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REVIEW ARTICLE

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Addressing obesity in the first 1000 days in high risk infants: Systematic review

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Abstract

Early intervention is critical for addressing the challenge of childhood obesity. Yet many preventive interventions do not target infants most at risk of future overweight or obesity. This systematic review examines interventions delivered before 2 years that aim to ameliorate excess weight gain among infants at high risk of overweight or obesity, due to sociodemographic characteristics, parental weight or health status, infant feeding or health behaviours. We searched six databases for interventions: (a) delivered before age two, (b) specifically aimed at infants at high risk of childhood obesity and (c) that reported outcomes by weight status beyond 28 days. The search identified over 27,000 titles, and 49 papers from 38 studies met inclusion criteria: 10 antenatal interventions, 16 postnatal and 12 conducted both before and after birth. Nearly all targeted infant and/or maternal nutrition. Studies varied widely in design, obesity risk factors, outcomes and quality. Overall, nine interventions of varying quality reported some evidence of significantly improved child weight trajectory, although effects tended to diminish over time. Interventions that improved weight outcomes tended to engage parents for a longer period, and most offered health professional input and support. Two studies of limited quality reported significantly worse weight outcomes in the intervention group.

KEYWORDS
childhood obesity, infant feeding, infant growth, maternal nutrition, physical activity, systematic review

1 | INTRODUCTION

Childhood obesity is a persistent global health issue. The World Health Organisation (WHO) estimates that in 2018, 40 million children under age five experienced overweight or obesity (World Health Organization, 2020). The consequences of childhood obesity are vital, both for the health and wellbeing of individuals and for national health systems. Childhood overweight and obesity are associated with higher risk of obesity in adolescence and adulthood (Herman et al., 2009), and multiple comorbidities (Guh et al., 2009).

Overweight and obesity in childhood and beyond are associated with several early life factors such as maternal and infant characteristics, sociodemographic attributes (Dubois & Girard, 2006; Lamb et al., 2010), and some cultural factors including preferences for larger infants (Cartagena et al., 2015; Hill et al., 2012; Kuswara et al., 2016; Rehayem et al., 2020; Wandel et al., 2016). Childhood overweight and

obesity are associated with poor early nutrition, including limited or no breastfeeding, and early introduction of complementary foods (Appleton, Russell, et al., 2018; Mihrshahi & Baur, 2018; Monasta et al., 2010; Woo Baidal et al., 2016). Excess weight gain may also relate to limited physical activity (Mihrshahi & Baur, 2018), birthweight, unsettled infant sleep patterns (Taylor et al., 2011, 2018) and parenting behaviour, including pressure to eat or use of food as reward (Russell et al., 2016). Another risk factor is rapid weight gain (RWG), defined as an increase in weight-for-age *z*-score of >0.67 standard deviations, that is, the crossing of two or more weight percentile lines, between birth and 2 years (Goodell et al., 2009). The antenatal period is critical, given evidence on how prenatal exposures influence the weight trajectories of infants and children. Longitudinal studies have identified greater risks of overweight among children of parents with overweight and obesity; those exposed to diabetes in utero (Catalano & Shankar, 2017; Gademan et al., 2014; Isganaitis et al., 2017; Lamb et al., 2010; Liao et al., 2019; Weng et al., 2012; Woo Baidal et al., 2016; Yu et al., 2013); or those born via elective caesarean section (Cai et al., 2018; Liao et al., 2019).

Given the early genesis of many risk factors, intervention is essential before dietary and activity behaviours become habitual. Interventions for school-aged children miss the opportunity to change behaviour early, as increasing numbers start school with existing overweight or obesity (Mihrshahi & Baur, 2018). Pregnancy and infancy present ideal opportunities for action; parents often seek health advice during this period of rapid change and may be willing to adopt healthier behaviours to protect infants against later obesity (Birch & Ventura, 2009).

To address this challenge, health practitioners and researchers have developed and evaluated initiatives targeting the rich opportunity offered during the 1,000 days from conception to age two (Blake-Lamb et al., 2016; Reilly et al., 2017; Woo Baidal et al., 2016). These approaches aim to support parents to adopt healthy eating and increase physical activity prior to birth or in early in infancy (Blake-Lamb et al., 2016; Campbell & Hesketh, 2007; Hennessy et al., 2019; Hesketh & Campbell, 2010; Laws et al., 2014; Matvienko-Sikar et al., 2018; Redsell, Edmonds, et al., 2016). Many interventions take a population-wide approach to preventing excess weight gain, targeting all pregnant women or all infants during infancy (Blake-Lamb et al., 2016; Ciampa et al., 2010; Hennessy et al., 2019; Hesketh & Campbell, 2010; Matvienko-Sikar et al., 2018; Rotevatn et al., 2019). Despite widespread evidence about potential risk factors, early interventions that focus specifically on infants who already have an increased risk of obesity are less common than universal programmes. A focus on interventions targeting children at higher risk could yield valuable insights for obesity prevention internationally and help target scarce health resources.

Several recent systematic reviews have focused on obesity prevention interventions for infants under 2 years (Blake-Lamb et al., 2016; Ciampa et al., 2010; Matvienko-Sikar et al., 2018; Redsell, Edmonds, et al., 2016; Rotevatn et al., 2019). Two more specifically considered young children from disadvantaged backgrounds (Laws et al., 2014; Russell et al., 2016), but not other risk factors. A recent narrative review of systematic reviews on infant feeding interventions for children aged 0–2 years focused on general interventions aimed at preventing overweight and obesity (Koplin et al., 2019). Similarly, systematic reviews of antenatal interventions typically focus on general populations (Blake-Lamb et al., 2016; Redsell, Edmonds, et al., 2016), although they may include individual studies involving women with risk factors such as high body mass index (BMI) or gestational diabetes. Many reviews of interventions for overweight and obesity during pregnancy report only maternal or neonatal outcomes such as birthweight or complications (Dodd et al., 2010; Flannery et al., 2019). Currently, we are not aware of reviews focussed exclusively on infants at increased risk of overweight or obesity that report outcomes beyond the neonatal period.

This systematic review therefore aims to explore interventions up to 2 years of age intended to prevent excess weight gain in infants specifically identified as having increased risk of developing overweight or obesity. It identifies interventions delivered during the postnatal period (0–2 years) and during pregnancy for parents whose characteristics increase their children's risk of excess weight gain, and it examines outcomes reported as infant or child weight status beyond 1 month of age.

Key messages

- Early intervention is critical to addressing unhealthy weight gain during infancy, to avoid obesity and related comorbidities in childhood, adolescence and adulthood.
- Although many nutrition interventions are aimed at general populations of infants, fewer are targeted specifically to infants with identified risks of overweight and obesity related to socio-demographic factors, feeding behaviour or parents' weight status.
- Studies of targeted interventions vary widely in design, duration, target population and quality.
- Successful interventions involved early childhood health professionals and recruited participants early, in order to support infants' health and well-being.
- There is scope for high-quality research investigating longer term effects of targeted interventions delivered in infancy and prior to birth.

2 | METHODS

2.1 | Research questions

This systematic review addresses the following questions:

1. What health, behavioural or demographic factors (including baseline sociodemographic characteristics) do researchers use to

predict infants at increased risk of overweight or obesity, for example, income or maternal education?
2. What are the elements of interventions aiming to prevent excess weight gain in infants at increased risk?
3. What interventions (or specific elements of interventions) are effective in reducing the risk of obesity among these young children?

The reviews followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines for systematic reviews (Moher et al., 2009). The review protocol was registered with Prospero (https://www.crd.york.ac.uk/prospero/), number CRD100138.

2.2 | Inclusion criteria

2.2.1 | Study design

The review included original experimental and quasi-experimental studies, including pre-test/post-test design, regardless of underlying theoretical base. We excluded systematic reviews from the results but assessed all studies included in these systematic reviews for eligibility.

2.2.2 | Participants

The review focused on two interrelated groups:

1. Healthy infants aged 0–2 years at increased risk of overweight and obesity. Regardless of the evidence regarding risk factors, we included studies where the authors stated specifically that they targeted characteristics potentially associated with childhood obesity, including low maternal education, specific ethnic backgrounds (e.g., Latin or native American families), low family income [e.g., families eligible for Special Supplemental Nutrition Program for Women's, Infants, and Children (WIC)], high birthweight, prenatal exposure to tobacco, formula feeding, early weaning, short sleep duration and RWG before age two (Appleton, Laws, et al., 2018; Collings et al., 2017; Pearce et al., 2013; Taveras et al., 2010; Van Den Berg et al., 2013; Weng et al., 2012; Woo Baidal et al., 2016; Wright et al., 2016; Zheng et al., 2018).
2. Parents with one or more characteristics linked to increased risk of childhood overweight and obesity, including high pre-pregnancy BMI, previous infants born large-for-gestational-age, excess gestational weight gain and/or with gestational or type 1 diabetes, and elective caesarean section (Cai et al., 2018; Monasta et al., 2010; Olson et al., 2009; Pei et al., 2013; Weng et al., 2012; Woo Baidal et al., 2016; Yu et al., 2013; Zhu et al., 2016). We also considered environmental and behavioural factors (e.g., parental smoking or intention to formula feed) (Liao et al., 2019).

2.2.3 | Interventions

The review focused on interventions aimed at preventing and managing excessive weight gain among infants identified with specific risk factors. Interventions were commenced prior to the age of 2 years, including pregnancy. Although formula feeding is a well-established obesity risk factor, we excluded studies that compared different compositions of infant formula, for example, levels of protein, given considerable literature on this topic (Escribano et al., 2012; Gruszfeld et al., 2016; Koletzko et al., 2009), including reviews (Patro-Golab, Zalewski, Kolodziej, et al., 2016; Patro-Golab, Zalewski, Kouwenhoven, et al., 2016).

2.2.4 | Comparison

Intervention studies were included if they utilised a control or comparison group receiving 'usual care', or a different intervention, or compared results with outcomes prior to programme implementation.

2.2.5 | Outcomes

The review selected studies reporting at least one quantitative weight outcome based on measures used in routine clinical care of infants (weight and length). Outcomes were reported as specified in the studies and included mean weight, proportions with overweight or obesity (defined by study authors), BMI, weight-for-length, weight-for-age and/or associated *z*-scores. We excluded anthropometric outcomes that require specialised equipment or training to measure.

2.2.6 | Setting

The review included research from any country, conducted in clinical and home-based settings, but not schools, pre-schools or childcare centres. Centre- and community-based interventions tend to be universal and not targeted to individual risk factors.

2.2.7 | Exclusion criteria

We excluded studies not published in peer-reviewed English-language journals or prior to 2008, the cut-off date for a comprehensive review of obesity prevention interventions for children aged 0–5 years old (Hesketh & Campbell, 2010). We also excluded studies reporting: non-primary research; instrument development; non-human subjects; the causes, prevalence or effects of obesity; intervention cost-effectiveness; attitudes or knowledge of health professionals or parents; infant formula composition; weight gain in infants whose growth is compromised by illness, prematurity or undernutrition; centre-based interventions; or universal interventions not targeted to

TABLE 1 Search strategy

Population terms	Obesity-related terms	Intervention-related terms
Infan*	Rapid weight gain	Weight control
Baby	Excess weight gain	Weight management
P(a)ediatric	Obes*	Obesity treatment
Toddler	Overweight	Obesity control
Under two (years)	BMI	Obesity management
	Body mass index	Intervention
	Weight for length	Dietary behavio(u)r
	Rapid growth	Dietary control
	Body weight	Nutrition intake
	Adipos*	
MeSH terms[a]	*MeSH terms*	*MeSH terms*
Infant	Body mass index	Diet, reducing
	Pediatric obesity	Obesity management
	Body weight changes	Weight reduction programs
	Infant nutrition disorders	Nutrition therapy

[a]Medical subject headings.

a defined risk factor. We also excluded observational studies of cohorts that did not receive an intervention or those that did not report a quantifiable weight outcome.

2.2.8 | Information sources

During June–July 2018, we searched six databases: Cumulative Index of Nursing and Allied Health Literature (CINAHL), EBM Reviews Complete, Embase, Joanna Briggs Institute EBP, Medline and ProQuest Nursing and Allied Health. We updated the database search in June 2020. Further, we hand-searched reference lists and forward citations of selected articles using Scopus for further relevant studies.

2.3 | Search

After a preliminary search to identify potential search terms, we used the terms in Table 1, combining all terms within each column with OR, then combining the three columns with AND.

2.4 | Study selection

The output from the database searches was transferred to Covidence for screening and to eliminate duplicates (https://www.covidence.org). One reviewer (CR) then removed titles clearly outside the scope of the review (pre-2008, animal studies and studies of older children/adolescents). Two reviewers (CR and HC) then independently screened the titles and abstracts of articles to assess relevance to the review questions. They then independently examined full text articles to confirm eligibility for the review. Disagreements about whether to include articles were resolved by the senior researcher (EDW). The search and review process is summarised in a PRISMA chart (Moher et al., 2009).

2.5 | Data extraction

One author extracted data on study characteristics (Table 2) including participant characteristics and risk factors, research design, outcomes and key findings relevant to the review questions, summarised to show differences between intervention and control cohorts, using measures and levels of statistical significance as reported by authors. This table summarises results that are often complex and multifaceted, especially in studies using stratified samples or multiple weight outcome measures. Another table presents further detail of interventions (theoretical framework, content, setting, provider, frequency and duration) (Table 3). Data extraction was cross-checked by another author.

2.6 | Quality assessment

Two researchers (CR and HC) independently assessed individual studies for research quality using the Mixed Methods Assessment Tool (MMAT) (Pluye et al., 2011), taking account of different study designs. Conflicts were resolved by the senior researcher (EDW). Ratings on relevant criteria are in Table S1. For MMAT items on completeness of outcome data, we adopted an acceptable drop-out rate of 20% for studies up to 12 months after intervention and 30% for longer follow-up.

2.7 | Synthesis of results

Given the heterogeneity of the interventions, outcome measures and the age at which children were assessed in identified studies, meta-analysis of the findings was inappropriate. Results are synthesised narratively.

3 | RESULTS

3.1 | Identification of studies

The database searches yielded 27,363 citations; subsequent hand-searching identified another 196 potential titles. After screening titles and abstracts, we reviewed 665 full-text articles and excluded 616 (Figure 1). The most common reason for excluding studies was

TABLE 2 Study characteristics and results *N* = 49 articles (38 studies)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
Risk factor—low income/socioeconomically disadvantaged							
Chaparro et al., 2019. USA.	To assess whether the effect of the 2009 Women, Infants, and Children (WIC) food package change on obesity outcomes varies by initial weight status and gender.	Cross-sectional study with matched samples at two time points. 2003–2016	Children in low-income families participating in WIC programme, Los Angeles county.	Children born after October 2009 in families receiving new WIC food package. *N* = 53,075 aged 0–5 (*n* aged 1 year at exposure not recorded).	Matched children who turned 5 before October 2009, receiving previous WIC food package. *N* = 53,075 aged 0–5 (*n* aged 1 year at exposure not recorded).	zWFH scores stratified by initial weight status at 1 year (low, average and high zWFH) and by gender. Measured by WIC staff every 6–12 mo. *Secondary outcomes not specified.*	*At 4 years* For children aged 1 year at exposure, mean zWFH was significantly lower in I group in all weight strata: zWFH—*boys:* *Low initial zWFH group:* Mean difference = **−0.17 (99% CI: −0.24 to 0.10), $p < 0.01$** *Average initial zWFH:* Mean difference = **−0.21 (99% CI: −0.25 to 0.16), $p < 0.01$** *High initial zWFH* Mean difference = **−0.15 (99% CI: −0.22 to 0.07), $p < 0.01$** zWFH—*girls:* *Low initial zWFH group:* Mean difference = **−0.19 (99% CI: −0.26 to 0.11), $p < 0.01$** *Average initial zWFH:* Mean difference = **−0.20 (99% CI: −0.25 to 0.16), $p < 0.01$** *High initial zWFH* Mean difference = **−0.15 (99% CI:**

(Continues)

TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
							−0.22 to 0.08), $p < 0.01$
Cloutier et al., 2018. Early Childhood Obesity Prevention—ECHO. USA	To test the feasibility of obesity prevention in children in first year of life.	Cluster RCT of two versions of home visiting (HV) programme, Nurturing Families Network (NFN). Recruited November 2013 to December 2014.	Mother/newborn dyads attending Brighter Future Family centre in low-income, underserved areas of Hartford, Connecticut.	NFN+: Standard NFN plus additional education and support about BF, goal setting, skills in behavioural strategies and links to community programmes to support healthy behaviour change. Delivered by NFN home supervisors. *N* = 26 baseline, 24 at 6 mo and 22 at 12 mo.	Standard NFN using parents-as-teachers curriculum. Weekly HV for 2 mo, then biweekly HV, focus on child development, parenting and family well-being. *N* = 21 baseline, 17 at 6 mo and 12 at 12 mo.	*Primary outcomes:* BF extent and duration; timing of solids; SSB/juice consumption; infant sleep patterns; TV viewing. *Secondary outcome:* Infant zWFL at 6 and 12 mo.	*At 6 months* WFL BMI: I = 17.5 (1.5) C = 16.9 (2.0), $p = 0.37$, NS zWFL: I = 0.4 (1.1) C = 0.9 (2.7), $p = 0.61$, NS *At 12 months* WFL BMI: I = 17.4 (1.6) C = 17.3 (1.0), $p = 0.83$, NS zWFL: I = 0.2 (1.2) C = 0.8 (2.4), $p = 0.51$ NS
de la Haye et al., 2019. USA	To explore whether the composition of mothers' social networks, based on the characteristics of network members, is associated with intervention outcomes.	Randomised pilot test. Dates not stated	Low-income families in California actively receiving home visiting programme (HVP) after their child's birth.	Standard HVP (see control) plus obesity prevention elements to deliver evidence-based nutrition and activity components and behavioural strategies to at-risk families. *N* = 30 baseline, 17 at 6 mo.	Standard HVP curriculum focusing on strengthening parent–child relationships and family functioning, promoting positive child development and linking to community resources. *N* = 20 baseline, 9 at 6 mo.	zWFL, classified as at-risk for overweight (zWFL > 1) at 6 mo. *Secondary outcomes not specified*	*At 6 months* Mean (SD) change in WFL (baseline—post): I = 1.58 (2.6) C = −0.29 (1.23) [Pilot test only—statistical analysis not reported due to small *n*]
French et al., 2012. USA	To evaluate the effect of two anticipatory guidance (AG) styles directed at mothers of infants aged 0–6 months on their infant feeding behaviours at 1 year	Cluster randomised trial. Recruited June 2005 to March 2006.	Low-income families, with children 0–2 mo, attending well-child visits at three paediatric primary care clinics in Columbus, Ohio.	Three-arm trial. Two AG interventions delivered in handouts by health professionals: Mother-focused [MOMS] aimed at	Usual care (UC), pre-existing nutrition guidance following Bright Futures. *N* = 99 baseline, 64 at 12 mo.	Infant height and weight, child feeding questionnaire, infant nutrition, measured at 12 mo. *Secondary outcomes not specified*	*At 12 months* zWFH/WFL: UC = 0.41 MOMS = 0.39 OP = 0.64, NS.

