 2006), reduced fetal mineralisation (Prentice 2000) and may increase a mother's predisposition to developing hypertensive disorders (Hofmeyr *et al.* 2010). Inadequate calcium consumption during lactation has been linked to a reduction in breast milk calcium concentration (Prentice 2000). This is concerning, given that approximately 87.3% of Canadian mothers report trying to breastfeed their child (Health Canada, Statistics Canada 2010). Given the numerous benefits associated with calcium consumption for both mother and child, it is essential to ensure that this important segment of the population is meeting the RDI of calcium.

While understanding the relationship between inadequate calcium consumption and fetal health during pregnancy and lactation has been of great research interest to biomedical researchers, there is a scarcity of research examining *how* to increase volitional consumption of dairy within pregnant and lactating women. To date, research aimed at increasing volitional consumption of dairy products has been limited largely to older women at risk of developing osteoporosis or children and young adults in the bone development phase. Few studies have examined dairy calcium consumption in pregnant and lactating mothers. Pregnancy and lactation represent a potential change in life-course perspective wherein new and expectant mothers shift their focus from taking care of solely themselves, to focusing on the health of their child, particularly in regard to nutrition (Szwajcer *et al.* 2007). This heightened awareness regarding nutritional behaviour comes with a desire to acquire new information on the best dietary choices to better the health of one's children (Szwajcer *et al.* 2005). Expectant and new mothers look for assistance from friends, family, experts and the Internet to seek out new information regarding

Key messages

- Very few interventions have attempted to increase volitional calcium intake in pregnant and lactating women, despite the known benefits of adequate calcium consumption for fetal and maternal health.
- Interventions aimed to improve overall maternal nutrition have been largely ineffective at positively influencing calcium consumption.
- Providing pregnant and lactating women with dairy or calcium-fortified foods is not a sustainable behavioural strategy.
- Future interventions in pregnant and lactating women aimed at increasing volitional calcium intake are encouraged to (1) use an evidence-based theoretical framework when developing intervention materials; (2) focus on calcium intake only; and (3) target intervention material to the population of interest.

nutrition (Szwajcer *et al*. 2005). Taken together, the heightened awareness of expectant and new mothers regarding healthy diets and the salient motives to consume adequate calcium may make this an opportune time in which to intervene to increase consumption of dairy products.

In order to successfully intervene, it is essential to examine previous behavioural strategies that have been used to increase calcium consumption during pregnancy and lactation. With this in mind, the purpose of this paper was to systematically review the research literature on behavioural interventions aiming to increase calcium consumption among pregnant and lactating women and provide practical recommendations for future research and public health strategies.

Objectives

The primary objective of this systematic review was to identify all published behavioural interventions designed to increase volitional calcium consumption in pregnant and lactating women. Building on this, the second objective was to establish the effectiveness of these interventions at increasing volitional calcium consumption and to identify characteristics of successful interventions. The third objective was to develop a set of practical strategies that could be used to guide future interventions to increase calcium consumption in pregnant and lactating women.

Methods

Search strategy

Three authors (MEJ, MJS, KAMG) developed the literature search strategy. The search strategy was based on the strategy employed in a previous systematic review of calcium intake interventions among adults (Jung *et al*., unpublished observations) and was then refined in consultation with a library scientist. Examples of search terms included: milk, calcium, dairy, calcium intake, dietary behaviour, behaviour change, pregnant, lactating and post-partum.[1] The complete search strategy can be obtained from the first author. Separate searches of published, English language articles were conducted in the following databases:

- MEDLINE (1946–June 2013, OVID Interface)
- EMBASE (1980–June 2013, OVID Interface)
- PsycINFO (1967–June 2013, OVID Interface)
- CINAHL (1989–June 2013)
- Cochrane databases (1898–June 2013)

Returned citations were exported to an online citation management system (RefWorks, Hamilton, Ontario, Canada). Duplicate citations were subsequently identified and removed from the database.