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
	compared with routine advice.			maternal eating habits. *N* = 99 baseline, 61 at 12 mo. Infant-focused [Ounce of Prevention, OP] with detailed programme for infant feeding, portion sizes and satiety cues. *N* = 95 baseline, 59 at 12 mo.			
da Costa Louzada et al., 2012. Vitolo et al., 2012. Brazil	To assess if maternal dietary counselling reduces sugar-dense and lipid-dense food intake in infants at 12 months (Vitolo et al., 2012); and food consumption, nutritional status and lipid profile of children at 7–8 years old (da Costa Louzada et al., 2012).	RCT with blinded randomisation. Infants born October 2001 to June 2002.	Mothers of healthy singleton, full term and normal birth weight infants, recruited from a hospital serving low-income families in San Leopoldo, Brazil.	Ten home visits with dietary counselling on exclusive BF and healthy complementary feeding during first 12 months, delivered by trained, paired undergraduate nutrition students as fieldworkers. *N* = 200 at baseline, 163–166 at 12- to 16-mo follow up (varies between papers), 149 at 3–4 y, 131 at 7–8 y.	Recommended standard care. Two interviews for data collection only (nutritional diagnoses provided and referred to health professionals), with fieldworkers at 6 and 12 mo. Advice to attend local health care provider if infant weight abnormal at 6 mo. *N* = 300 at baseline, 230–234 at 12- to 16-mo follow up (varies between papers), 195 at 3–4 y, 177 at 7–8 y.	*Primary outcome at 12 mo*: Intake of sugar-dense and lipid-dense foods. Infant overweight (zBMI > 1.5) calculated and used as independent variable. *Primary outcome at 7-8 y*: Lipid profile at 3–4 and 7–8 y. *Secondary outcomes at 7–8 y*: Food intake, anthropometric data at 12–16 mo, 3–4 y and 7–8 y. Overweight defined as zBMI > + 1. Obesity defined as zBMI > + 2. Obesity defined as zBMI > + 2.	*At 12–16 months* Overweight: *Boys*: I = 32.3% C = 33.8%, NS *Girls*: I = 39.7% C = 40.0%, NS Obesity: *Boys*: I = 6.5% C = 7.7%, NS *Girls*: I = 13.7% C = 11.0%, NS *At 3–4 years* Overweight: *Boys*: I = 19.3% C = 18.3%, NS *Girls*: I = 25.8% C = 20.9%, NS Obesity: *Boys*: I = 4.8% C = 3.7%, NS *Girls*:

(Continues)

TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
							I = 10.6% C = 3.5%, NS *At 7–8 years* Overweight: *Boys:* I = 31.6% C = 26.3%, NS *Girls:* I = 29.1% C = 24.4%, NS Obesity: *Boys:* I = 15.8% C = 26.3%, NS *Girls:* I = 12.7% C = 10.3%, NS
Machuca et al., 2016. Well Baby Group Trial. USA	To evaluate the effectiveness of a novel group well-child care intervention for primary obesity prevention at age 2 years.	Non-randomised observational comparison group design. Recruited 2007–2011.	Families with infant aged < 2 months attending health Centre serving low-income, predominantly minority population in south Bronx, New York.	Well Baby Group (WBG), facilitated by a paediatrician and nutritionist, to foster positive dietary behaviours, responsive parenting and feeding practices, and peer support via 11 × 2-hr group sessions during the first 18 mo. N = 47 at baseline	Traditional one-on-one well-child care. *N* = 140 at baseline.	*Primary outcome:* BMI-for-age ≥ 85th percentile at 2 years.	*At 2 years* BMI ≥ 85th percentile: I = 2.1% C = 15.0%, **OR = 0.12 (95% CI: 0.02 to 0.94), *p* = 0.02.** After adjusting for confounders **aOR = 0.12 (95%CI: 0.02 to 0.93), *p* = 0.04.**
Navarro et al., 2013. Dominican Republic	To reduce both malnutrition and the risk of overweight in the first 2 years of age.	Quasi-experimental study in paired geographic areas matched on socio-economic and cultural characteristics. Recruited April 2005 to September 2007.	Low-income families in 16 areas of Dominican Republic.	Monthly home visits and fortnightly small group meetings with education on nutrition, child safety, newborn care, prevention and treatment of infection diseases,	Did not receive intervention. *N* = 337 mother–child dyads at baseline, 259 at follow-up.	*Primary outcomes:* zLFA, prevalence of stunting (zLFA < −2), mean zBMI for age, prevalence of BMI for age >85th percentile (at risk for overweight).	*At 13–24 months* Mean (SD) zBMI: I = 0.13 (0.94) C = 35 (0.92) **Adjusted effect = −0.31, *p* = 0 .001.** Proportion BMI > 85th percentile: I = 15.5%

(Continues)

TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
				delivered by trained peers. *N* = 266 mother–child dyads at baseline, 193 at follow-up.			C = 22.4% **aOR = 0.43 (95% CI: 0.23 to 0.77), *p* = 0 .005.** zBMI +2: I = 1.6% C-3.5%, *p* = 0.209, NS.
Thomson et al., 2018. Delta Healthy Sprouts. USA	To determine if infant growth outcomes differed between treatment arms of an 18-month, maternal, infant and early childhood home visiting project.	Randomised parallel controlled trial. Recruited March 2013 to December 2014.	Women > 18 living in lower Mississippi Delta with singleton pregnancy (first, second or third pregnancy <19-week gestation)	Parents as Teachers Experimental arm (PaTE): PaT with additional culturally tailored, maternal weight management and early childhood obesity components. These included supplemental nutrition and physical activity lessons and materials. *N* = 39 baseline, 21 at 12 mo.	Parents as Teachers (PaT) curriculum: One-on-one HV, optional monthly group meetings, developmental screening and resource network. *N* = 43 baseline, 25 at 12 mo.	*Primary outcomes:* Weight status—WFL and WFA percentiles, zWFL and zWFA. Overweight defined as WFL > 97.7th percentile based on WHO growth curves. RWG defined as increase from birth in zWFA > 0.67 SD. Assessed using time-to-event analysis (median months to event occurring). *Secondary outcomes:* Dietary intake and health behaviours of mothers and infants	*At 12 months* Overweight: I = 75.0% C = 73.3%, NS Overweight median survival time (95% CI): I = 3.6 (1.25–10.71) C = 2.9 (1.35–6.37), NS RWG: I = 75.0% C = 73.3% RWG median survival time (95% CI): I = 6.0 (3.58–10.20) C = 7.0 (3.94–8.84), NS
Watt et al., 2009. Scheiwe et al., 2010. Infant Feeding Peer Support Trial. United Kingdom.	To ascertain if monthly home visits from trained volunteers could improve infant feeding practices at 12 months (Watt et al., 2009) and 4 years (Scheiwe et al., 2010) in a	Single-blind RCT with blinded allocation and assessment. Recruited December 2002 to February 2004, infants born September 2002 to November 2003. Qualitative follow up with phone or face to face	Low-income mothers with non-professional job occupation, with full-term, singleton, normal birth weight babies aged <12 w, recruited from baby clinics in two disadvantaged neighbourhoods of	Monthly home visits with trained volunteer mothers on introducing solids, appropriate foods for infants and cessation of feeding bottles. *N* = 157 baseline, 115 at 12-mo follow up, 104 at 18-mo	Usual support from health visitors and GPs. *N* = 155 baseline, 124 at 12-mo follow up, 108 at 18-mo follow up, 46 at 4-y follow up.	*Primary outcome at 12 mo:* Vitamin C from fruit *Primary outcome at 4 y:* Height, weight, BMI (only at face to face interviews), general and oral health, dietary habits, mothers' nutritional	*At 12 months* Mean (SD) infant weight (kg): I = 10.3 (1.2) C = 9.9 (1.15), *p* = 0.05 *At 18 months* Mean (SD) infant weight (kg): I = 11.6 (1.3)

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
	lower income population.	interviews at 4 years.	London where Sure Start programme operated.	follow up, 55 at 4-y follow up.		knowledge and confidence, infant feeding practices with subsequent children (n = 43 - too small for analysis) *Secondary outcomes at 12 mo:* Infant nutritional intake, feeding practices and anthropometric outcomes at 12 and 18 mo, including caloric intake, weight, length, exclusive BF for <4 mo, introducing solids, regular F&V consumption.	C = 11.3 (1.4), p = 0.12 *At ~4 years* Mean BMI for both groups (n = 86) was 16.3, with 9.3% of all children had overweight and 7.0% obesity. Mean difference = 0.42 (95% CI: −0.40 to 1.24), NS
Wen, Baur, Simpson, et al., 2012; Wen et al., 2015. Healthy Beginnings Trial. Australia	To assess the effectiveness of a home-based early intervention on children's BMI at age 2 (Wen, Baur, Simpson, et al., 2012) and sustainability at 5 years (Wen et al., 2015). The intervention aimed to improve infant feeding practices, eating habits, and active play and to reduce TV viewing time, and family behavioural risk	Single-blind RCT. Recruited 2007–2008.	Women pregnant with first child, living in socially and economically disadvantaged area of Sydney, attending antenatal clinics at 24- to 34-w gestation.	Eight home visits from specially trained community nurses delivering a staged home-based intervention, once at 30- to 36-w gestation, and at 1, 3, 5, 9, 12, 18 and 24 mo of age. Timing of visits designed to coincide with early childhood developmental milestones. N = 337 baseline, 255 at 24-mo follow-up, 191 at 5-y follow up.	Usual care from child and family health nurses, including 1 + HV; home safety information at 6 and 12 mos. N = 330 baseline, 242 at 24 mo follow-up, 178 at 5-y follow up.	*Primary outcome at 2 y:* Infant BMI at 2 y *Secondary outcomes at 2 y:* Infant eating habits; TV viewing time; active play time. Analysed with complete cases only (n = 483) and multiple imputation (n = 497) with missing values replaced by imputed values. Intention to treat analysis (n = 667) imputed the values from 184 missing cases.	*At 2 years* *Complete case analysis* Mean (SD) BMI: I = 16.49 (1.76) C = 16.87 (1.62) **Difference = 0.38 (95% CI: 0.08 to 0.68), p = 0.01** *Multiple imputation analysis* Mean (SD) BMI: I = 16.49 (1.76) C = 16.87 (1.62) **Difference = 0.38 (95% CI: 0.08 to 0.68), p = 0.01** *Intention to treat analysis* Mean (SD) BMI: I = 16.53 (0.2)

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
	factors for childhood obesity.					*Primary outcome at 5 y*: Infants' BMI and zBMI at 3.5 and 5 y. *Secondary outcomes at 5 y*: Infant eating habits; TV viewing time; active play time at 3.5 and 5 y.	C = 16.82 (0.18) **Difference = 0.29 (95% CI: 0.02 to 0.5), *p* = 0.04** Overweight + obesity: I = 11.2% C = 14.1% Difference = 2.9% (95%CI: −3.0 to 8.3), NS *At 3.5 years* Mean (SD) BMI: I = 16.74 (1.93) C = 16.80 (1.64), aDiff = 0.15 (95% CI: −0.16 to 0.46), p = 0.33, NS Mean (SD) zBMI: I = 0.89 (1.29) C = 0.97 (1.06), aDiff = 0.08 (95% CI: −0.12 to 0.28), *p* = 0.44, NS Overweight + obesity: I = 27.4% C = 29.6%, *p* = 0.34, NS *At 5 years* Mean (SD) BMI: I = 16.31 (1.70) C = 16.28 (1.56), aDiff = 0.27 (95% CI: -0.01 to 0.56), *p = 0.06, NS* Mean (SD) zBMI: I = 0.65 (1.04) C = 0.63 (0.97), aDiff = 0.17 (95% CI: −0.0004 to 0.36), *p* = 0.06, NS Overweight + obesity: I = 22.6%

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Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
							C = 21.7%, p = 0.73, NS
Risk factor—ethnicity							
Karanja et al., 2010. TOTS Intervention. USA	To test (1) the feasibility of delivering community-wide interventions, alone or in combination with family-based interventions, to promote BF and reduce the consumption of SSBs; and (2) whether these interventions decrease zBMI scores in children 18–24 months of age.	Cohort study with matched comparison group from 2 years earlier (paired pre-test). Recruitment dates not reported.	Expectant mothers from three American Indian (AI) tribes Northwest Portland Area Indian Health Service (Idaho, Oregon, Washington).	Three cohorts (Tribes A, B and C) received tailored community-wide intervention to raise awareness, provide health education, aid behaviour change, augment public health practice and modify environments related to BF, SSB and water consumption. Plus 2 cohorts (Tribes B and C) also received family intervention: 7–21 HV by community health workers, delivered flexibly according to families' needs. Some visits prenatal. N = 63 (Tribe A) + 62 (B) + 80 (C) = 205 enrolled. 53 + 56 + 69 = 178 completed trial.	Comparison data from matched pairs of children born in same tribes 2 years earlier, N = 205.	BF status and weight and length/height (zBMI, zWFH and zWFL) at 6, 12, 18 and 24 mo. To account for community-specific growth patterns, data from infants in trial were paired with data from another child matched for gender, birth month and age at 18–24 mo measurement point. *Secondary outcomes not specified.*	*From 0 to 24 months* zBMI: *Tribes B + C* I = 2.18 (1.80) C = 2.01 (1.50) *Tribe A* I = 2.92 (1.82) C = 2.03 (2.22) zWFA change: *Tribes B ± C* I = 0.89 (1.46) C = 0.75 (1.24) *Tribe A* I = 1.57 (1.64) C = 1.22 (1.75) *Intervention effect* Tribe A vs. Tribes B + C: –0.24, p = 0.173 Lower rate of increase in zBMI in tribes B + C shows moderating effect of family component of the intervention, but not in zWFA.
Palacios et al., 2018. USA	To test the effects of weekly SMS for improving infant feeding practices and infant weight.	Multi-site RCT. Dates not reported.	Healthy term infants 0–2 months participating in WIC clinics in Puerto Rico and Hawaii (infant obesity is higher, and exclusive BF is	Standard WIC care and receipt of weekly short messaging service (SMS) for improving feeding practices for 4 mo.	Standard WIC care and receipt of weekly SMS messages about general infant health issues. N = 100 baseline, 86 after 4 mo.	Nutrition assessment, anthropometric measures (including zWFL scores) and infant feeding practices measured at end of trial (after 4 mo).	*Between baseline and 4–6 mo visit* RWG between visits (>0.67 SD change): I = 44.1% C = 51.9%, p = 0.363, NS *At 4–6 months*

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Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
			lower, in Hispanics and native Hawaiians)	*N* = 102 baseline, 84 after 4 mo.		*Secondary outcomes not specified.*	Obesity (zWHL > 2): I = 25.6% C = 27.4%, *p* = 0.777, NS
Washio et al., 2017. USA	To examine the effect of monthly financial incentives contingent on observed breastfeeding in addition to WIC breastfeeding support on maintaining breastfeeding.	Randomised controlled trial. Recruited February 2015 to February 2016.	Low-income Puerto Rican women enrolled in WIC programme who had initiated BF recruited at maternity hospital in Philadelphia.	Usual BF support through WIC and monthly financial incentives contingent on continued BF ($20 at the end of the first month and increased by $10 every month until the end of 6 months). *N* = 18	Usual BF support through WIC (on-site lactation support, peer counselling, peer support meetings, breast pump and food package). *N* = 17	Mean infant weight; zWFA scores at 1, 3 and 6 mo. *Secondary outcomes not specified.*	*At 6 months* Mean (SD) infant weight (g) I = 7610.3 (950.5) C = 7726.4 (1294.1), NS Mean (SD) zWFA I = 0.67 (0.48) C = 0.86 (0.77), NS
Risk factor—adolescent or young mothers (±low income)							
Ordway et al., 2018. Minding the Baby programme. USA	To examine whether a prevention-focused home visiting (HV) intervention based on a socioecological model could decrease the rate of childhood overweight and obesity early in life, with a focus on prevention for Hispanic children.	Prospective longitudinal cohort study with cluster randomisation. Data from pilot testing 2002–2008 and efficacy trial 2008–2016.	First-time, young mothers (14–25 y) who lived in low socio-economic status (SES) medically underserved communities, receiving prenatal care at two inner-city community health centres (CHC) in Connecticut.	Parenting intervention that aimed to enhance parent–child attachment and maternal reflective functioning with weekly HV from social worker and paediatric nurse from third trimester to first birthday, then biweekly to second birthday. *N* = 95 baseline, 92 at 24 mo (Hispanic subsample *n* = 71)	Standard group prenatal and primary care at both CHCs. *N* = 106 baseline, 66 at 24 mo. (Hispanic subsample *n* = 39) NB control infants were significantly heavier at birth.	*Primary outcome:* Prevalence of overweight (≥85th percentile) or obesity (≥95th percentile) in children at 2 years	*At 24 months*: In healthy weight range: **I = 78.3%** **C = 63.6%, *p* = 0.03** Mean (SD) BMI: **I = 16.8 (1.3)** **C = 17.7 (2.3), *p* < 0.01** Mean (SD) zBMI: **I = 0.19 (1.00)** **C = 0.68 (1.12), *p* = <0.01** Obesity: I = 3.3% C = 19.7% **aOR = 0.12 (95% CI: 0.03 to 0.47), *p* < 0.05.** *Hispanic children only*: **aOR = 0.14 (95% CI: 0.03 to 0.53), *p* < 0.05.**

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Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
							Overweight + obesity: I = 19.6% C = 33.3% aOR = 0.52, 95% CI: 0.24 to 1.11 NS *Hispanic children only:* **aOR = 0.32, 95% CI: 0.13 to 0.78, $p < 0.05$**
Schwartz et al., 2015. Brazil	To assess the effect of a pro-BF and healthy complementary feeding intervention, targeted to adolescent mothers and maternal grandmothers, on growth and prevalence of overweight and obesity in children at preschool age.	RCT. Recruited May 2006 to January 2008.	Mothers aged <20 and maternal grandmothers (where they cohabited), recruited at public hospital in Porto Alegre.	Counselling sessions on BF and healthy complementary feeding, delivered by nurses, dietitian and physician at maternity ward (1–3 days) and at home at 7, 15, 30, 60 and 120 days. Initial sessions separate for mothers and grandmothers, jointly thereafter. *N* = 163 at baseline, 98 at 4–7 y (*n* = 30 grandmothers)	Standard maternity ward care. *N* = 160 at baseline, 109 at 4–7 y. (*n* = 25 grandmothers)	*Primary outcome*: BF rates. *Secondary outcomes:* Infant feeding data measured monthly until 12 mo, then bimonthly. BMI for age, height for age (HFA) and data on dietary habits at 4–7 y.	*At 4–7 years*: Mean (SD) zBMI for age: I = 0.87 (1.37) C = 0.73 (1.33), $p = 0.461$, NS Mean (SD) HFA: I = 0.12 (0.93) C = -0.01 (1.04), $p = 0.331$, NS Overweight + obesity: I = 38.8% C = 31.2%, $p = 0.318$, NS
Risk factor—high maternal BMI and/or gestational weight gain (±low income)							
Carlsen et al., 2013. Denmark	To evaluate whether telephone-based support could increase the duration of breastfeeding in women with obesity and, thereby, reduce offspring growth.	Randomised trial. Recruited December 2010 to June 2012.	Healthy singleton infants <48 h old; mothers with pre-pregnancy BMI ≥ 30 kg/m^2, who had participated in earlier study (TOP trial) to minimise GWG at a University Hospital in Hvidore.	Telephone-based advisory support service delivered by certified lactation consultant, aimed to prolong duration of exclusive and partial BF. Mean of 6.9 sessions during first 6 mo starting in first week. *N* = 105, 90 at 6 mo.	Standard postnatal care from health visitor and standard BF support at local hospital. *N* = 102, 102 at 6 mo.	*Primary outcome*: BF rates *Secondary outcome:* Infant weight, length, abdomen and head circumference measured at baseline and 6-mo triceps and subscapular skinfolds at 6 mo.	*At 6 months* Mean (SD) infant weight (g): I = 8,169 (963) C = 8,356 (959), $p = 0.18$, NS WFL and BMI > 2 NS difference (data not reported) WFL and BMI > 3 NS difference (data not reported) Mean (SD) zBMI:

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Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
							I = 0.16 (1.02) C = 0.22 (1.03), NS Mean (SD) zWFH: I = 0.28 (1.01) C = 0.33 (101), NS
Claesson et al., 2016. Sweden	To estimate the effect of a GWG restriction programme for pregnant women with obesity on the children's early weight for length/height (WFL/WFH) development and BMI at 5 years.	Follow-up study of case–control intervention. Recruited 2004–2006.	Pregnant women with BMI ≥ 30 kg/m^2 attending antenatal clinic (ANC) in Linkoping, Sweden.	Individual weekly visits during pregnancy and every 6 mo during the first 2 y after childbirth, with a specially trained midwife aiming to change behaviours regarding nutrition and physical activity. Invitation to join aqua aerobic classes especially designed for women with obesity. *N* = 157 baseline, 137 at 5-y follow-up	Pregnant women with obesity from nearby cities, who received routine ANC programme. *N* = 196 baseline, 165 at 5-y follow-up.	WFL and WFH measured at 2, 6, 12 and 18 months and 4 and 5 years. BMI and zBMI at 5 years. *Secondary outcomes not specified.*	*At 5 years* *Girls* Mean (SD) BMI: I = 16.7 (1.94) C = 16.3 (1.97), *p* = 0.139, NS Mean (SD) zBMI: I = 0.063 (1.04) C = −0.144 (1.06), *p* = 0.139, NS ≥ + 1SD over national mean BMI: I = 37.1% C = 32.1%, NS *Boys* Mean (SD) BMI: I = 16.7 (1.87) C = 16.6 (1.69), *p* = 0.783, NS Mean (SD) zBMI: I = 0.089 (1.01) C = 0.029 (0.91), *p* = 0.783, NS ≥ + 1SD over national mean BMI: I = 33.8% C = 36.6%, NS *When stratifying by maternal GWG (<7 kg vs ≥7 kg),* the only significant difference in findings: boys whose mothers had <7 kg GWG, *p* = 0.039, but after

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Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
							adjusting for sociodemographic factors and BF, $p = 0.407$. All other stratified results NS difference between I and C groups.
Dodd, McPhee et al., 2018; Dodd, Louise et al., 2018. LIMIT Trial. Australia	To evaluate the effect of an antenatal dietary intervention in women with overweight or obesity on infant outcomes 6 months after birth (Dodd, McPhee et al. 2018) and at 18 months (Dodd, Louise et al. 2018).	Follow-up study of multicentre randomised trial. Recruited June 2008 to December 2011.	Women with singleton pregnancy with BMI ≥ 25 kg/m^2, at three maternity hospitals in Adelaide.	Lifestyle advice throughout pregnancy, including dietary, exercise and behavioural strategies (goal setting, self-monitoring), delivered by dietitian and research assistants. *N* = 1,071 baseline, 869 at 6 mo, 816 at 18 mo.	Standard antenatal care. *N* = 1,065 baseline, 885 at 6 mo, 786 at 18 mo.	*Primary outcomes:* Infant zBMI >85th centile and zBMI > 90th centile for infant sex and age. *Secondary outcomes:* Several infant anthropometric measures, neurodevelopment, general health, and infant feeding.	*At 6 months* zBMI > 85th centile: I = 27.9% C = 28.5% aRR 0.97 (95% CI: 0.84 to 1.13), $p = 0.71$, NS zBMI > 90th centile: I = 21.7% C = 21.9% aRR 0.99 (95% CI: 0.82 to 1.18), $p = 0.882$, NS Mean (SD) zBMI: I = 0.37 (1.17) C = 0.38 (1.16) aRR = −0.01 (95% CI: −0.12 to 0.09), $p = 0.792$, NS *At 18 months* zBMI > 85th percentile: I = 47.1% C = 45.4% aRR 1.04 (95% CI: 0.94 to 1.16), $p = 0.454$, NS zBMI > 90th percentile: I = 38.0% C = 37.0%

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Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
							aRR 1.02 (95% CI: 0.90 to 1.15), p = 0.779, NS Mean (SD) zBMI: I = 0.96 (1.17) C = 0.92 (1.06) aRR 0.03 (−0.07 to 0.14), p = 0.547, NS.
Fiks et al., 2017. Grow2Gether. USA	To test the impact of a peer-group intervention delivered via private Facebook group on feeding practices, sleep, parenting and maternal wellbeing.	RCT. Recruited March to August 2014.	Medicaid insured (low-income) mothers with pre-pregnancy BMI ≥ 25 kg/m^2. Enrolled at 20-32w gestation at two high-volume obstetric clinics in Philadelphia.	Four Facebook peer groups, focused on healthy parenting and infant growth, from 32-week gestation, including short videos. Plus 2 in-person meetings. Facilitated by psychologist. *N* = 43 at enrolment, 34 at 9 mo.	Received text messages for infant primary care visits. *N* = 42 at enrolment, 37 at 9 mo.	*Primary outcome:* Feeding-related behaviour measured using Infant Feeding Style Questionnaire (IFSQ) assessed at 6 and 9 mo. *Secondary outcomes:* Infant weight and length measured at age 2, 6 and 9 mo.	*At 9 months* Mean zWFL (estimated from figure 4 using WebPlot digitizer): I = 0.54 C = 0.45, NS
Gregory et al., 2016. Nutrition in Pregnancy intervention. USA	To assess the growth profiles of infants born to overweight pregnant women participating in a clinic to limit GWG.	Retrospective cohort study. Intervention group recruited late 2011 to April 2014. Controls recruited January 2009 to December 2011.	Pregnant women receiving Medicaid with pre-pregnancy BMI ≥ 30 kg/m^2, attending tertiary referral centre in Baltimore.	Participants late 2011 to April 2014. Fortnightly visits until 36/40, then weekly with obstetrician/NP and nutritionist who provided general nutrition education. *N* = 61 dyads.	Participants January 2009 to December 2011. Attendance at same centre to receive regular prenatal care. *N* = 145 dyads, matched on age, BMI category, race, parity, hypertension and history of preterm birth.	*Primary outcome:* Weight for length (WFL) percentile at 12 mo. *Secondary outcomes:* Crossing two major WFL percentiles in 6 months; and peak BMI in infancy >17 kg/m^2 associated with subsequent obesity.	*At 6 months* WFL ≥ 90th percentile I = 31% C = 28%, p = 0.71, NS *At 12 months* Mean (SD) percentile WFL: I = 67th (29th) C = 62nd (30th), p = 0.36 WFL ≥ 95th percentile: I = 17% C = 15%, p = 0.66, NS *Between 6 and 12 months* Crossed ≥2 major percentiles: I = 31%

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
							C = 28%, p = 0.71, NS NB this is different to figure shown in data table Peak BMI > 17 kg/m^2: I = 89% C = 87%, p = 0.75, NS
Kong et al., 2014. USA	To compare postpartum weight retention and offspring outcomes of women with overweight and obesity who enrolled in an unsupervised walking intervention during pregnancy with control group; and to examine the association between trimester specific GWG rates with infant anthropometric outcomes at 1 and 6 months.	Randomised controlled trial	Women with singleton pregnancy, self-reported overweight (BMI > 25 kg/m^2) or obesity (BMI > 30 kg/m^2) before pregnancy, engaged in <30 min three times pw leisure time physical activity (PA), recruited via mass email to staff, students and faculty of university, online advertisement or flyers in local community, hospitals and obstetric clinics in Iowa.	Unsupervised walking intervention to promote moderately intense PA (150 + minutes pw preferably spread through the week) during weeks 15–35 wk gestation, using treadmills. No dietary advice as part of intervention. *N* = 19 at baseline, 15 at 6-mo follow-up.	No access to PA advice or treadmills but not restricted from participating in PA. *N* = 23 at baseline, 19 at 6-mo follow-up.	Infant length, weight and body composition, converted to *z*-scores and ponderal index, at 1 and 6 mo. *Secondary outcomes not specified*	*At 6 months* NS difference between groups in infant measures, although infants of women with obesity in I group remained smaller from birth to 6 mo. Mean (SD) WFL: *Infants of women with obesity* I = 0.17 (0.71) C = 1.04 (1.26), p = 0.430, NS. *Infants of women with overweight (n = 17)* I = 0.26 (0.76) C = 0.04 (1.47), NS
Mustila et al., 2013, 2018. VACOPP Study. Finland	To report the effects of antenatal dietary and PA counselling on pregnancy and infant weight gain outcomes at 12 months (Mustila et al., 2013) and up to 6 years of age (Mustila et al., 2018).	Nonrandomised controlled pragmatic trial. Recruited 2008–2010.	Women with singleton pregnancies at risk of GDM (BMI > 25 kg/m^2, macrosomic newborn, previous GDM, family history of diabetes or age ≥ 40) at all 8 maternity and all 14	At-risk women, pregnant February 2009 to April 2010. Counselling on diet and PA by municipal health-care staff (nurse, dietician and physiotherapist), starting at end of first trimester of pregnancy and	Mothers attending maternity and child health care centres with infants born in 2008. Usual care, prior to intervention. *N* = 89 baseline, 89 at 12 mo, 76 at 6 y.	*Primary outcome at 12 mo:* BMI and proportion of children with overweight or obesity. *Secondary outcomes at 12 mo:* Differences in weight-for-length standard deviation score	*At 12 months* Mean (SD) WFL SDS: I = 0.09 (1.06) C = 0.06 (1.11) p = 0.85, NS Mean (SD) BMI: I = 17.2 (1.4) C = 17.2 (1.60), p = 0.89, NS WFL ≥ 10%: I = 17.2%

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Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
			child health care clinics in Vaasa.	continuing at yearly appointments with a public health-nurse at clinics. *N* = 127 baseline, 96 at 12 mo, 71 at 6 y.		(SDS) and changes in weight-for-length SDS at 0, 4, 6 and 12 mo; absolute BMI differences in the groups, and the proportions of infants with overweight and obesity. *Primary outcome at 6 y:* BMI and proportion with overweight (WFH > 10%) or obesity (WFH > 20%) at 6 years, assessed as BMI SDS; ISO-BMI (i.e., proportions on track for adult overweight (BMI > 25 kg/m^2) or obesity (BMI > 30 kg/m^2) if child's BMI stayed the same).	C = 20.2%, *p* = 0.60, NS WFL > 20%: I = 3.2% C = 1.1%, *p* = 0.62, NS *0–12 months* Mean (SD) change in WFL SDS: I = 0.16 (1.20) C = 0.14 (1.39), *p* = 0.89, NS Change in WFL ≥ 0.67 SDS: I = 34.4% C = 34.8%, *p* = 0.95, NS *6–12 months* Mean (SD) change in WFL SDS: I = –0.02 (0.74) C = –0.14 (0.66), *p* = 0.28, NS Change in WFL ≥ 0.67 SDS: I = 14.0% C = 12.4%, *p* = 0.75, NS *At 6 years* Overweight: I = 20.0% C = 22.4%, *p* = 0.73, NS ISO-BMI ≥ 25: I = 18.3% C = 19.7%, *p* = 0.83, NS Obesity: I = 12.9% C = 13.2%, *p* = 0.96, NS ISO-BMI ≥ 30: I = 9.9%

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
							C = 11.8%, p = 0.70, NS
Parat et al., 2019. ETOIG study. France.	To evaluate whether pre and perinatal education of pregnant women would reduce childhood overweight up to the age of 2 years.	Multicentre RCT. Recruited September 2008 to September 2010.	Pregnant women 18 + years, up to 21 weeks gestation, with pre-pregnancy BMI > 25 kg/m^2, attending four maternity hospitals.	Therapeutic education programme, using individually tailored plan with strategies to achieve lifestyle changes in diet and PA, infant nutrition; face-to-face interviews with dietitian, and group sessions (at 21-, 28-, 35-week gestation and 2-mo post-partum). Women diagnosed with GDM referred to MDT and received individual dietary advice and insulin treatment. *N* = 132	General oral and written information about diet and exercise at baseline visit to dietician at 26 weeks; option of additional visit to dietician. *N* = 136. NB. APGAR score at 5 min was significantly lower in the intervention group than in the control group (median 10 (0–10) vs. 10 (7–10), p = 0.028).	*Primary outcome*: Infant weight gain from birth to 2 years. Excessive weight gain defined as >0.67 change in weight SD score 0–2 yrs. *Secondary outcomes:* Excessive infant weight gain from 0 to 6 mo, LGA infants, BMI > 19 kg/m^2 at 2 years, BF rates and age of food diversification. Analysed using intention to treat model (missing values treated as excessive weight gain) and available data analysis.	*At 2 years* *Intention-to-treat model* Excessive postnatal weight gain 0–2 years: I = 59.1% C = 60.3% RR = 0.98 (95% CI: 0.80 to 1.19), p = 0.84, NS. BMI > 19 kg/m^2: I = 23.5% C = 29.4%, p = 0.27, NS *Available data analysis* Excessive postnatal weight gain 0–2 years: I = 47.1% C = 48.1%, RR = 0.98 (95% CI: 0.73 to 1.30), p = 0.88, NS BMI > 19 kg/m$^{2:}$ **I = 0%** **C = 6.8%, p = 0.014.** *Per protocol analysis* excessive postnatal weight gain 0-2 years: I = 45.8% C = 50.0%, RR = 0.92 (95% CI: 0.67 to 1.25) p = 0.57, NS. BMI > 19 kg/m^2: **I = 0%** **C = 6.4%, p = 0.03.**

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Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
Patel et al., 2017. UK Pregnancies Better Eating and Activity Trial (UPBEAT). UK	To determine whether an antenatal lifestyle intervention for pregnant women with obesity and associated with improved maternal diet and reduced GWG leads to a reduction in infant adiposity and sustained improvements in maternal lifestyle behaviours at 6-month postpartum.	Postnatal follow up of RCT of a complex behavioural intervention. Recruited July 2010 to May 2015	Pregnant women with pre-pregnancy BMI ≥ 30 kg/m^2, recruited at 15 to <19-week gestation at eight NHS trust hospitals in the United Kingdom.	Intense behavioural intervention targeting improved insulin sensitivity through PA and reduced dietary GI and saturated fat intake. *N* = 783 at baseline, 765 infants at birth, 342 at 6 mo.	Standard antenatal care. *N* = 772 at baseline, 757 infants at birth, 356 at 6 mo.	*Primary outcome:* Infant adiposity measured by skinfold thickness (SFTM) at triceps and subscapular. *Secondary outcomes:* Total body fat, weight, abdominal and upper mid-arm circumferences, converted to *z*-scores.	*At 6 months* Mean (SD) zBMI: I = −0.07 (1.86) C = 0.04 (1.78), aRR = -0.12 (95% CI: −0.40 to 0.16), *p* = 0.393, NS
Phelan et al., 2019. Fit Moms/Mamas Activas. USA	To examine whether a 12-month internet-based weight loss intervention for postpartum mothers had a positive ripple effect on participants' infants.	Cluster RCT. Recruited July 2011 to May 2015	Low-income women 6-week to 12-mo post-partum, either with overweight/ obesity or exceeding pre-pregnancy weight by ≥4.5 kg, attending WIC clinics in California.	12-month internet-based weight loss programme for mothers; text messages and monthly face-to-face groups. *N* = 159	Standard WIC care + written information on weight control, exercise, nutrition and wellness (not specifically child-related). *N* = 174 NB infants in control group had significantly higher zBMI and WFA at birth.	*Primary outcome:* Infant zBMI at 0, 6 and 12 mo. *Secondary outcomes:* Skinfolds at 0, 6 and 12 mo. Food intake diary.	*0–6 months* Mean change in zBMI: I = 0.23 C = 0.65 **Between group difference = 0.40 (95% CI: 0.16 to 0.63), *p* = 0.001** *0–12 months* Mean change in zBMI: I = 0.62 C = 0.81 Between group difference = 0.19 (95% CI: −0.08 to 0.46), *p* = 0.16, NS
Reifsnider et al., 2018. McCormick et al., 2020. USA	To assess whether parent education, initiated prenatally and provided in the home, would reduce the incidence of infant overweight at	Prospective randomised controlled study. Recruited March 2013 to October 2014.	Healthy, pregnant Mexican American women aged 18–40, with BMI > 25 kg/m^2, attending WIC special	Home visits (HV) by bi-lingual promotoras (community health workers) trained in BF support, child development,	HV only for measurements by research assistant. *N* = 83 baseline, 58 at 12 mo., 52 at 24–36 mo.	*Primary outcome:* zWFL scores, at 12 mo and at final visit during the period 24–36 months.	*At 12 months* WFL > 85th percentile: I = 42.7% C = 35.0%, NS Mean (SD) zWFL: I = 0.72 (1.13)