Screening and study inclusion/exclusion criteria

The second author scanned the title and abstract of each citation to determine if it met the following inclusion criteria: (1) intervention study (experimental or quasi-experimental design) of any duration with a focus on increasing calcium and/or dairy intake; (2) participants were pregnant, breastfeeding or post-partum women; and (3) primary outcome measures included calcium intake or dairy intake. Following this, the first and fourth authors reviewed all abstracts with titles that were highlighted as potentially meeting the inclusion criteria by the second author. Studies were excluded if the intervention focused exclusively on increasing the intake of calcium supplements as opposed to dietary sources of calcium. During the screening process, reviewers were not blinded to the study authors or journals. Three authors (MEJ, JEB, MJS) retrieved full articles for citations that met the inclusion criteria and read each one to confirm its inclusion in the review. Reasons for excluding articles were noted. Reference lists from relevant articles were scanned for any additional relevant articles. Figure 1 provides an overview of the full search process.

[1]Post-partum women, who may or may not have been breastfeeding, were included in the systematic review search terms to ensure all relevant studies aimed at increasing calcium consumption within expectant or new mother samples were captured.

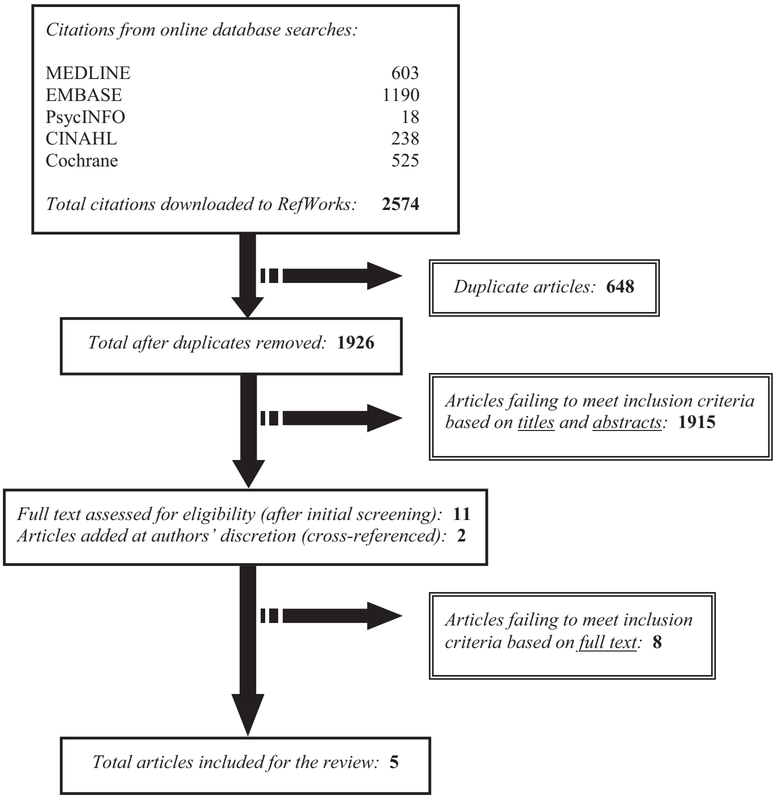

Fig. 1. Results of the literature search for calcium and dairy intake interventions.

Data extraction

Two authors (MJS and JS) followed a standardised protocol for extracting the following information from each article: study location (i.e. country), sample size, mean age of the sample, intervention intensity, intervention components, theoretical basis for the intervention and change in calcium and/or dairy consumption. Articles were not blinded during data extraction.