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
	age 12 months (Reifsnider et al.) and at age 24–36 months (McCormick et al.).		supplemental programme in a southwestern metropolitan area.	nutrition, parenting, safety and sleep hygiene. HV prenatal and at 2, 4, 6 9 and 12 mo, promoting BF, and avoiding excess FF or adding sugar or solids to bottle. Referral for medical or lactation care if required. *N* = 91 baseline, 61 at 12 mo, 54 at 24–36 mo.	NB WIC programme promoted BF to all participants, including controls.	Growth classifications at 24–36 mo: Underweight < 10th percentile (zBMI < −1.28). Normal weight 10th to <85th percentile (zBMI −1.28 to <1.04). Overweight 85th to <95th percentile (zBMI 1.04 to <1.64). Obesity >95th percentile (zBMI >1.64).	C = 0.84 (1.20), p = 0.66, NS *At 24–36 months* Underweight: I = 11.1% C = 7.7%, NS Normal weight: I = 48.1% C = 48.1%, NS Overweight: I = 22.2% C = 17.3%, NS Obesity: I = 18.5% C = 26.9%, NS
Tanvig et al., 2014. Lifestyle in Pregnancy and Offspring (LiPO) Study. Denmark.	To assess whether lower GWG during pregnancy in the lifestyle intervention group resulted in differences in offspring anthropometrics and body composition at 2.8 years; and to compare outcomes to a reference group of children born to women with a normal BMI.	Unblinded RCT, stratified for smoking status. Recruited October 2007 to October 2010.	Women with BMI 30–45 kg/m^2 with single pregnancy, referred to two Danish university OBGYN department, at 10–14 weeks of gestation.	4 sessions of dietetic counselling to limit GWG, at 15, 20, 28 and 35 weeks gestation; advice to do 30-60 min PA daily; 6-mo free full time fitness centre membership; weekly 1 hr physiotherapy classes for 6 mo. *N* = 180 at baseline, 150 infants born, 82 at 2.5–3 y follow up.	Access to website with advice about diet and PA in pregnancy. *N* = 180 at baseline, 154 infants born, 75 at 2.5–3 y follow up. PLUS Reference group (ref) of singleton, term infants of mothers with normal BMI. *N* = 97	*Primary outcome:* Infant zBMI at 2.5-3y. *Secondary outcomes:* BMI, SFT, abdominal circumference, hip circumference, abdominal/hip ratio, and the DEXA values of total fat mass, total lean mass and fat percentage; identification of children with overweight or obesity at 2.5–3 y.	*At 2.8 years* (range: 2.5–3.2 years) Mean (95%CI) BMI: I = 16.4 (16.1 to 16.7) C = 16.1 (15.8 to 16.4), NS Mean (95%CI) zBMI: I = 0.06 (−0.17 to 0.29) C = −0.18 (−0.43 to 0.05), NS Ref = −0.21 (−0.38 to −0.04), NS Overweight or obesity: I = 10.9% C = 6.7%, NS Ref = 4.1%, NS.
Vesco et al., 2016. Healthy Moms trial USA.	To assess whether lower GWG during pregnancy for women with obesity affects offspring weight.	Single-blind RCT. Recruited October 2009 to July 2011.	Women BMI ≥ 30 kg/m^2 with single pregnancy, receiving prenatal care at an Oregon not-for-profit health maintenance	Two dietetic consultations and weekly group education sessions on diet and lifestyle changes to limit GWG and	Single dietetic consultation on health eating during pregnancy. *N* = 58 baseline, 46 at 12-mo follow-up.	*Primary outcome:* Maternal weight at 12-mo postpartum. *Secondary outcomes:* Infant weight-for-age and weight-for-	*At 12 months* Mean (SD) weight (kg): I = 9.83 (0.93) C = 10.01 (1.24) **Mean difference = −0.20 (95%CI**

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
			organisation, recruited at 10–20 weeks gestation.	encourage 30-min PA daily for 16 wks. *N* = 56 baseline, 43 at 12-mo follow-up.		length *z*-scores at 12 mo.	**−0.38 to −0.02), *p* = 0.031** Mean (SD) zWFA: I = 0.37 (0.74) C = 0.51 (0.94) **Mean difference = −0.40 (95% CI: −0.75 to −0.05), *p* = 0.024** Mean (SD) zWFL: I = 0.53 (0.72) C = 0.60 (0.92) Mean difference = 0.20 (95% CI: −0.59 to 0.20) NS WFL ≥ 97.7th percentile: I = 2.3% C = 9.8% OR = 0.22 (95%CI 0.02 to 2.01), *p* = 0.18, NS
Risk factor—maternal gestational diabetes mellitus							
Gillman et al., 2010. Australian Carbohydrate Intolerance Study (ACHOIS). Australia	To assess the effect of treatment for mild GDM on the BMI of 4- to 5-year-old children.	Multicentre RCT, data linked with state-wide health surveillance data. Recruited 1993–2003	Women enrolled in existing multicentre trial who had mild GDM at 24–34 weeks gestation, living in South Australia (SA).	Dietary advice, blood glucose monitoring, insulin therapy if required. *N* = 265 children in SA at baseline, 94 at 4–5 y	Routine care. *N* = 275 children in SA at baseline, 105 at 4–5 y.	zBMI at 4–5 years (state-wide health checks at kindergartens and preschools). *Secondary outcomes not specified*	*At 4–5 years* Mean (SD) zBMI: I = 0.49 (1.20) C = 0.41 (1.40) Adjusted treatment effect 0.08 (95% CI: −0.29 to 0.45), NS BMI > 85th percentile: I = 33.0% C = 27.6% aRR = 1.17 (95% CI: 0.77 to 1.78), NS
Ijäs et al., 2015. Finland	To compare the growth and development of children born to mothers with	Follow-up of RCT.	Women with GDM treated at two hospitals in Oulu and Kajaani.	Women treated with metformin (including supplemental insulin for *n* = 15)	Women treated with insulin *N* = 50 at baseline, 48 at 18 mo.	*Primary outcome:* Weight and height at 6, 12 and 18 mo. *Secondary outcomes:*	*At 12 months* **Mean (SD) weight (kg):** **I = 10.5 (1.5)**

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
	gestational diabetes mellitus (GDM) requiring pharmacological treatment, and randomised to treatment with metformin or insulin			*N* = 50 at baseline, 45 at 18 mo.		Body composition defined by PI, incidence of overweight and obesity defined by WFL.	**C = 9.8 (1.3), *p* = 0.038** Mean (SD) height (cm): I = 76.9 (3.3) C = 75.6 (3.1), *p* = 0.062, NS Weight ≥ 95th percentile: I = 8.9% C = 6.3%, , *p* = 0.709, NS *At 18 months* **Mean (SD) weight (kg):** **I = 12.1 (1.9)** **C = 11.3 (1.5), *p* = 0.04** **Mean (SD) height (cm):** **I = 83.9 (3.6)** **C = 82.2 (3.1), *p* = 0.023** NS difference in PI, WFL > 10% or WFL 20% at either time point.
Kizirian et al., 2016. GI Baby 4 Study. Australia	To explore the effect of a low-glycaemic index (low-GI) diet during pregnancy on offspring growth, adiposity, and arterial wall thickness during infancy.	Prospective follow-up study of self-selected subgroup of a sample from RCT (GI Baby 3 study). Recruited June 2011 to February 2013.	Pregnant women with 1 + risk factors for GDM: BMI ≥ 30 kg/m^2; age ≥ 35; PCOS; previous history of GDM or glucose intolerance; previous newborn >4,000 g; family history of type 2 diabetes; member of ethnic group with high prevalence of	Low-GI diet during pregnancy. *N* = 30 baseline, 27 at 12 mo.	High fibre (HF) diet during pregnancy. *N* = 29 baseline, 22 at 12 mo.	*Primary outcome:* Body composition at 12 mo. Anthropometric measures taken monthly for 6 mo, then 9 and 12 mo; adiposity at 0 and 3 mo;	*0–12 months* NS difference in infant growth trajectories using zWFA, zLFA, zWFL or zBMI. *At 12 months* Mean (SEM) weight (kg) (*n* = 47): I = 9.7 (0.2) C = 9.7 (0.2), Adjusted *p* = 0.862, NS

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
			GDM. Attending hospital antenatal clinic.				
Rowan et al., 2011, 2018. Metformin in Gestational diabetes—long Term Offspring Follow Up (MiG TOFU) study. Australia and New Zealand	To compare body composition in children of women who participated in the MiG trial and, in particular, to compare measures of adiposity at 2 years (Rowan et al., 2011) and to compare body composition and metabolic outcomes at 7–9 years (Rowan et al., 2018).	Randomised trial and longitudinal follow-up	Women with GDM in Adelaide (ADL) and Auckland (AUK). Long-term follow up was at 7 years in ADL and 9 years in AUK.	Mothers treated with metformin *N* = 373 baseline, 154 at 2 years. Follow-up *n* = 58 at 7 years (ADL) + *n* = 45 at 9 years (AUK).	Mothers treated with insulin *N = 378 baseline, 164 at 2 years. Follow-up n = 51 at 7 years (ADL) + n = 54 at 9 years (AUK).*	*Primary outcome:* Composite of neonatal complications (for original MiG trial). *Secondary outcomes:* Body composition at 2 years. Body fat and other anthropometric data, bioimpedance analysis, dual energy X-ray absorptionometry (DEXA), MRI and blood tests at 7 years (ADL) and 9 years (AUK).	*At 2 years* Mean (SD) weight (kg): I = 14.3 (2.1) C = 14.0 (2.2), *p = 0.18, NS* In *Adelaide*, at 7 years: Mean (SD) BMI: I = 17.2 (2.5) C = 16.9 (2.5), *p* = 0.48, NS In *Auckland* at 9 years: Mean (SD) BMI: I = 19.3 (4.6) C = 17.7 (3.0), *p* = 0.051, NS
Risk factor—previous baby large for gestational age							
Horan, McGowan et al., 2016; Horan, Donnelly et al., 2016. ROLO Study. Ireland	To examine the effect of a maternal low GI dietary intervention on offspring adiposity at 6 months and to explore the association between diet and lifestyle factors in pregnancy and infant body composition at 6 months (Horan, McGowan et al., 2016) and at 2 years (Horan, Donnelly et al.).	RCT. Recruited January 2007–January 2011	Secundigravida women who had previously given birth to a macrosomic baby (>4 kg), recruited at maternity hospital, Dublin.	Low GI dietary advice given at Week 14 of pregnancy. *N* = 138 mother infant dyads at 6 mo, 134 at 2 years	Usual care. *N* = 142 mother infant dyads at 6 mo, 147 at 2 years.	*Primary outcome:* Birthweight (original ROLO study). *Secondary outcomes:* GWG; glucose intolerance; infant weight and length at 6 mo (*n* = 280); other anthropometric data (*n* = 217); infant anthropometry at 2 y.	*At 6 months* Mean (SD) zWFL: I = 0.34(1.90) C = 0.12 (1.05), *p* = 0.241, NS. Mean (SD) zWFA: I = 0.93 (1.59) C = 0.65 (1.00), *p = 0.075, NS.* Mean (SD) zBMI for age: I = 0.20 (1.95) C = –0.011 (1.05), *p* = 0.263, NS. *At 2 years* NS difference reported between I and C (comparative data not given),

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Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
							except for lower mean hip circumference in C group. zBMI for age was positively associated with maternal BMI at 2 year post-partum (B = 0.105, p = 0.015) and negatively associated with GI intake in Trimester 1 (B = −0.045, p = 0.014).
Risk factor—formula feeding (±low income)							
Bonuck et al., 2014. USA.	To evaluate the impact of a WIC-based counselling intervention on (milk) bottle consumption, energy intake from bottles and on WFL.	RCT. Recruitment and follow-up spanned 2008–2011.	Infants who consumed greater than two bottles of milk or juice per day, attending WIC programme, aged 11–13 mo, at WIC site in New York.	Education intervention delivered by nutritionists during WIC visits re healthy weight, dental caries and iron deficiency related to bottle feeding. N = 147 baseline; 49 after 12 mo.	Regular WIC care. N = 148 baseline, 55 after 12 mo. NB intervention group had significantly higher calorie intake and WFL at baseline.	*Primary outcome:* Bottle use frequency *Secondary outcomes:* Dietary intake and proportion >85th percentile WFL at baseline and after 3, 6, 9 and 12 mo (age approx. 15, 18, 21 and 24 mo)	*At 24 months old* WFL > 85th percentile: OR: 1.02 (0.5–2.0), p = 0.95, NS Reduction in risk factors but not risk of overweight.
Chaparro, Anderson, et al., 2020. USA	To investigate (1) the effect of duration of receipt (dose) of the new WIC child food package; and (2) the effect of the new infant food package on growth trajectories from 0 to 4 years and obesity risk at age 4 among children who	Longitudinal study using administrative data. 2003–2016	WIC participating children in Los Angeles County throughout ages 0–4 y and who were never breastfed (N = 74,871).	Aim 1: Fully FF children participating in WIC after 2009. N = 8,528 (received new child food package <1 y) N = 8,117 (new package 1 to <2 y) N = 8,698 (new package 2 to <3 y)	Aim 1: Fully FF children participating in WIC before 2009. N = 21,641 *Aim 2: Subsample of FF children who received the old infant package followed by the new child package for >3.5 y.*	*zWFH growth trajectories from birth to 4 y; obesity at age 4 y (BMI for age ≥ 95th percentile).* *Secondary outcomes not specified*	*At 4 years* Boys Aim 1 zWFH: **Small significant differences in zWFH for boys in all dose comparisons at various ages** Obesity:

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
	were fully formula fed as infants.			*N* = 9,187 (new package 3 - < 4 y) *N* = 18,700 (new packed for 4 + y) Aim 2: Subsample of FF children who received the new infant package and the new child package for >3.5 y. (N not stated)	*(N not stated)*		Those receiving new child food package for 4years had 7% lower obesity risk. **Mean difference (SE): −0.09 (0.02), $p < 0.001$.** **RR = 0.93 (95% CI: 0.89 to 0.98).** Aim 2 Obesity at 4 years: RR = 1.04 (95% CI: 0.98 to 1.12), NS *Girls* Aim 1 Mean zWFH: NS differences when comparing girls who received other doses < 4 year. Obesity: Those receiving new child food package for 4years had 6% lower obesity risk. **Mean difference (SE): −0.08 (0.02), $p < 0.001$.** **RR = 0.94 (95% CI: 0.89–0.99)** Aim 2 Obesity at 4-years RR = 1.00 (95% CI: 0.93 to 1.08), NS
Chaparro, Wang, et al., 2020. USA.	To investigate the association between the WIC food package change and growth trajectories and obesity by	Longitudinal study using administrative data. 2003–2016	WIC participating children in Los Angeles County throughout ages 0–4 y (*N* = 116,991). Families received	Two matched intervention groups: Period 2: Children born 2005–2008 who received old infant package + some but not all	Matched control group: Period 1: Children born 2003–2004 who only received old infant and child packages.	zWFH growth trajectories from birth to 4 y; obesity at age 4 y (BMI for age ≥ 95th percentile).	*At age 4, analysis by infant feeding type.* Relative risk of obesity compared with Period 3 *Fully BF* Boys

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
	examining whether the association varies by the type of food package received during infancy.		different food packages according to infant feeding type: Fully breastfed (*n* = 9,129), mostly breastfed (*n* = 24,864), mostly formula fed (*n* = 48,480) and fully formula fed (*n* = 34,518).	new child food packages introduced in 2009. *N* = 38,997 Period 3: Children born from 2009 to 2011 who only received new food packages. *N* = 38,997	*N* = 38,997	*Secondary outcomes not specified.*	Period 2: RR = 1.02 (95% CI: 0.88 to 1.18), NS Period 1: RR = 1.00 (95% CI: 0.86 to 1.16), NS Girls Period 2: RR = 1.10 (95% CI: 0.94 to 1.30), NS Period 1: RR = 1.00 (95% CI: 0.93 to 1.29), NS *Mostly BF* Boys **Period 2: RR = 1.17 (95% CI: 1.07 to 1.27), $p < 0.05$** **Period 1: RR = 1.27 (95% CI: 1.17 to 1.38), $p < 0.05$** Girls Period 2: RR = 1.07 (95% CI: 0.98 to 1.17), NS **Period 1: RR = 1.17 (95% CI: 1.07 to 1.28), $p < 0.05$** *Mostly FF* Boys **Period 2: RR = 1.06 (95% CI: 1.01 to 1.12), $p < 0.05$** **Period 1: RR = 1.07 (95% CI: 1.02 to 1.12), $p < 0.05$** Girls Period 2: RR = 1.06 (95% CI: 1.00 to 1.13), NS