Hendrie *et al.*'s (2013) scaling system and methodology were used to calculate intervention intensity. Intervention intensity was based on ratings of four dimensions: intervention duration, frequency of contact, type of contact and reach. Intervention duration was coded using a categorical scale where 1 = <6 weeks, 2 = 6 to 11 weeks, 3 = 12 weeks to 5 months, 4 = 6 to 12 months and 5 = >12 months. Frequency of contact within the intervention was coded with a 5-point categorical scale: 1 = annually, 2 = bimonthly to quarterly, 3 = monthly, 4 = weekly and 5 = daily. Note that in one study (Schafer *et al*. 1998), insufficient information was provided to determine the exact duration of the intervention and the frequency of contact. For this study, conservative assessments were made based on the limited information provided (see Table 1). Type of contact was rated as follows: 1 = environmental (physical, policy or legislative level), 2 = environmental with a small group/ education component, 3 = group, 4 = group with an individual component (goal setting, homework task) and 5 = individual (one-on-one). The reach, or number of settings used to reach the target audience, was rated on a 3-point scale where 1 = one setting, 3 = two settings and 5 = three settings (there are no values for 2 and 4 because the maximum number of settings was 3). Scores for each rated dimension were summed to obtain overall intervention intensity; higher scores indicated greater intervention intensity, with a maximum possible score of 20.

Table 1. Characteristics of the interventions included in the review

First author	Sample size	Sample characteristics	Mean age	Treatment conditions	Contact	Duration	Type of contact	Reach	Total intensity score	Intake change	Effect size within group	Effect size between groups
Chan *et al.* (2006)	72	Pregnant	16.60	Orange juice + Calcium	4	3	5	5	17	+616 mg	1.72	2.26*, 0.73†
				Dairy	4	3	5	5	17	+954 mg	3.27	1.95*
				CONTROL						+27 mg	0.09	
Fung *et al.* (2010)	511	Pregnant/lactation/ post-partum	26.20	Experimental	3	1	5	3	12	+0.13*	0.00	0.08*
				CONTROL						+0.01*	−0.06	
Gray-Donald *et al.* (2000)	219	Pregnant	24.05	Experimental	3	3	5	5	16	Not reported		
				CONTROL								
Hunt *et al.* (1976)	344	Pregnant	25.00	Experimental	2	3	4	3	11	+193 mg	0.56	0.27*
				CONTROL						+117 mg	0.27	
Schafer *et al.* (1998)	72	Pregnant/post-partum	24.15	Experimental	2‡	3‡	5	2	12‡	+83.9mg†	0.31	
				CONTROL						Not reported		

*Based on 8 fl oz servings of dairy. †Based on mg of calcium/1000 kcal consumed. ‡Conservative assessment based on minimal information provided. *Contact:* 1 = annually, 2 = bimonthly to quarterly, 3 = monthly, 4 = weekly, 5 = daily. *Duration:* 1 = <6 weeks, 2 = 6 to 11 weeks, 3 = 12 weeks to 5 months, 4 = 6 to 12 months, 5 = >12 months. *Type of Contact:* 1 = environmental (intervening at the physical, policy, or legislative level), 2 = environmental with a small group/education component, 3 = group, 4 = group with an individual component (goal setting, homework task), 5 = individual (one-on-one personalised contact). *Reach:* 1 = one setting, 3 = two settings, 5 = three or more settings.

The components of each intervention were classified using the 40-item CALO-RE taxonomy (2011), which is a revised form of Abraham & Michie's (2008) 26-item taxonomy (CALO) for classifying healthy eating and physical activity behaviour change techniques. The CALO-RE (Michie *et al.* 2011) identifies and provides clear definitions of 40 behaviour change techniques (e.g. goal setting, action planning, barrier identification/problem solving) and has demonstrated good interrater reliability ($\kappa = 0.79$).

Intervention effect sizes were calculated as Cohen's *d*. When possible, *d* was calculated from means and standard deviations (SDs). Otherwise, *d* was calculated from the available descriptive or inferential statistics (e.g. F values, counts and percentages). Within-groups and between-groups effect sizes were calculated for both changes in dairy servings and changes in milligrams of calcium (see Table 1) for studies that provided such data.

Information and data extraction, coding and calculations were conducted individually by two authors (MJS and JS); who met with authors KAMG and MEJ to discuss any discrepancies and all were resolved through consensus.