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
							Period 1: RR = 1.06 (95% CI: 1.00 to 1.12), NS *Fully FF* Boys Period 2: RR = 1.03 (95% CI: 0.97 to 1.10), NS **Period 1: RR = 1.13 (95% CI: 1.06 to 1.20), $p < 0.05$** Girls Period 2: RR = 1.04 (95% CI: 0.97 to 1.11), NS Period 1: RR = 1.07 (95% CI: 1.00 to 1.14), NS
Kavanagh et al., 2008. USA.	To evaluate whether education about infant satiety cues would alter FF practices and infant formula intake and weight gain.	Double-blind, RCT. Recruitment dates not reported.	Exclusively FF infants aged 3–10 weeks attending WIC clinics in Sacramento California.	General guidance on infant feeding + education to avoid making larger amounts of FF than necessary, to promote awareness of satiety cues and to discourage bottles >6 oz before 4 mo. *N* = 44 baseline, 19 completed final data collection.	General guidance on infant feeding. *N* = 57 baseline, 21 completed final data collection	Formula intake (ml/24 h); weight gain (g/week) measured before (1–2 mo) and after (4–5 mo) the intervention. *Secondary outcomes not specified*	*[After 4 months] 20–27 weeks old* Adjusted mean weight (g): **I = 7,214** **C = 6,758 , $p = 0.006$**
Lakshman et al., 2018a. Baby Milk Trial. UK.	To assess the efficacy of a theory-based behavioural intervention to prevent RWG in FF infants.	Single-blind, RCT. Recruited March 2011 to June 2015.	Healthy, full-term infants FF within 14 weeks of birth, recruited via GPs, research staff on postnatal hospital ward, mail-out or self-referral.	Intervention aimed to reduce formula milk intake and promote responsive feeding and growth monitoring delivered by trained nurse facilitators via three F2F contacts,	Same number of contacts, but discussed general topics other than FF. *N* = 329 baseline, 293 at 12 mo.	*Primary outcome:* Change in weight SDS between birth and 12 mo. Weight, length, BMI, abdominal and head circumference at 0, 6 and 12 mo.	*0–12 months* Mean (SD) change in weight SDS: I = 0.28 (0.96) C = 0.35 (1.05) Adjusted difference = –0.04 (95%CI –0.17 to 0.10), $p = 0.61$, NS

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
				two phone contacts and written materials. Incorporated motivational, action planning and coping planning components. *N* = 340 baseline, 293 at 12 mo.		RWG defined as crossing ≥ + 0.67 SDS. *Secondary outcomes:* Milk intake at 3, 4, 5 and 6 mo.	Rapid weight gain (≥ + 0.67 SDS): I = 40.3% C = 45.9% OR = 0.84 (95% CI: 0.59 to 1.17), NS Mean (SD) change in BMI SDS: I = 0.69 (0.89) C = 0.68 (0.86) Difference = −0.01 (95% CI: −0.14 to 0.12), NS
Tang et al., 2018, 2019. USA.	To directly compare the effect of protein from two common complementary food sources, meat and dairy, on infant growth and weight trajectory (Tang et al., 2018), and long-term effect on growth status (Tang et al., 2019).	Stratified RCT. Recruited September 2013 to January 2016.	Healthy term, formula-fed infants aged 3–5 mo, recruited by flyer from the metro Denver area.	Pureed meat as complementary food from 5 to 12 mo, plus standard milk protein-based FF, unlimited cereal, F&V. *N* = 35 baseline, 32 at 12 mo, 27 at 24 mo.	Pureed dairy food (yoghurt, cheese or whey protein powder) as complementary food from 5 to 12 mo, plus standard milk protein-based FF, unlimited cereal, F&V. *N* = 36 baseline, 32 at 12 mo, 26 at 24 mo.	*Primary outcome at 12 mo:* Growth, measured as longitudinal change in weight (kg), length (cm), and respective age- and sex-specific *z*-scores. Anthropometric measures were obtained during monthly HV (7–12 mo). Dietary records at 5, 10 and 12 mo. *Primary outcome at 24 mo:* Growth, and respective age- and sex-specific *z*-scores; diet diversity; blood-based biomarkers.	*At 5 months* Mean (SD) weight (kg): I (meat) = 7.37 (0.67) C = 7.35 (0.74) , NS *At 12 months* Mean (SD) weight (kg): I (meat) = 9.92 (0.91) C = 9.92 (0.74) , NS Mean zWFL: I (meat) = 0.30 (0.17) C = 0.76 (0.21), NS *At 24 months* Mean weight (kg): I (meat) = 12.6 (1.0) C = 12.4 (1.5), $p = 0.38$, NS zWFA: Difference $p = 0.65$. Time effect $p = 0.42$, NS zWFL Difference $p = 0.40$ Time effect $p = 0.15$, NS
Risk factor—infant sleep problems							
Wake et al., 2011. Kids Sleep Study/ follow up study to	To determine if infant sleep intervention improves	Cluster-RCT with blinded allocation and data collection.	Mothers reporting infant sleeping problems, recruited	Individualised sleep management plan at 7–8 mo, delivered	Usual community nurse care.	*Primary outcomes:* BMI (kg/m^2) and BMI status at 6 years.	*At 6 years* Mean (SD) zBMI score:

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TABLE 2 (Continued)

Author. Date. [Study name]. Country	Aim or objective	Study design. Dates of recruitment	Participants: risk factor, age and setting	Intervention (I): description and number	Comparison or control (C): description and number	Outcome/s: relevant measures and timing	Key findings
Infant Sleep Study. Australia.	anthropometric outcomes at 6 years.	Recruited October–November 2003.	from maternal child health clinics in Melbourne, when infants were 4 mo and sleep problem confirmed at 7 mo.	by specially trained community nurses and choice of one of 'controlled crying' or 'camping out' infant sleep strategy, with 2-week follow up. *N* = 174 families, 101 at 6 year follow up.	*N* = 154 families, 92 at 6 year follow up.	*Secondary outcome:* Waist circumference (cm) at 6 years.	I = 0.5 (0.9) C = 0.4 (0.9), aDiff = 0.2 (95% CI: −0.1 to 0.4), *p* = 0.3% Overweight/obesity: I = 20% C = 17%, aOR = 1.4 (95% CI: 0.7 to 2.8), *p* = 0.4, NS. Mean (SD) waist circumference: I = 54.9 (4.5) C = 55.2 (5.2), aOR = −0.3 (95% CI: −1.6 to 1.1), *p* = 0.7, NS

Note: Statistically significant difference between intervention and control in bold; subgroup analysis in italics and underlined.

Abbreviations: 95% CI, 95% confidence interval; aDiff, adjusted difference in means; Adj, adjusted; ADL, Adelaide (Australia); AG, anticipatory guidance; AI, American Indian; ANC, antenatal clinic; aOR, adjusted odds ratio; aRR, adjusted relative risk; AUK, Auckland (New Zealand); BF, breast feeding/breast fed; BMI, body mass index; C, control (comparison) group; CHC, community health centre; CI, confidence interval; DEXA, dual energy X-ray absorptionometry; DVD, digital video disc; F&V, fruit and vegetables; F2F, face to face; FF, formula fed or formula feeding; GDM, gestational diabetes mellitus; GI, glycaemic index; GP, general practitioner; GWG, gestational weight gain; HEI, Healthy Eating Index; HF, high fibre; HV, home visiting; I, intervention group; IFSQ, Infant Feeding Style Questionnaire; kg, kilogram; LGA, large for gestational age; MDT, multidisciplinary team; mm, millimetre; mo, month; MOMS, mother focused programme; MRI, magnetic resonance imaging; NFN, Nurturing Families Network; NHS, National Health Service; NPSG, nutrition and parenting support group; NS, not (statistically) significant; OBGYN, obstetrics and gynaecology; OP, Ounce of Prevention programme; OR, odds ratio; *p*, probability; PA, physical activity; PCOS, polycystic ovary syndrome; pd, per day; PP, per protocol; pw, per week; RCT, randomised controlled trial; ref, reference group; RR, relative risk; RWG, rapid weight gain; SA, South Australia; SD, standard deviation; se, standard error; SFT, skinfold thickness; SSB, sugar sweetened beverage; UC, usual care; USA, United States of America; w, week; WFA, weight for age; WFH, weight for height; WFL, weight for length; WHO, World Health Organization; WIC, Women, Infants, and Children [programme];

y, year; zBMI, body mass index for age *z*-score; zLFA, length for age *z*-score; zWFA, weight for age *z*-score; zWFH, weight for height *z*-score; zWFL, weight for length *z*-score.

TABLE 3 Characteristics of interventions *N* = 38 studies

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
Risk factor—low income/socioeconomically disadvantaged							
Chaparro et al., 2019. ***See also Chaparro, Anderson, et al., 2020***; ***Chaparro, Wang, et al., 2020*** below. USA. ANTENATAL & POSTNATAL	Children in low-income families participating in WIC programme.	Special Supplemental Nutrition Program for Women, Infants and Children (WIC) No theory specified.	Change in content of monthly WIC supplemental food packages: more fruit, vegetables and whole grains; less juice and whole milk; and lower amounts of formula for BF infants.	Dietary change—WIC food package	No specific setting	NA	Vouchers available monthly. Duration: from pregnancy to child's fifth birthday, while family is eligible under income test.
Cloutier et al., 2018. USA. POSTNATAL	Mother/newborn dyads in low-income, underserved areas.	*Early Childhood Obesity Prevention (ECHO) trial*. Grounded in Chronic Care Model (Chen & Brodenheimer 2008) and ecological model of obesity prevention. ECHO is delivered in the context of the Nurturing Families Network (NFN) home visiting programme, using the *Parents as Teachers—Born to Learn* and *Partners for a Healthy Baby* curricula.	ECHO—standard NFN curriculum [control] plus: Maternal skills: goal setting, problem-solving, and stimulus control. Target behaviours: BF, juice consumption, introduction of solids, TV/screen time and infant routines and cues around sleep, hunger and satiety. Components include a Family Wellness Plan and behavioural strategies for core skills related to healthy eating and activity. Links to community programmes that support healthy eating.	Home visit + additional content	Home	Home visitors—qualification not indicated. ECHO home visitors received additional training on engaging mothers in behavioural change strategies, delivering intervention modules, and on BF skills and support.	Weekly visits of 60–90 min for 2 months, then bi-weekly visits from 2 to 12 months. Duration: newborn to 1 year.

(Continues)

TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
de la Haye et al., 2019. USA. POSTNATAL	Low-income families in California actively receiving home visiting programme (HVP) after their child's birth (mean age at baseline = 3.8 mo).	*Healthy families America home visitors* Pilot test. Social network theory	Standard home visiting programme plus obesity prevention elements: Didactic education—parent modelling healthy behaviours and goal setting. Social experiential activities—group activities in partner facilities. Nutrition goals include increasing intake of F&V and limiting intake of high-saturated fat (for children eating solid foods), eliminating intake of SSB and juice, learning healthy portion sizes, sustaining BF and gradually introducing complementary feeding to support healthy infant eating. Physical activity goals for children < – daily planned physical activities, e.g., tummy time; 30 min of supervised unstructured physical activity; avoiding being sedentary for >60 min at a time; and limited screen time. Parents taught to make activity and play a daily habit for family.	Home visit + additional content. Group	Home. Group location unclear	Trained and accredited home visitors (nurses) who received 2 days' training in obesity prevention components.	Delivered weekly for 6 months. Duration: newborn to 6 months.

(Continues)

TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
French et al., 2012. USA. POSTNATAL	Low-income urban areas, with children 0–2 months, attending well-child visits at three paediatric primary care clinics.	Two different anticipatory guidance intervention: maternal-focused eating programme (*MOMS*) and infant-focused programme (*Ounce of Prevention*). No specified theory.	*MOMS:* personal nutrition education for the mother (aimed at maternal eating habits). *Ounce of Prevention:* nutrition education about feeding infants in the first year of life with focus on serving size, introducing different foods and not using pressure feeding or food as reward practices.	Well child clinic + additional content	Clinics of the Nationwide Children's Hospital Primary Care Network in low-income metropolitan areas.	Staff seen for usual well child visits (either physician, paediatric resident, clinic nurse, or clinic medical assistant). Materials pilot tested by paediatric group.	Part of usual well-child visits at 2, 4, 6, 9 and 12 months. Duration: up to 1 year.
da Costa Louzada et al., 2012 Vitolo et al., 2012. Brazil. POSTNATAL	Mother–child dyads from maternity hospitals serving low-income families.	Content based on national *Ten Steps for Healthy Feeding for Brazilian Children from Birth to 2 Years of Age*. No specified theory.	Dietary counselling topics including exclusive BF, introducing solids, feeding to infant cues, offering a variety of healthy foods and avoiding discretionary foods.	Home visits	Home	Undergraduate nutrition science students.	10 × 40-min visits: monthly for first 6 months of infants' life then at 8, 10 and 12 months. Duration: newborn to 1 year
Machuca et al., 2016. USA. POSTNATAL	Families with infant aged <2 months attending health centre serving low-income, predominantly minority population.	*Well Baby Group Care*, draws on constructs from trans-theoretical model stages of change and social learning theory (goal setting, interactive learning, skill building, modelling, reinforcement, and peer support). Freirean framework (reciprocal dialogue, reflective practice, individual and collective goals).	Group care with a curriculum focussed on positive dietary behaviours, responsive parenting and feeding practices. Group sessions also provide peer support.	Group	Health centre	Paediatrician and registered dietitian.	11 × 2-h sessions with 30-min nutritional component. Duration: first 18 months of infant's life.

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TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
Navarro et al., 2013 Dominican Republic. ANTENATAL & POSTNATAL	Infants in low-income country.	*Maternal-Child Pastoral programme* adapted from the Brazilian Child Pastoral Programme with addition of nutritional counselling components. Transformational education process based on the UNICEF/WHO Triple A decision-making process: assessment, analysis, action. Part of Integrated Management of Childhood Illness strategy.	Small group meetings, semi-structured home visits and education materials on nutrition: Health and nutrition in pregnancy, BF, complementary feeding, growth monitoring, iron and vitamin A supplements (plus vaccination, infection prevention, newborn care, safety, early stimulation). Advice protocol tailored to results on growth monitoring. If RWG evident, advice was to decrease energetic ingestion. If RWG continued for two evaluations, referral to health professional.	Home visit. Group. Written info.	Home. Group meetings: location not indicated.	Lay community counsellors with similar formal education profile as the mothers, who receive 60-hour basic training from health professionals.	Ten group meetings every 15 days during pregnancy, then monthly. Home visits: monthly during pregnancy, then fortnightly for 6 weeks after birth, then monthly Duration: from third quarter of pregnancy until children aged 13–24 months.
Thomson et al., 2018. USA. ANTENATAL & POSTNATAL	Women > 18 living in disadvantaged lower Mississippi Delta with singleton pregnancy (first, second or third pregnancy <19-week gestation)	*Delta Healthy Sprouts* Parents as Teachers Enhanced (PATE) programme. Built on Parents as Teachers (PAT, control). PATE based on social cognitive theory and transtheoretical model of behaviour change	PATE elements were based on Diabetes Prevention programme (DPP) and the Infant Feeding Activity and Nutrition Trial (InFANT) and included maternal weight management and early childhood obesity prevention components (BF, appropriate introduction of solid foods, and parental modelling of positive nutrition, physical activity behaviours and infant weight monitoring).	Home visits + additional content.	Home	Community-based parent educators (with extensive training in the PAT and PATE)	Monthly visits 90–120 min. Duration: from early second trimester of pregnancy to 12 months of age.

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TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
			Lessons include hands-on activities, instructional DVDs, and goalsetting for both diet and exercise. Parents receive the USDA MyPlate daily eating plan, tracking sheets, weight gain and loss charts.				
Watt et al., 2009. Scheiwe et al., 2010. United Kingdom. POSTNATAL	Low-income mothers with non-professional job occupation, with full-term, singleton, normal birth weight babies, recruited from baby clinics in two disadvantaged neighbourhoods of London.	*Infant Feeding Peer Support Trial*. Based on social support theoretical model.	Practical and non-judgemental support and advice on infant feeding practices, in particular: introduction to solids; appropriate foods and drinks for child food, emphasising F&V intake; cessation of feeding bottles.	Home visits	Home	Trained volunteers (training: 12-session programme delivered over a 4-week period).	Monthly visits from infant age 3–12 months. Duration: from age 3 months to 1 year.
Wen, Baur, Rissel, et al., 2012; Wen et al., 2015. Australia. ANTENATAL & POSTNATAL	Women pregnant with first child, living in socially and economically disadvantaged area, attending antenatal clinics at 24–34 weeks gestation.	*Healthy Beginnings Trial*. Health promotion principles and theories (including health belief model).	Nurse identified individual parental needs in relation to nutrition, feeding and age-appropriate physical activity/inactivity, using a checklist. Nurse provided consultation, information and recommendations, problem-solving activities, and pro-active telephone support between home visits. Individualised information kits provided to parents. Topics covered: Promoting BF, appropriate timing of introduction of solids, "tummy time" and	Home visits. Proactive telephone support	Home	Child and family health nurses.	8 × 1-h home visits: ~30–36 weeks gestation, then at 1, 3, 5, 9, 12, 15 and 24 months after birth. Duration: pregnancy to 2 years

(Continues)

TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
			active play, as well as family nutrition and physical activity.				
Risk factor—ethnicity							
Karanja et al., 2010. USA. ANTENATAL & POSTNATAL	Expectant mothers from three American Indian tribes in Northwest Portland Area Indian Health Service.	*Toddler overweight and tooth decay prevention study (TOTS intervention).* Based on principles of behaviour change and motivational interviewing.	Two interventions: *Community-wide* intervention aimed to raise awareness, health education, behaviour change, inform public health and environment/policies. *Family-based intervention*: motivational interviewing and behaviour change (working with families to create a plan) with focus on exclusive BF, not offering SSBs and offering water.	Community intervention. Home visits (some contact could be via phone if parents preferred) (tribes B and C)	Home and community	*Community-wide*: brochures, videos, newspaper articles, flyers, or other media. *Family-based*: community health workers. Tribal staff and researchers designed interventions and trained community health workers.	*Community-wide*: six monthly cycles *Family-based*: delivered in eight visit clusters. Each cluster up to three contacts (at least one face to face, others potentially by phone). Potentially 7–21 contacts Cluster 1 during antenatal period. Duration: pregnancy to 2 years
Palacios et al., 2018. USA. POSTNATAL	Healthy term infants 0–2 months participating in WIC clinics in Puerto Rico and Hawaii.	Transtheoretical model.	Intervention content reinforced WIC health promotion messages of BF, preventing overfeeding, delayed introduction of solids, and delayed/reduced juice consumption, other general infant health issues, e.g., safe sleep positions.	SMS messages	NA	SMS messaging. Messages designed with paediatricians and WIC staff.	1 SMS weekly. Duration: 4 months
Washio et al., 2017 USA. POSTNATAL	Low-income Puerto Rican women enrolled in WIC programme who had initiated BF	No theory stated.	Standard BF support through WIC (on-site lactation consultation, bilingual peer counselling, weekly peer support meetings, free breast pump, and enhanced food package) plus monthly financial	WIC support + financial incentive	WIC offices or participants' home	WIC staff and peer counsellors. Research staff verified continued BF	Monthly visits by research staff to visually verify BF. Infants weighed at 1, 3 and 6 months. Duration: newborn to 6 months.

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TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
			incentives for those who demonstrated BF to research staff (US$20 at the end of the first month and increased by $10 every month until the end of 6 months, up to $270 if still BF at 6 months).				
Risk factor—adolescent or young mothers (±low income)							
Ordway et al., 2018. USA. ANTENATAL & POSTNATAL	First-time, young mothers (33% aged <20) who lived in low SES medically underserved communities.	*Minding the Baby study*. Socio-ecological systems theory.	Programme is relationship-based, including maternal reflective functioning to promote maternal-child attachment, reflective functioning and a range of positive parenting behaviours to promote healthy family lifestyle and diet.	Home visits	Home (or other venue convenient for mother)	Social worker and paediatric nurse.	1-h visits weekly from third trimester to infant age 12 months, then biweekly until age 24 months. Duration: pregnancy to 2 years.
Schwartz et al., 2015. Brazil. POSTNATAL	New mothers aged <20 and maternal grandmothers (where they cohabited).	No theory stated.	BF promotion counselling intervention with mothers and grandmothers.	Face to face postnatal counselling. Home visits	Maternity ward then home	Two nurses, a dietician and a paediatrician (three IBCLCs).	Six sessions, between birth and infant age 4 months. Duration: birth to 4 months
Risk factor—high maternal BMI and/or gestational weight gain (±low income)							
Carlsen et al., 2013. Denmark. POSTNATAL	Healthy singleton infants <48 h old; mothers with pre-pregnancy BMI $\geq$ 30 kg/m^2.	None specified.	Intervention designed to promote BF duration and exclusivity. Telephone contacts involved asking questions and providing support and advice.	Phone-based advice and support. Routine home visits	Home.	Lactation consultants (IBCLCs).	9+ telephone contacts. Duration: birth to 6 months
Claesson et al., 2016. Sweden. ANTENATAL & POSTNATAL	Pregnant women with BMI $\geq$ 30 kg/m^2 attending antenatal clinic (ANC) in Linkoping, Sweden.	Intervention based on motivational interview.	Extra visits aimed to change motivation and knowledge about nutrition and physical activity. Individual sessions addressed weight control and	Clinic visits + additional content. Aqua aerobics class	Antenatal clinic. Swimming pool	Specially trained midwife.	Weekly visits face to face of 30 min during pregnancy (10–12 weeks gestation) then every 6 months to child age 2 years.

(Continues)

TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
			personal support. Access to aqua aerobic classes designed for women with obesity.				Aerobics class 1–2 times per week. Duration: pregnancy to 2 years
Dodd, Louise et al., 2018. Dodd, McPhee et al., 2018. Australia. ANTENATAL	Women with singleton pregnancy with BMI $\geq$ 25 kg/m^2, at three maternity hospitals in Adelaide.	*LIMIT trial*. Behaviour strategies based on stage theories of health decision.	Combinations of dietary, exercise and behavioural strategies base on Australian dietary standards. Included individual diet and physical activity plans, goal setting, recipe book and example menu plans.	Individual clinic sessions + additional content. Phone support × 3.	Clinic. No specific setting (phone support)	Research dietician and trained research assistants.	Six contacts: three times face to face and three times telephone sessions. Duration: 10 to 20 weeks to 36 weeks' gestation.
Fiks et al., 2017. USA. ANTENATAL & POSTNATAL	Medicaid insured (low income) mothers with pre-pregnancy BMI $\geq$ 25 kg/m^2. Enrolled at 20- to 32-week gestation.	*Grow2Gether*. Based on Social Learning Theory.	Online activities: education video and written information, then group participation and interaction. Topics matched to infant developmental stage: infant feeding, sleep, cues, calming infants, parenting expectations and maternal well-being.	Groups × 2 (prenatal + 4 months postnatal). Facebook group. Video + written info.	Online. (two face to face meetings antenatal to form group and at infant aged 4 months).	Online peer group activities facilitated by a psychologist. Consumer focus group involvement in implementation strategy and intervention content.	Videos posted weekly for first 6 months, then bi-weekly to age 9 months. Duration: 2 months prenatal to age 9 months
Gregory et al., 2016. USA. ANTENATAL	Pregnant women receiving Medicaid with pre-pregnancy BMI $\geq$ 30 kg/m^2. Tertiary referral centre in Baltimore.	*Nutrition in Pregnancy (NIP) clinic* No theory indicated.	Combined regular obstetric care with added nutrition care	Individual clinic sessions	Clinic	Obstetrician/nurse practitioner and nutritionist	Minimum three visits (one per trimester) available: fortnightly visits during first and second trimester then weekly from 36-week gestation. Duration: pregnancy up to 36 weeks' gestation.
Kong et al., 2014. USA. ANTENATAL	Women with singleton pregnancy, with self-reported overweight	No theory indicated.	Unsupervised walking programme. Participants provided with treadmills and encouraged to walk for a minimum of	Treadmill. Face to face session re advice on physical activity and safety.	Home. Location of F2F session not indicated	Interventionist not indicated.	One clinic session Duration: 12 to 15 weeks to 35 weeks' gestation.

(Continues)

TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
	(BMI > 25 kg/m^2) or obesity (BMI > 30 kg/m^2) before pregnancy, recruited via mass email to staff, students and faculty of university, online advertisement or flyers in local community, hospitals and obstetric clinics in Iowa.		150 min per week. One training session for safe use of treadmills.				
Mustila et al., 2013, 2018. Finland. ANTENATAL & POSTNATAL	Women with singleton pregnancies at risk of GDM (BMI > 25 kg/m^2, macrosomic newborn, previous GDM, family history of diabetes or age ≥ 40).	*VACOPP Study*. No stated theory.	Multifaceted lifestyle counselling—initially diet and exercise during pregnancy, then BF promotion. After birth, extended sessions with public health nurse at child health clinics, addressing child diet, age-appropriate physical exercise, sleep, and screen time. Motivational interviewing.	Individual clinic sessions + additional content	Clinic	Physiotherapist, dietician and public health nurses.	3 × 1.5-h session in second and third trimester and when child aged 1–2 years. Then five times yearly sessions with public health nurse during check-ups at child age 1, 2, 3, 4 and 5 years for 30–60 min longer than standard appointment. Duration: pregnancy to 5 years
Parat et al., 2019. France. ANTENATAL & POSTNATAL	Pregnant women 18 + years, up to 21 weeks gestation, with pre-pregnancy BMI > 25 kg/m^2, attending four maternity hospitals.	*ETOIG study* Therapeutic education approach. No theory indicated	Tailored plan with goals to promote healthy lifestyle changes (including healthy diet and physical activity), without focusing on specific weight objectives. All received booklet on nutrition during pregnancy. Final 2 sessions focused on	Individual clinic sessions + individually tailored plan. Group education sessions	Clinic	Physician (paediatrician or endocrinologist), dietician, or midwife.	At least two face-to-face visits with a dietician (at 26 and 30 GW) and 4 group education sessions (at 21, 28, 35 GW and then 2-month postpartum).

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TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
			baby's health, nutrition and weaning.				Duration: first trimester to age 2 months
Patel et al., 2018. UK. ANTENATAL	Pregnant women with pre-pregnancy BMI ≥ 30 kg/m^{2,} recruited at 15 to <19 weeks gestation at 8 NHS trust hospitals in UK.	*UPBEAT trial*. Control theory and social cognitive theory.	Complex behavioural intervention with dietary aims to promote a healthier pattern of eating but does not aim to restrict energy intake; physical activity aims to increase daily step count, and general activity. Women receive handbook, DVD of safe exercises, pedometer and logbook for goals for self-monitoring.	Individual session + written info + pedometer	Antenatal clinic (or if individual sessions not attended in person; health trainer covers the session material by phone or email).	Health trainer (not necessarily health professional qualifications, but relevant experience), who received study-specific training.	Up to 8 weekly visits of 1–1.5 h. Duration: approx. 8 weeks during the second trimester of pregnancy
Phelan et al., 2019. USA. POSTNATAL	Low-income women 6–52 weeks post-partum, either with overweight/obesity or exceeding pre-pregnancy weight by ≥4.5 kg, attending WIC clinics.	*Fit Moms/Mamas Activas*. Internet-based weight control programme for mothers. No stated theory.	Standard WIC support + online self-reported weight monitoring, individualised goals, tailored feedback. Programme lessons via video, text and visuals (website). Topics: selecting appropriate calorie goals, increasing fibre, grocery shopping, label reading, restaurant eating, beginning exercise, aerobic fitness, self-monitoring, stimulus control, problem solving, social assertion, goal setting, body image, cognitive strategies, overcoming barriers, relapse prevention training and strategies of successful weight losers.	Online programme + SMS messages + peer support. Groups. Weekly updates and check-ins delivered online, generating tailored pre-programmed feedback. Reminder text messages four times per week to reinforce use of the online programme. NB Attendance at face-to-face group was low	Online. F2F at WIC clinics	Monthly face-to-face group sessions run by WIC staff.	Weekly updates and check-ins online (website). Monthly face-to-face group sessions. Duration: up to 1 year

(Continues)

TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
			Weekly blog from peers (WIC mothers' experience with weight loss).				
Reifsnider et al., 2018. McCormick et al., 2020. USA. ANTENATAL & POSTNATAL	Healthy, pregnant Mexican American women aged 18–40, with BMI > 25 kg/m^2, attending WIC special supplemental programme.	Intervention created through community-based participatory research.	Growth monitoring and feedback. Education topics: BF, solid food timing, amounts of food for age, cease bottle feeding at 12 months, have nothing but breast milk/formula/juice in bottle, limit juice amount to 4 oz day, introduce cup by 10–11 months, no SSBs, limited amounts of sweets. Recognising hunger and satiation cues, handling colic/crying, engaging baby in play, being active with the baby, no screen time for baby and limited to 1 h for 1- to 3 year-olds, promote active play, normal infant sleep and sleep environment.	Home visits + additional content.	Home	Promotoras—community health workers with 6-month training and certification but no formal health professional training. One visit from lactation consultant (if BF problems).	One prenatal visit, and then at ages 1, 2 weeks, 2, 4, 6, 9 and 12 months. Duration: pregnancy to 1 year.
Tanvig et al., 2014. Denmark. ANTENATAL	Women with BMI 30–45 kg/m^2 with single pregnancy, referred to two Danish university obsstetric department, at 10–14 weeks gestation.	*LiPO (Lifestyle in Pregnancy Offspring) study*.	Dietary counselling, physical activity and coaching: including a pedometer and access to fitness centre. 4 dietary counselling session, 4–6 groups session with physiotherapist about physical activity in daily life and weekly 1-hour group fitness sessions.	Individual clinic sessions. Group education sessions Group fitness sessions. Gym membership + pedometer	Fitness centre.	Dieticians and physiotherapists	8–10 sessions with physiotherapist or dietician and weekly fitness classes. Duration: 10 to 14 weeks to approx. 35 weeks' gestation

(Continues)

TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
Vesco et al., 2016. USA. ANTENATAL	Women with BMI ≥ 30 kg/m^2 with single pregnancy, receiving prenatal care at an Oregon not-for-profit health maintenance organisation, recruited at 10–20 weeks gestation.	*Healthy Moms study*. No specified theory, but intervention based other on similar weight loss interventions (PREMIER and Weight Loss Maintenance [WLM] trials)	Group-based, diet and lifestyle intervention with aims to keep weight within 3% of their start weight, aim for 30 min of moderate physical exercise, calorie intake goal and Dietary Approaches to Stop Hypertension (DASH) diet that emphasises consumption of fruits, vegetables, and low- fat dairy products	Individual clinic sessions . Group education sessions.	Clinic	Unclear 'interventionist' and study dietician	16 weekly group sessions of 1.5 h (and two individual sessions). Duration: 10 to 20 weeks' gestation to birth
Risk factor—maternal gestational diabetes mellitus							
Gillman et al., 2010. Australia. ANTENATAL	Women enrolled in existing multicentre trial who had mild GDM at 24–34 weeks gestation, living in South Australia	*ACHOIS (Australian Carbohydrate Intolerance Study)* No theory indicated.	Screening for GDM then for those with GDM individual dietary advice, home blood glucose monitoring and insulin therapy (if needed).	Antenatal clinic sessions + additional content	Clinic	Dietician	Duration: 24 to 34 weeks' gestation to birth
Ijäs et al., 2015. Finland. ANTENATAL	Women with GDM treated at two hospitals in Oulu and Kajaani.	No theory indicated.	Home blood glucose monitoring. Women randomised to metformin or insulin treatment.	Medication	Antenatal clinic	Not indicated	Check-ups monthly up to 32 weeks gestation then fortnightly. Duration: 12–34 weeks' gestation to birth.
Kizirian et al., 2016. Australia. ANTENATAL	Pregnant women with 1 + risk factors for GDM: BMI ≥ 30 kg/m^2; age ≥ 35; PCOS; previous history of GDM or glucose intolerance; previous newborn >4,000 g; family history of type 2 diabetes; member	*GI Baby 4 Study*. Pilot prospective follow up of infants born to mothers enrolled in GI Baby 3 study. No theory indicated.	Randomised to a low GI OR high fibre diet. Insulin treatment if required.	Dietary—maternal. Individual consultations with dietitian	Clinic.	Dietician	Five consultations throughout pregnancy (14–20, 18–24, 22–28, 26–32 and 34–36 weeks.) Duration: 14 to 20 weeks' gestation

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TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
	of ethnic group with high prevalence of GDM. Attending antenatal clinic at hospital in Sydney.						
Rowan et al., 2011, 2018. Australia and New Zealand. ANTENATAL	Women with GDM in Adelaide and Auckland	*MiG TOFU (Metformin in Gestational diabetes—long Term Offspring Follow Up) study* No theory indicated.	Metformin OR insulin treatment	Medication	Hospital antenatal clinic	Not indicated	Duration: 20 to 33 weeks' gestation to birth
Risk factor—previous baby large for gestational age							
2016. 2016. Ireland. ANTENATAL	*Secundigravida women who had previously given birth to a macrosomic baby (>4 kg), recruited at maternity hospital, Dublin.*	*ROLO study (Randomised cOntrol trial of LOw GI diet).* No theory indicated.	Dietary education session with additional written resources focused on healthy eating in pregnancy and low GI foods.	Dietary—maternal. Individual session for individualised low GI diet. Group session	Clinic.	Research dietician	Education session approx. 12–16 weeks gestation, follow-up assessments at 28 weeks and 34 weeks gestation. Duration: 16 weeks' gestation to birth.
Risk factor—formula feeding (±low income)							
Bonuck et al., 2014. USA. POSTNATAL	Infants aged 11–13 months who consumed more than two bottles of milk or juice per day, attending WIC programme.	*Feeding Young Children Study.* No specified theory.	Educational intervention: Food amounts booklet, sippy cup and counselling guided by a flipchart.	Individual education session	WIC clinic	WIC nutritionists. Educational flipchart developed with WIC staff and client input.	One WIC visit
Chaparro, Anderson, et al., 2020. Chaparro, Wang, et al., 2020. ***See also Chaparro et al., 2019 .*** USA. ANTENATAL & POSTNATAL	WIC participating children in Los Angeles country throughout ages 0–4 y and who were never breastfed	Special Supplemental Nutrition Programme for Women, Infants and Children (WIC). No theory specified.	Change in content of monthly WIC supplemental food packages (vouchers supplied): more F&V and whole grains; less juice and whole milk. For fully FF infants: 403 fl oz. formula per month up to 4 mo, 442 fl oz. pm for	Dietary change—WIC food package	No specific setting	NA	Vouchers available monthly. Duration: pregnancy until age 4, while family is eligible under income test.

(Continues)

TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
			4–5.9 mo, and 312 fl oz. pm for 6–11.9 mo				
Kavanagh et al., 2008. USA. POSTNATAL	Exclusively FF infants aged 3–10 weeks attending WIC clinics.	Intervention educational modules based on Kolb's experiential learning cycle.	Responsive feeding—education and discussion about infant satiation cues. Preparation of <6-oz bottles and education about infant stomach size. Handout with techniques for calming crying baby.	Group education session.	WIC clinic	WIC educators.	1 × 45–60-min education class
Lakshman et al., 2018a. UK. POSTNATAL	Healthy, full-term FF infants, aged 0–14 weeks.	*Baby Milk Trial*. Motivational component based on social-cognitive theory.	Focus: healthy infant growth and nutrition, amounts of formula-feeds, hunger cues, growth charts and rapid weight gain Tools: goal setting, action plans, monitor plan, and if/then problem solving. Specific guidance for amount of formula (different to formula tin/packet guidance).	Face to face sessions. Phone sessions. Written materials.	Clinic. Other setting (phone support)	Research nurses. Programme resources and protocol developed with mothers, health visitors and midwives.	3 × 30–45-min face-to-face and 2 × 15–20-min telephone contacts, two leaflets Duration: age 2 to 14 weeks to 6 months
Tang et al., 2018, 2019. USA. POSTNATAL	Healthy term, FF infants aged 3–5 months.	None specified.	Two different infant complementary diets: predominantly milk protein-based foods vs. predominantly meat protein based (pureed). F&V intake unrestricted. Home visits for assessment and food delivery only. Parents received tailored feeding guidelines and were encouraged to feed according to infant appetite.	Dietary—different source of main protein.	No specific setting (home).	NA	Duration: age 5 to 12 months

(Continues)

TABLE 3 (Continued)

Author. Date. Country. Timing.	Participants: Risk factor, age	Intervention name and theory	Intervention content	Main elements	Setting	Intervention delivered by	Intervention frequency and duration
Risk factor—infant sleep problems							
Wake et al., 2011. Australia. POSTNATAL	Mothers attending maternal child health clinics, who reported infant sleeping problems when infants were 4 months, with sleep problem confirmed at 7 months.	*Kids Sleep Study*. Follow up study to *Infant Sleep Study*. No theory stated.	Identified sleep problem, discussed normal infant sleep, potential solutions and management strategies. 2-week sleep diary, two sleep strategies offered 'controlled crying' (responding to infant cry at increasing time intervals) and 'camping out' (parent presence with child slowly reducing over time). Follow-up visits to recognise sleep patterns and improvements and set further goals.	Individual sessions.	Health clinic	Maternal and child health nurses.	Two to three visits commencing at infant age 8 months (visits around 2 weeks apart). Duration: age 8 to 10 months.