In addition, the risk of bias in each study was assessed using a tool developed by the Cochrane Collaboration (Higgins *et al.* 2011). The tool covers six domains of potential bias: detection, selection, performance, attrition, reporting and other. For each domain, an assessment of risk of bias is made by first extracting relevant trial characteristics (e.g. blinding) and then judging whether the characteristics have low, high or unclear risk of bias of sufficient magnitude to have notable effect on the trial outcomes or conclusions. Tool users must decide which domains are most relevant within the context of a particular review (Higgins *et al.* 2011). Accordingly, biases associated with participant randomisation as well as the blinding of outcome assessments were our focus. The evaluations were made independently by two authors (KAMG and MJS) who subsequently met and resolved discrepancies through consensus.

Results

The initial search yielded 2574 papers to be considered for review. Five articles met all inclusion criteria (see Fig. 1 for the flow of papers through the screening process).

Study characteristics

The five intervention studies included in the review reported a total of six treatment conditions. Specifically, four studies had one treatment arm and one study (Chan *et al*. 2006) had two treatment arms. Four of the five studies were conducted in the United States and one was conducted in Canada (Gray-Donald *et al*. 2000). Three studies used randomised experimental designs (Hunt *et al*. 1976; Chan *et al*. 2006; Fung *et al*. 2010) while the other two used quasi-experimental designs (Schafer *et al*. 1998; Gray-Donald *et al*. 2000) such that participants were not randomly allocated to the treatment and control conditions.

Specific subsets of the population were targeted in each of the five studies. These included adolescent mothers, low-income earners, ethnic minorities, low-income earners who are also ethnic minorities and low-income earners from rural communities. Sample sizes ranged from 72 to 456 participants. The mean number of participants across studies was 220 (SD = 160). The mean age of participants was 23 years (SD = 4).

Intervention characteristics

The primary objective of three of the five intervention studies was to improve dietary behaviours among pregnant women, including consumption of calcium. A fourth intervention (Schafer *et al*. 1998) had a primary focus on promoting breastfeeding and increasing calcium consumption was part of the secondary goal of improving nutrition. The fifth study was focused on increasing daily servings of yoghurt among pregnant, lactating and post-partum women (Fung *et al*. 2010). Across the interventions, there was inconsistency in the measurement of calcium intake as well as the manner in which outcomes were reported. Four of the studies explicitly reported either number of dairy servings ($n = 1$), milligrams of calcium consumed from dairy ($n = 2$) and milligrams of calcium consumed from dairy per 1000 kilocalories consumed ($n = 1$). One study reported calcium intake in milligrams at baseline, but did not report post-intervention calcium intake (Gray-Donald *et al*. 2000). One study included calcium supplementation in the total calcium intake outcome (Chan *et al*. 2006).

Table 1 shows how each intervention was rated across the five scored dimensions. Regarding type of contact, most of the interventions were conducted in individual settings ($n = 4$) and one was conducted in a combination of individual and group settings ($n = 1$). All five interventions were delivered in person. One study also used radio broadcast to intervene (Gray-Donald *et al*. 2000).

With regard to theory, as shown in Table 2, only one intervention (Gray-Donald *et al*. 2000) used a guiding theoretical framework: the Social Learning Theory (Bandura 1986). The other studies either were atheoretical or did not provide sufficient information for conclusions to be made regarding the use of theory.

Outcomes

Four studies reported changes in calcium intake (measured in milligrams or servings of dairy) across intervention periods that ranged from less than 6 weeks (Fung *et al*. 2010) to 5 months (Chan *et al*. 2006). However, only Chan *et al*. (2006) found significant differences between control and treatment conditions and only Hunt *et al*. (1976) found significant within-groups differences. Within the treatment conditions, changes in calcium intake varied significantly (see Table 1). Gray-Donald *et al*. (2000) indicated that there were no significant differences in calcium intake between the treatment and control conditions post-intervention; however, they did not provide any descriptive or inferential statistics pertaining to this finding.