Abbreviations: ANC, antenatal clinic; BF, breastfeeding, breastfed; BMI, body mass index; DVD, digital video disk; ECHO, Early Childhood Obesity Prevention trial; FF, formula feeding/formula fed; F&V, fruit and vegetables; GDM, gestational diabetes mellitus; GI, glycaemic index; GW, gestational weeks; h, hours; IBCLC, International Board Certified Lactation Consultants; kg, kilograms; m, metres; min, minutes; NA, not applicable; NFN, Nurturing Families Network; oz, ounce; PCOS, polycystic ovary syndrome; RWG, rapid weight gain; SES, socio-economic status; SMS, short message service (text); SSB, sugar sweetened beverage; TV, television; UK, United Kingdom; UNICEF, United Nations Children's Fund; USA, United States of America; WHO, World Health Organisation; WIC, Women Infants & Children programme.

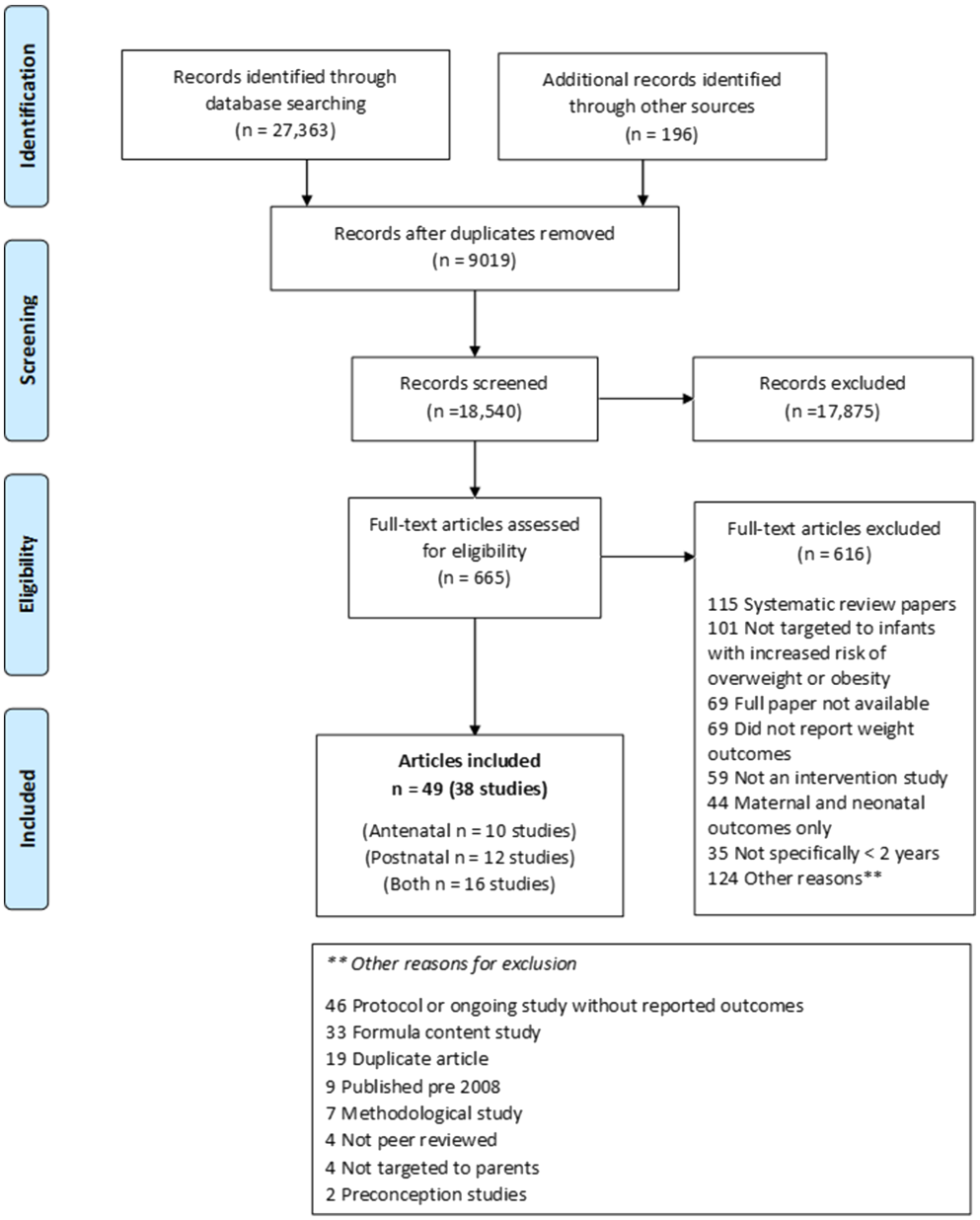

FIGURE 1 PRISMA flowchart

that they were systematic reviews (*n* = 115) or did not target infants with specific risk factors for later overweight (*n* = 101). Overall, 49 articles met all inclusion criteria.

3.2 | Study characteristics and risk factors

The 49 articles reported 38 separate interventions. Table 2 summarises the studies, stratified by the main risk factor targeted by each intervention. All but three (da Costa Louzada et al., 2012; Navarro et al., 2013; Schwartz et al., 2015; Vitolo et al., 2012) were conducted in high-income countries. A majority (18/38) were conducted in the United States and five in Australia. Three studies were conducted in the United Kingdom, and two each in Brazil, Denmark and Finland. The remaining studies were undertaken in the Dominican Republic, France, Ireland, Puerto Rico, Sweden and one conducted across Australia and New Zealand.

The most common risk factors targeted were high maternal pre-pregnancy BMI or gestational weight gain (*n* = 13) (Carlsen et al., 2013; Claesson et al., 2016; Dodd, Louise et al., 2018; Dodd, McPhee, et al., 2018; Fiks et al., 2017; Gregory et al., 2016; Kong et al., 2014; McCormick et al., 2020; Mustila et al., 2013; Mustila et al., 2018; Parat et al., 2019; Patel et al., 2017; Phelan et al., 2019; Reifsnider et al., 2018; Tanvig et al., 2014; Vesco et al., 2016), although none addressed paternal BMI. Many interventions targeted individuals or regions with socio-economic disadvantage, sometimes in conjunction with criteria such as adolescent mothers (Ordway et al., 2018; Schwartz et al., 2015) or formula feeding (Bonuck et al., 2014; Chaparro et al., 2019; Chaparro, Anderson, et al., 2020; Kavanagh et al., 2008). No studies explicitly focused on low parental

education attainment, another potential risk factor (Van Den Berg et al., 2013).

Four antenatal interventions addressed gestational diabetes: two with medication (Ijäs et al., 2015; Rowan et al., 2011, 2018) and two with dietary changes (Gillman et al., 2010; Kizirian et al., 2016). Five studies focused on formula-fed infants (Bonuck et al., 2014; Chaparro, Anderson, et al., 2020; Chaparro, Wang, et al., 2020; Kavanagh et al., 2008; Lakshman et al., 2018a; Tang et al., 2018, 2019), but none targeted infants who commenced complementary foods earlier than the recommended 4–6 months. A few studies specifically targeted ethnic groups with increased risk of childhood obesity (Karanja et al., 2010; Palacios et al., 2018; Washio et al., 2017) or infants with disturbed sleep (Wake et al., 2011). Although several studies reported RWG as an outcome, none targeted infants with established RWG during early infancy as a risk factor. One study recruited women with previous infants born large-for-gestational-age (Horan, Donnelly, et al., 2016; Horan, McGowan, et al., 2016). None addressed prenatal tobacco exposure.

3.3 | Quality assessment

Few of the selected studies met all the relevant criteria of the MMAT (Table S1). It was difficult to assess adherence to the intervention in several studies where this was not reported—participants may not accurately reveal the extent to which they complied with dietary guidelines or exercise regimes—so the effect of intervention fidelity is often unknown. Several randomised controlled trials (RCTs) did not report whether the outcome assessors were blind to the intervention, and some indicated this was not the case. Over half the papers reported substantial sample attrition—losing over 20% for 12-month follow-up or more than 30% over longer periods (Table S1). Less than half reported an underlying theoretical base (Table 3).

3.4 | Interventions

Table 3 summarises the 38 interventions. It demonstrates the heterogeneity of content, provider, setting, dose and frequency, as well as the theoretical bases informing intervention delivery.

3.4.1 | Timing

Ten studies were antenatal interventions focused on the health characteristics of pregnant women, either gestational diabetes or overweight (Dodd, Louise, et al., 2018; Dodd, McPhee, et al., 2018; Gillman et al., 2010; Gregory et al., 2016; Ijäs et al., 2015; Kizirian et al., 2016; Kong et al., 2014; Patel et al., 2017; Rowan et al., 2011, 2018; Tanvig et al., 2014; Vesco et al., 2016). Sixteen were conducted entirely in the postnatal period (Bonuck et al., 2014; Carlsen et al., 2013; Cloutier et al., 2018; da Costa Louzada et al., 2012; de la Haye et al., 2019; French et al., 2012; Kavanagh et al., 2008; Lakshman et al., 2018b; Machuca et al., 2016; Palacios et al., 2018; Phelan et al., 2019; Scheiwe et al., 2010; Schwartz et al., 2015; Tang et al., 2018, 2019; Vitolo et al., 2012; Wake et al., 2011; Washio et al., 2017; Watt et al., 2009), and twelve started during pregnancy and continued after birth (Chaparro et al., 2019; Chaparro, Anderson, et al., 2020; Chaparro, Wang, et al., 2020; Claesson et al., 2016; Fiks et al., 2017; Horan, Donnelly, et al., 2016; Horan, McGowan, et al., 2016; Karanja et al., 2010; McCormick et al., 2020; Mustila et al., 2013, 2018; Navarro et al., 2013; Ordway et al., 2018; Parat et al., 2019; Reifsnider et al., 2018; Thomson et al., 2018; Wen, Baur, Simpson, et al., 2012; Wen et al., 2015).

3.4.2 | Type of intervention

Twelve of 38 interventions incorporated home visits—all had postnatal components, although some commenced during pregnancy. In six studies, the home visitor was a health professional (Carlsen et al., 2013; de la Haye et al., 2019; Karanja et al., 2010; Ordway et al., 2018; Schwartz et al., 2015; Wen, Baur, Rissel, et al., 2012), three used volunteers (sometimes with extensive training) (Navarro et al., 2013; Scheiwe et al., 2010; Thomson et al., 2018; Watt et al., 2009), one used nutrition students (da Costa Louzada et al., 2012; Vitolo et al., 2012), one used trained community health workers without formal health professional qualifications (McCormick et al., 2020; Reifsnider et al., 2018) and one study did not indicate the providers' qualifications (Cloutier et al., 2018). Another 19 interventions involved face-to-face sessions with health professionals in a clinic (typically antenatal or well-child clinics) (Bonuck et al., 2014; Claesson et al., 2016; Dodd, Louise, et al., 2018; Dodd, McPhee, et al., 2018; French et al., 2012; Gillman et al., 2010; Gregory et al., 2016; Horan, Donnelly, et al., 2016; Horan, McGowan, et al., 2016; Ijäs et al., 2015; Kavanagh et al., 2008; Kizirian et al., 2016; Lakshman et al., 2018b; Mustila et al., 2013; Mustila et al., 2018; Parat et al., 2019; Patel et al., 2018; Rowan et al., 2011, 2018; Schwartz et al., 2015; Tanvig, 2014; Vesco et al., 2016; Wake et al., 2011; Washio et al., 2017). In some cases, these were routine visits where the intervention group received additional education or counselling regarding infant weight outcomes. Ten studies included groups (de la Haye et al., 2019; Fiks et al., 2017; Horan, McGowan, et al., 2016; Horan, Donnelly, et al., 2016; Kavanagh et al., 2008; Machuca et al., 2016; Navarro et al., 2013; Parat et al., 2019; Phelan et al., 2015; Tanvig et al., 2014; Vesco et al., 2016), sometimes in conjunction with other intervention elements (e.g., clinic or home visits); one utilised Facebook groups (Fiks et al., 2017). Five interventions involved telephone support (Carlsen et al., 2013; Dodd, Louise, et al., 2018; Dodd, McPhee et al., 2018; Karanja et al., 2010; Lakshman et al., 2018b; Wen, Baur, Simpson, et al., 2012; Wen et al., 2015), two used short message service (SMS) (Palacios et al., 2018; Phelan et al., 2019) (one as the sole element of the intervention) and two used online support (Fiks et al., 2017;

Phelan et al., 2019). Four studies with a physical activity focus facilitated participants' involvement by providing gym membership (Tanvig et al., 2014), aquarobics sessions (Claesson et al., 2016), pedometers (Patel et al., 2017) or a treadmill (Kong et al., 2014). Other interventions compared maternal or infant diets (low glycaemic index vs. high-fibre, Kizirian et al., 2016; meat vs. dairy-based complementary foods, Tang et al., 2018, 2019), or alternate medications for gestational diabetes (Ijäs et al., 2015; Rowan et al., 2011, 2018). One major intervention involved changes in the content of the WIC supplemental food packages available as vouchers for low-income families (Chaparro et al., 2019; Chaparro, Anderson, et al., 2020; Chaparro, Wang, et al., 2020). Another study examined financial incentives for WIC recipients to continue breastfeeding (Washio et al., 2017).

Nearly all interventions focused on maternal and/or infant nutrition through promoting exclusive breastfeeding for 6 months, increasing fruit and vegetable intake and avoiding discretionary foods. Dietary initiatives were sometimes combined with other components such as increased physical activity for pregnant women or infants (Table 3). The remaining interventions that did not address nutrition were two antenatal interventions comparing alternative GDM medications (metformin vs. insulin treatment) (Ijäs et al., 2015; Rowan et al., 2011, 2018); a brief antenatal intervention increasing maternal physical activity (Kong et al., 2014) and one postnatal study investigating a behavioural sleep strategy for unsettled infants (Wake et al., 2011).

3.5 | Setting

The most common location for interventions were clinics and health facilities, for groups and face-to-face consultation with clinicians, either antenatally or postnatally (Table 3). In several studies, all participants (including controls) attended clinics, for standard well-child or antenatal care, and intervention group members received additional education or counselling input related to the study objectives. Clinic visits were sometimes supplemented with other elements such as phone or online support to parents. Other settings included participants' homes and fitness centres (swimming pools and gyms). Some interventions were not linked to a specific setting, such as online interventions or the WIC programme food package changes (see Table 3).

3.6 | Duration

Table 3 indicates that interventions ranged from simple interactions, such as one clinic-based education class (Kavanagh et al., 2008) or weekly SMS messages over 4 months (Palacios et al., 2018), through to intensive contact between participants and providers; some continued for a sustained period, such as studies of dietary changes in the WIC programme food packages (Chaparro et al., 2019; Chaparro, Anderson, et al., 2020; Chaparro, Wang, et al., 2020), which can potentially last from pregnancy through to the child's fifth birthday if the family remains eligible.

3.7 | Consumer involvement

There was limited consumer involvement in the design of interventions (Table 3). Three studies (Fiks et al., 2017; Karanja et al., 2010; Lakshman et al., 2018b) involved community representatives or potential consumers in intervention development; three included them in developing or pilot-testing resources (Bonuck et al., 2014; French et al., 2012; Lakshman et al., 2018b).

3.8 | Study design and measures

All selected studies used experimental research designs, and the majority were RCTs (22 RCTs, 7 cluster RCTs, 1 stratified RCT and 1 pilot RCT). The remaining non-randomised studies used various designs (Table 2). Studies reported diverse outcomes at diverse time points, limiting synthesis of findings. Whereas some studies reported mean weight in each cohort, most standardised outcomes were reported by using mean BMI and/or *z*-scores for weight-for-height (zWFH), weight-for-length (zWFL) or weight-for-age (zWFA). Some studies reported the proportions of infants with overweight or obesity, or in a 'healthy weight range', defined using criteria unique to each study. Most reported weight outcomes at one or more single time points. However, some studies reported RWG by comparing changes in standardised weight standard deviation score (SDS) over various time intervals (Kizirian et al., 2016; Lakshman et al., 2018b; Mustila et al., 2013; Palacios et al., 2018; Parat et al., 2019; Phelan et al., 2019; Thomson et al., 2018).

3.9 | Study outcomes

Nine of the 38 interventions reported a statistically significant positive impact on one or more measures of weight outcome (shown in bold in Table 2). These included two antenatal interventions (Ijäs et al., 2015; Vesco et al., 2016), two postnatal (Machuca et al., 2016; Phelan et al., 2019) and five spanning the period before and after birth (Chaparro et al., 2019; Chaparro, Anderson, et al., 2020; Chaparro, Wang, et al., 2020; Navarro et al., 2013; Ordway et al., 2018; Parat et al., 2019; Wen, Baur, Simpson, et al., 2012; Wen et al., 2015). Conversely, two postnatal trials reported significantly higher mean weight among the intervention cohorts compared with controls (Kavanagh et al., 2008; Watt et al., 2009) (Table 2).

Most of the successful postnatal interventions specifically targeted socio-economically disadvantaged families (some in conjunction with other risk factors). Chaparro and colleagues used matched samples from national administrative datasets from 2003 to 2016 to compare children in families receiving WIC programme support before and after changes in the supplemental food package contents in 2009.

The new package contained more fruit, vegetables and whole grains; less juice, whole milk, cheese and eggs; and lower amounts of infant formula. Children aged 1 year participating in WIC receiving the new food package had a significantly lower mean zWFH than other children receiving WIC, regardless of gender or initial weight status (low, average or high zWFH) (Chaparro et al., 2019). Among exclusively formula-fed infants receiving WIC food packages, those who received the new child food package had significantly lower zWFH at age four than those receiving food packages before the programme change (Chaparro, Anderson, et al., 2020). A related study found significantly lower relative risk of obesity at 4 years among some groups of children who received the new food packages compared with matched children born before the change took effect, namely, children who were mostly breastfed (but not among those fully breastfed), and boys who were mostly or fully formula-fed (Chaparro, Wang, et al., 2020).