Effectiveness

A total of 13 effect sizes could be calculated from data provided in the studies (five between-groups effects and eight within-group effects). Effect sizes are

Table 2. Theoretical frameworks and behaviour change techniques used in each intervention

Study	Theoretical framework	Number of behaviour change techniques used	Behaviour change technique applied within the intervention*
Chan *et al.*			
Treatment arm 1 (Orange juice + Calcium)		2	Goal setting (behaviour)[5], prompt review of behavioural goals[10]
Treatment arm 2 (Dairy)		2	Goal setting (behaviour)[5], prompt review of behavioural goals[10]
Fung *et al.*		3	Education (consequences of behaviour in general)[1], education (how to perform behaviour)[21]
Gray-Donald *et al.*		3	Education (consequences of behaviour to individual)[2], prompt self-monitoring of behaviour[16], model/demonstrate the behaviour[22]
Hunt *et al.*		3	Education (consequences of behaviour to individual)[2], education (how to perform behaviour)[21], model/demonstrate the behaviour[22]
Schafer *et al.*	Social Learning Theory	1	Education (consequences of behaviour to individual)[2]

*Behaviour change techniques were classified using the CALO-RE taxonomy; superscript numbers correspond with the CALO-RE codes described by Michie *et al*. (2011).

reported in the final two columns of Table 1. Of the five between-groups effects, four were based on changes in milligrams of calcium per day and one was based on changes in dairy servings. Of the eight within-group effects, six were calculated as changes in milligrams of calcium per day and two were calculated as changes in dairy servings. Using Cohen's (1988) conventions for interpreting effect sizes (0.20 = small, 0.50 = medium, 0.80 = large), there were four large-, two medium- and three small-sized effects. The other four effect sizes were less than 0.20. Note that one study (Gray-Donald *et al*. 2000) provided insufficient information to calculate effect sizes, although the authors noted no significant between-groups differences.

Intervention characteristics associated with large effects

Table 2 shows the behaviour change techniques used in each intervention. Characteristics of the interventions (theoretical framework, behaviour change techniques, intensity) yielding the largest effect sizes were examined. The only study that yielded large effect sizes was conducted by Chan *et al*. (2006). Specifically, this study yielded large between-group effects, as well as large within-group effects. Chan *et al*.'s study was atheoretical and both arms utilised the same two-behaviour change techniques: goal setting (behaviour) and prompting review of behavioural goals. Specifically, the two treatment arms were given the goal to consume at least four servings of orange juice fortified with calcium per day (orange juice condition) or four servings of dairy products per day (dairy condition), depending on treatment arm allocation. To assess behaviour change, 24-h dietary recalls were completed on a randomised and unscheduled basis, prompting participants to review their intake goals. Both treatment arms had an intervention intensity score of 17. The interventions were delivered in a one-on-one format, with contact between interventionists and participants occurring weekly. It is important to note, however, that part way through the study, women in the orange juice condition were provided with calcium supplement tablets because they were unable to consume four daily servings of juice. Thus, the large effects observed in this condition are not necessarily reflective of effects solely attributable to drinking calcium-fortified orange juice. As with all of the studies included in our review, no follow-up data were provided to determine if the increase in calcium consumption was maintained once the intervention period ended.

Risk of bias

Two studies had risks of bias related to randomisation and blinding of assessments characterised as 'low' to 'unclear' (Chan *et al*. 2006; Fung *et al*. 2010). Two studies had 'high' risk of bias across these domains (Schafer *et al*. 1998; Gray-Donald *et al*. 2000). One study (Hunt *et al*. 1976) had 'low' to 'unclear' risk of bias related to randomisation and high risk of bias related to blinding of assessments.

Discussion

The objectives of this review were to (1) identify interventions focused on increasing calcium consumption in pregnant, lactating and post-partum women; (2) examine the effectiveness of these interventions and identify intervention characteristics common to all successful interventions; and (3) provide practical suggestions for future interventions based on research conducted to date. Of the 2574 papers that were identified, only five met all inclusion criteria and were included in the review. This review clearly highlights the lack of intervention research targeting calcium consumption in women who arguably need it most (i.e. those who are pregnant or lactating). Furthermore, the efficacy of these five interventions for eliciting volitional behaviour change was noticeably low, with only one of the five interventions being classified as effective.