The *Well Baby Group* trial in a disadvantaged area of New York provided a parenting support group facilitated by dietitians and paediatricians for 18 months. At 2 years, the researchers found a significantly lower proportion ≥85th BMI percentile, compared with infants receiving traditional well-child care (Machuca et al., 2016). The *Healthy Beginnings* trial provided support to low-income Australian families through home visits from trained community nurses, timed to fit with developmental milestones during the first 2 years, with additional phone support. By age two, the mean BMI was significantly lower in the home visiting group than those receiving usual care (Wen, Baur, Simpson, et al., 2012). However, by 3.5 and 5 years, there were no statistically significant differences in weight measures between the two cohorts (Wen et al., 2015). The *Fit Moms/Mamas Activas* programme in California provided online post-partum support and information about children's weight, and regular face-to-face groups over 12 months for low-income mothers with overweight or obesity. Intervention group infants experienced significantly lower increases in zBMI over the first 6 months, compared with control group infants whose families received standard WIC support and general weight loss information; however, differences were not maintained at 12 months (Phelan et al., 2019). The *Minding the Baby* programme provided parenting support to young mothers in medically underserved areas, through home visits from a social worker and paediatric nurse from late pregnancy to 24 months post-partum. Significantly more intervention group infants had a 'healthy' weight at 2 years than controls. They had significantly lower rates of obesity and, among Hispanic participants, significantly lower rates of combined overweight and obesity (Ordway et al., 2018). Finally, a peer nutrition education intervention in the Dominican Republic aimed to reduce both malnutrition and the risk of overweight in infants under 2 years through group meetings and home visits provided lay community counsellors. During their second year, intervention group infants had a significantly lower zBMI score, and proportion of infants ≥85th BMI percentile (Navarro et al., 2013). This was the only study in a middle-income country that reported improved outcomes.

Three trials that reported significantly improved child weight outcomes at follow-up were targeted to maternal overweight. The *Fit Moms/Mamas Activas* programme targeted low-income women with overweight and obesity, providing online and SMS support in addition to the standard WIC programme. Women received individual weight goals and monitoring and personal feedback, as well as online lessons and a weekly blog from peers, resulting in significant differences in mean infant zBMI between birth and 6 months (Phelan et al., 2019). The *ETOIG* trial reported lower prevalence of high BMI (>19 kg/m^2) in infants aged 2 years, following a healthy lifestyle education intervention with mothers with pre-pregnancy BMI over 25 kg/m^2 (Parat et al., 2019). However, the result was only statistically significant using the per protocol or available data analyses, and not using intention to treat analysis where missing values were treated as excessive weight gain. There were no significant differences in RWG between birth and 2 years using any means of analysis. The *Healthy Moms* trial studied a diet and activity intervention for women with BMI ≥ 30 kg/m^2, and found significantly lower mean weight and zWFA at 12 months but no significant differences in zWFL or proportions of WFL > 97.7th percentile (Vesco et al., 2016). Another study that found significantly lower mean weight and height at 12 and 18 months among infants whose mothers had received insulin treatment compared with metformin (Parat et al., 2019) for gestational diabetes but no difference in ponderal index, proportions with weight at or above the 95th percentile or high weight-for-length readings (Ijäs et al., 2015).

One common factor among the studies reporting significantly improved infant weight outcomes was their sustained duration. Nearly all studies conducted during the postnatal period continued to 12 months (Phelan et al., 2015), 18 months (Machuca et al., 2016), 24 months (Navarro et al., 2013; Ordway et al., 2018; Wen, Baur, Simpson, et al., 2012) or until withdrawal from the WIC programme, potentially at 5 years of age (Chaparro, Anderson, et al., 2020; Chaparro et al., 2019; Chaparro, Wang, et al., 2020). These interventions were typically provided regularly, with weekly or monthly support. Some successful antenatal interventions recruited women relatively early in pregnancy. The *Healthy Moms* study recruited from 10 to 20 weeks with a mean gestation of 15.1 weeks (Vesco et al., 2016). The *ETOIG* study continued from the first trimester through to 2 months of age (Parat et al., 2019). Six studies reporting improved outcomes were randomised controlled trials. However, these studies all contained some methodological limitations against the MMAT (Table S1). Although randomisation appeared effective, three studies did not demonstrate comparable cohorts at baseline (Ordway et al., 2018; Phelan et al., 2019; Wen, Baur, Simpson, et al., 2012); one indicated that the intervention group had a significantly lower mean birthweight (Ordway et al., 2018) and another that controls had significantly lower zBMI and WFA before the intervention (Phelan et al., 2019). However, several intervention designs meant that participants were not blinded to researchers or that it was difficult to monitor adherence to the intervention by participants. Three of these studies experienced substantial sample attrition before follow-up assessment (Ordway et al., 2018; Phelan et al., 2019; Vesco et al., 2016). The remaining non-randomised interventions reporting improved weight trajectories included a population-based study examining the impact of the changed WIC food packages (Chaparro et al., 2019; Chaparro, Anderson, et al., 2020; Chaparro, Wang,

et al., 2020), which met all MMAT quality criteria with impressive sample sizes. Another well-conducted study used a retrospective approach albeit with a relatively small intervention group (n = 47) (Machuca et al., 2016). The other study used a quasi-experimental design in matched locations with sample attrition of one-quarter, and uncertain adherence to the intervention strategy (Navarro et al., 2013).

Two postnatal RCTs reported higher mean weight among intervention groups at follow-up. One US study of exclusively formula-fed infants reported significantly higher mean weight after a 4-month education programme about feeding to satiety compared with controls (Kavanagh et al., 2008). A UK study of home visits to low-income families by volunteers to support improved infant feeding practices reported that intervention group infants had higher mean weight than control group infants at 12 months (bordering on statistical significance at p = 0.05). However, this difference was not significant by 18 months (Watt et al., 2009) or at 4 years (Scheiwe et al., 2010). Both studies had considerable loss to follow-up and uncertain adherence to the intervention (Table S1); one retained a small sample at follow up (n = 40 after 4 months) (Kavanagh et al., 2008).

The remaining studies reported no significant differences between intervention and comparison groups on weight-specific measures (potentially due to sample size). However, several indicated improvements on other outcomes not assessed here regarding physical activity or nutrition behaviour, such as increased breastfeeding initiation and duration, delayed introduction of solid food, reduced consumption of sugar-sweetened beverages, or greater parental knowledge about healthy nutrition.

4 | DISCUSSION

This review explored the impact of interventions specifically targeting parents of infants with characteristics that increased risk of later obesity or overweight. Whereas previous reviews of early intervention studies have addressed effects among general populations of infants (Blake-Lamb et al., 2016; Ciampa et al., 2010; Hesketh & Campbell, 2010; Koplin et al., 2019; Laws et al., 2014; Matvienko-Sikar et al., 2018; Redsell, Edmonds, et al., 2016; Rotevatn et al., 2019), this is the first review to focus specifically on those children who are most susceptible to unhealthy weight gain. Overall, this review provides limited evidence that a focus on the most at risk in early life can be beneficial with around one quarter of the studies identified showing significantly improved weight outcomes among intervention cohorts. Control groups in two studies demonstrated lower mean weight than intervention groups, with the remainder showing a null effect on measured weight outcomes.

The majority of studies focused on two important risk factors: low family income and/or maternal weight status, sometimes in conjunction with other characteristics. An earlier review found that over half the obesity prevention interventions for children 0–5 years involved low-income populations (Hesketh & Campbell, 2010). Targeting these populations is warranted given the disproportionate prevalence of overweight and obesity in low-income populations (Woo Baidal et al., 2016). Low income often coincides with low educational attainment, another potential risk factor (Van Den Berg et al., 2013), although this was not specified in the studies identified. Interventions to support parents with limited formal education therefore require materials and approaches that do not rely on complex information or high reading-ages. Peer educators and community health workers may also be more appropriate sources of advice. Thirteen studies targeted mothers with high BMI, including seven that that addressed maternal diet and exercise during pregnancy. However, none focused on paternal weight status, despite higher risks of overweight among children whose fathers have high BMI (Weng et al., 2013).

These findings correspond with Reilly et al. (2017), who examined the various risk factors targeted in studies identified in a comprehensive review by Blake-Lamb et al., (2016), concluding that some factors (such as maternal smoking and short sleep duration) have been relatively overlooked in published research to date. We did not identify any studies targeting prenatal exposure to tobacco as a risk characteristic and only identified one eligible study that recruited infants with sleep problems (Wake et al., 2011) that met our inclusion criteria. This may be due to the specific research focus, demonstrating where health research may exist in silos. Further, our search terms did not specifically include 'smoking', 'tobacco' or 'sleep'. Despite the established link between unsettled sleep and child overweight and emerging interest in this association, current research such as the POI study (Taylor et al., 2017) largely focuses on universal interventions. Many interventions have endeavoured to reduce parental smoking—to improve outcomes on multiple dimensions. However, anti-smoking interventions typically stand alone, with the predominant aim of reducing exposure to tobacco for mother and infant, rather than focusing uniquely on infant overweight or obesity. As such, we did not identify any studies of anti-smoking interventions that reported infant weight status beyond the immediate neonatal period.

Further, although some studies reported RWG as an outcome, none of the interventions targeted infants with early RWG, another significant risk factor for subsequent overweight (Monasta et al., 2010; Weng et al., 2012; Zheng et al., 2018). All the postnatal studies identified started at birth or within the first few months of life (Table 3), before RWG was established. This highlights the importance of monitoring early infant growth and communicating with parents as soon as RWG is identified to initiate behaviour change (Weng et al., 2013).

Risk factors for infant obesity are multifaceted and sometimes clustered (Redsell, Weng, et al., 2016; Weng et al., 2013), making it hard to distinguish the most influential to target. Further, children and their families exist within a wider social, economic and cultural environment, where complex and entrenched phenomena determine health outcomes. In addition to targeted and tailored advice, more intensive work is required to address the underlying forces that increase the risks of overweight in some population groups.

Of the nine studies that reported significantly improved weight outcomes among intervention groups, most targeted low-income populations (Chaparro et al., 2019; Chaparro, Anderson, et al., 2020 Chaparro, Wang, et al., 2020; Machuca et al., 2016; Navarro

et al., 2013; Ordway et al., 2018; Wen, Baur, Simpson, et al., 2012; Wen et al., 2015) or high maternal BMI (Parat et al., 2019; Phelan et al., 2019; Vesco et al., 2016). Studies of low-income families also addressed other risk factors: young motherhood (Ordway et al., 2018) and formula feeding (Chaparro, Anderson, et al., 2020). One intervention treated women with gestational diabetes, regardless of whether or not they had other risk factors (Ijäs et al., 2015). These factors are readily identifiable and can guide health professionals where to target interventions.

The studies that reported significantly improved weight outcomes used a range of intervention modes. Three incorporated home visits as part of the intervention (Navarro et al., 2013; Ordway et al., 2018; Wen, Baur, Simpson, et al., 2012) and four utilised group sessions (Machuca et al., 2016; Navarro et al., 2013; Phelan et al., 2019). Only two successful interventions were limited to the antenatal period (Ijäs et al., 2015; Vesco et al., 2016); the remainder commenced during pregnancy or shortly after birth and continued postnatally. This suggests that interventions need to encompass both the antenatal period and continue postnatally to achieve success.

The two antenatal interventions targeting women with GDM reported significantly improved infant weight outcomes using diverse methods. One featured individual counselling and planning for participants, focusing on both diet and physical activity supplemented with group sessions (Parat et al., 2019), whereas the other compared insulin with metformin treatment (Ijäs et al., 2015). These findings highlight the limited research to date investigating longer term infant outcomes from antenatal interventions to prevent child obesity specifically among parents whose children have an increased risk.

Research by Chaparro and colleagues on changes to the content of the WIC supplemental food programme (Chaparro et al., 2019; Chaparro, Anderson, et al., 2020) highlights the importance of ready access to healthy food as a cornerstone of lifestyle intervention and change. It also demonstrates that policy-driven social welfare (food availability) for identified population groups can support improved health outcomes on a larger scale than individual targeted behaviour change alone. However, WIC participation has declined since 2015–2016, with mothers of fully formula-fed infants three times less likely to recertify at 1 year compared with mothers of fully breast-fed infants (Almeida et al., 2020); subsequently, this may limit disadvantaged families' access to healthy food.

In terms of providers, one intervention was delivered by lay counsellors who worked with low-income women in the Dominican Republic (Navarro et al., 2013), although other successful interventions were delivered by health professionals. Among these, some incorporated individualised counselling, health planning and goal-setting to address potential barriers (Parat et al., 2019; Wen, Baur, Simpson, et al., 2012; Wen et al., 2015). The *Minding the Baby* study also focused on maternal reflexivity to promote attachment and ongoing healthy lifestyles during home visits (Ordway et al., 2018). Home visits and/or group sessions with health professionals are among the elements of effective obesity prevention programmes identified in other reviews (Blake-Lamb et al., 2016; Matvienko-Sikar et al., 2018). In women experiencing social or economic disadvantage, home visits may be a more achievable avenue for intervention in the early post-partum period if transport or caring for other children are problematic.

Although the *Fit Moms/Mamas Activas* intervention incorporated face-to-face groups at WIC clinics, these were not well attended, and the intervention was primarily internet-based, including online weight checking and education content, personalised feedback, internet diary and motivational text messages to reinforce learning. Even with limited personal contact, the intervention provided individualised information and support. Participants received incentives for positive weight changes and logging into the website (Phelan et al., 2015). As the successful components of this latter intervention did not involve high intensity and therefore high-cost involvement of health care professionals, it could be a candidate for wide dissemination at relatively low cost.

As noted, most of the interventions with statistically significant improvements in infant weight engaged participants for a sustained period. However, two studies reported a diminished effect of the intervention on child weight measures over time: the *Healthy Beginnings* trial reported statistically significant differences in weight outcomes at 2 years, but not at the next follow-ups (3.5 and 5 years); the *Fit Moms/Mamas Activas* study reported significant differences in zBMI between birth and 6 months, but not between birth and 12 months (Phelan et al., 2019; Wen et al., 2015). Other systematic reviews of less targeted interventions have also highlighted the difficulty of sustaining the early benefits of nutrition-related interventions on infant weight outcomes beyond infancy (Koplin et al., 2019; Laws et al., 2014a; Rotevatn et al., 2019). This highlights the importance of continued interaction between participants and health professionals to enhance engagement and adherence with the intervention. As Rotevatn and colleagues point out, the context and delivery of interventions is critical, as parents value tailored, consistent and non-judgemental support and guidance (Rotevatn et al., 2019). This is common to all parents of young children as well as those whose children are vulnerable to unhealthy weight gain.

This review suggests that successful interventions to prevent excess weight gain in infants that target parental behaviours, related to both the mother and to infant feeding should be of sufficient duration to target key ages and stages where obesity promoting behaviours can be adopted. Many interventions may require relatively intensive or long-term support from health care professionals, and the cost of programmes needs to be balanced against the long-term cost of child obesity. Changes to the food supply for vulnerable families is one promising strategy.

4.1 | Strengths and limitations

This review was broad in scope, embracing heterogeneous research designs, risk factors, outcomes and timeframes, precluding any meta-analysis of results. The diversity of interventions and results limited our ability to synthesise study findings or generalise them to other populations of children at risk of excess weight gain.

It is possible that we overlooked some publications that met the review criteria, especially more recent research; however, the update and the extensive hand-searching process minimised this risk. The review process may have generated some publication bias in study selection. Given the heterogeneity of approaches, we were unable to assess this statistically. However, several studies reported nil results, especially in weight measures, suggesting that at least some research is published notwithstanding its non-significant findings.

The quality of the individual studies was variable using MMAT criteria; some studies reporting significantly improved weight outcomes did not rate strongly on all criteria (Ijäs et al., 2015; Navarro et al., 2013; Ordway et al., 2018; Phelan et al., 2019; Wen, Baur, Simpson, et al., 2012). We found little risk of selection bias. However, some articles could not preclude detection bias. Several had considerable loss to follow-up, which was potentially detrimental to the aim of assessing longer-term weight outcomes for children. Another persistent shortcoming was the limited information on participants' adherence to the interventions. The MMAT did not address reporting bias.

Although several studies used tailored interventions, to respond to participants' specific circumstances and needs, it is notable that very few involved consumers in codesigning interventions.

4.2 | Implications for practice and policy

Given the necessity of early intervention to address childhood obesity, this review has demonstrated the importance of not only working with parents of infants under 2 years, including expectant parents but also targeting interventions to infants who face greater risks of excess weight gain. Parental and sociodemographic risk factors for later obesity are well established, and most can be identified early. It is vital that these infants are offered evidence-based programmes early to prevent unhealthy weight gain. The review highlighted the importance of sustained duration including contact with health professionals. Most successful interventions recruited participants early, through maternity hospitals, community health clinics or WIC centres. These facilities offer scope for access to early childhood health professionals, at a time when parents may be particularly motivated to support their infants' health and well-being.

4.3 | Implications for further research

This review has highlighted the importance of follow-up to examine the longer-term effects of targeted interventions delivered in pregnancy and infancy; longitudinal research is thus particularly relevant. Further high-quality research is also required into interventions that target risk factors not examined in the selected studies such as paternal weight status, exposure to tobacco smoke, sleep disturbances and in particular, interventions to assist infants with early RWG. There is likewise a need for research comparing the relative effectiveness of interventions that are targeted compared with universal programmes for obesity prevention, ideally with robust samples to identify whether weight trajectories differ among infants with established risk factors from those of general populations. There is clearly scope for interventions and research in low- and middle-income countries, given the increasing prevalence of child obesity in these regions, the large populations potentially affected and the relative scarcity of peer-reviewed research to date.

5 | CONCLUSION

There is an extensive literature on obesity prevention interventions aimed at general populations, at children older than two, or that assesses behavioural outcomes related to diet and activity. This review identified a limited number of studies that met our narrower criteria: studies specifically targeted on infants with increased risk of child overweight and obesity that reported quantifiable weight outcomes. However, its findings were in line with other reviews of prevention interventions aimed at universal populations, with modest evidence of statistically significant improvement in weight outcomes (Koplin et al., 2019). The studies were of mixed quality and tended to show a diminishing effect over time.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTIONS

All authors developed the review strategy under the guidance of EDW. CR conducted database searches and managed review software. HC, EDW and CR screened titles, reviewed full text articles and conducted quality appraisal. JA, HC and CR compiled tables. All authors contributed to the manuscript and approved the final version.

DATA AVAILABILITY STATEMENT

As this article is a systematic review, the 'data' are articles published in academic journals that are already in the public domain. Data sharing is not applicable to this article.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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