The most effective study, with a low risk of bias relative to the other studies was conducted by Chan *et al*. (2006) and consisted of two treatment arms, designed to increase dietary calcium in adolescent mothers. One treatment arm aimed to increase dietary calcium through increased consumption of dairy products, while the second treatment arm aimed to increase dietary calcium through calcium-fortified orange juice. This intervention led to increases in calcium consumption of 616 mg in the orange juice treatment arm and 954 mg in the dairy consumption treatment arm, as compared with a calcium consumption increase of 27 mg in the control condition that was instructed to consume their regular diet.

In contrast, none of the interventions ($n = 3$) conducted with the goal of increasing overall healthy nutrition were effective. These interventions were conducted for varying reasons including (1) to reduce weight gain and gestational diabetes during pregnancy (Gray-Donald *et al*. 2000); (2) to increase breastfeeding behaviour (Schafer *et al*. 1998); and (3) to increase general nutrition (Hunt *et al*. 1976). Schafer *et al*. (1998) saw no changes in calcium consumption following the intervention, while Hunt *et al*. (1976) saw an increase in calcium consumption after the intervention, but this increase did not differ from what was seen in the control condition. Similarly, Gray-Donald *et al*. (2000) reported no differences in calcium intake between the control and intervention group at the end of the intervention.

These findings suggest that focusing on a discrete nutritional behaviour may be more beneficial than trying to change numerous nutritional behaviours at once. Focusing on one nutritional behaviour allows for more time and resources to be directed to positively impacting that single outcome. Furthermore, participants may view a discrete behaviour change as seemingly minor and therefore more manageable than a global change in diet, potentially leading to more potent changes. This finding is in line with observations made by Hendrie *et al*. (2013), who suggested that focusing on changing fewer behaviours is more effective than trying to completely overhaul a child's diet and Lutes *et al*. (2008), who demonstrated that modest changes in diet can lead to sustained dietary changes over 3 months.

The number of behaviour change techniques used within the five interventions was small (ranging from one to three). Our analyses indicated no link between number of behaviour change techniques used and intervention effectiveness, as based on effect size calculations. The most effective study (Chan *et al*. 2006), utilised two specific behavioural change techniques, including goal setting and review of these goals to encourage consumption. The remaining four studies utilised education as a key behaviour change strategy. Although education was the most widely reported behaviour change technique, there was no indication that it was associated with increased calcium consumption. A recent systematic review revealed that the relationship between nutrition knowledge and food intake is in fact weak (Spronk *et al*. 2014). Specifically, Worsley (2002) suggests that while knowledge is required, it is not sufficient to promote behaviour change alone, a view commonly accepted in many other health domains, such as exercise (Dishman 1982), energy conservation and alcohol consumption (Ajzen *et al*. 2011). In addition to knowledge, individuals must be taught how to manage their behaviour in order to obtain desired outcomes. Therefore, the 'how to' aspect of behaviour change is considered essential (Worsley 2002).

One study appeared to combine both knowledge and practical behaviour change strategies in an effort to reduce weight gain and gestational diabetes in a Canadian First Nations sample through increasing overall healthy nutrition (Gray-Donald *et al*. 2000). In addition, this was the only intervention that was guided by a theoretical framework (Gray-Donald *et al*. 2000), namely Social Learning Theory (Bandura 1986). Specifically, the intervention incorporated self-monitoring and modelling of behaviour techniques, in addition to education. These behaviour change techniques centred on the overall intervention goal of weight reduction with intervention activities such as exercise and walking groups, supermarket tours and cooking demonstrations. There were no activities within this intervention that specifically targeted changing calcium consumption. Unfortunately, the authors did not report changes in calcium intake before and after the intervention; however, calcium consumption did not differ between the treatment group and control group post-intervention. This intervention may have been unsuccessful at increasing calcium consumption for two reasons; first, given the numerous target outcomes of this intervention, the impact of specific behavioural change techniques on calcium per se may have been diluted. Second, the authors reported that the Cree women were not interested in the overall purpose of the intervention (i.e. weight loss), in fact being 'plump' was considered desirable. As such, the goals of the researchers did not align with those of the community.

As an additional behaviour change technique, Fung *et al*. (2010) examined the utility of providing vouchers for different dairy products for individuals enrolled in the Special Supplemental Nutrition Program for Women, Infants and Children in California. Specifically, the programme provides nutrition education and vouchers for food to individuals living on a low income. Fung *et al*. examined the impact of substituting milk vouchers for yoghurt vouchers on individuals' yoghurt consumption, as compared with providing no substitutions for the control group. The results revealed that participants reported a slight increase in yoghurt consumption following the intervention as compared with the control group ($P = 0.09$); however, there was no overall increase in total dairy consumption. This finding is not surprising given dairy product vouchers were provided in both conditions. The individuals in the study were changing their product consumption based on what was being made available to them via the vouchers. While changing behaviour through the provision of food products or vouchers for products may influence consumption, the long-term feasibility of this strategy is questionable.

Overall, this review demonstrates a paucity of research examining behaviour change interventions aimed at increasing volitional dietary calcium consumption in pregnant, lactating and post-partum women. Studies to date report limited detail within published papers, which subsequently reduces our ability to provide direct comparisons of effectiveness between studies. In addition, the studies did not appear to be particularly strong in methodological design. Greater rigour is needed in terms of ensuring random allocation to conditions and, particularly, blinding of those doing the nutritional assessments. Specifically, the person delivering the intervention should not be the same person measuring the effectiveness of that intervention (e.g. Hunt *et al*. 1976). What is apparent from the limited research conducted to date is that nutrition education on the benefits of calcium is not an effective enough strategy to increase volitional calcium consumption within this population. Rather, interventions should aim to target calcium intake, independent of other dietary behaviours, through individualised behaviour change strategies. Teaching individuals how to set realistic goals and practice the desired behaviour outside of the laboratory setting appear to be plausible techniques.

This systematic review evaluated interventions that had an *a priori* aim to increase volitional calcium intake, and thus is limited to interventions that purposefully developed strategies to increase consumption. While general nutrition interventions or campaigns may exist for pregnant, lactating or post-partum women that could inadvertently increase calcium intake, the specific purpose of this review was to uncover the most effective behavioural strategies for directly increasing calcium intake. This review represents the first systematic analysis to highlight which specific behavioural strategies are useful for increasing volitional calcium intake in this population.

It is strongly recommended that researchers wishing to intervene to improve pregnant, lactating and post-partum women's nutritional intake, incorporate a theoretical framework into their intervention plan. Theoretical frameworks provide researchers with an understanding of what factors to target in order to increase the likelihood of the desired behaviours occurring. In addition, a theoretical framework can assist in the development of evidence-based intervention guidelines that can be utilised by future researchers.

The final recommendation from this review is that interventions should target the needs of the specific population. Previous research conducted by Jung *et al*. (2011; unpublished observations) has demonstrated that while behaviour change techniques, such as goal setting, appear to be effective at influencing calcium consumption, directly targeting the population of interest will lead to significant changes in behaviour. Borra *et al*. (2003) highlight the importance of conducting preliminary qualitative research in order to identify the issues of concern to the population of interest. This information can be invaluable in the development of targeted interventions and can increase the chances of successful behaviour change (Keller & Lehmann 2008). Following this step-by-step process may be particularly important among pregnant, lactating and post-partum women who are entering a new chapter of life associated with new beliefs and values regarding their health and dietary choices (Szwajcer *et al*. 2007). As such, pregnancy and new motherhood represent an optimal time in which to intervene to increase calcium consumption. Effective interventions during this time would ensure that acute and long-term benefits of adequate calcium are accrued for both the mother and her child. Future research should seek to develop targeted behaviour-change material, based on a sound theoretical underpinning, with the aim of increasing volitional consumption of calcium among pregnant and lactating women.

Source of funding

This research was funded by the Dairy Farmers of Canada.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

MJ was Principal investigator and oversaw all parts of the review. MS and JS conducted the search and data extractions. JB and KMG assisted with the coding of data, bias assessments, and editing of this paper.

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Appendix S1. List of Search Terms Used.