Appetite 210 (2025) 107980

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

# Outcome measurement instruments used to measure diet-related outcomes in infancy: A scoping review

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ARTICLE INFO

*Keywords:*
Childhood obesity
Diet
Infant feeding
Outcome measurement
Complementary feeding
Breastfeeding

ABSTRACT

*Introduction:* Supporting positive diet behaviours during infancy is essential to support child health and prevent childhood obesity. How infant diet-related outcomes are measured in trials is crucial to determining intervention effectiveness. This scoping review examined what and how outcome measurement instruments are currently used to measure 13 infant diet-related outcomes from a previously developed core outcome set.
*Methods:* The databases EMBASE, MEDLINE, CINAHL and PsycINFO were searched from inception to September 2023. Eligible studies reported trials that included infants ≤1 year old and at least one diet-related outcome measurement instrument. Titles/abstracts and full texts were independently screened in duplicate. Data were narratively synthesised.
*Results:* 136 studies reporting 133 trials were included. Outcome measurement instruments used included 66 questionnaires (n = 70 studies), 65 individual questions (n = 45 studies), 24 food diaries/records (n = 21 studies), 11 24-hour dietary recall (n = 11 studies), and healthcare record data (n = 6 studies). Outcome measurement instruments were predominantly self-administered by researchers in participants homes. There was a lack of reporting for some outcome measurements used.
*Conclusion:* Review findings highlight the need to improve clarity and completeness of outcome reporting. The findings also provide an important first step to address heterogeneity in measurement of infant diet-related outcomes. Consistent measurement of diet-related outcomes is needed to improve synthesis and evaluation of obesity prevention interventions.

## 1. Introduction

Establishing health promoting behaviours in infancy, including diet and eating habits, is important to achieve positive growth, health and wellbeing, and to prevent childhood obesity (Dalal et al., 2022; Martín-Rodríguez et al., 2022). Currently approximately one in four children globally live with overweight or obesity (Moschonis et al., 2022), and rates are estimated to continue rising (World Obesity Federation, 2023).

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https://doi.org/10.1016/j.appet.2025.107980
Received 3 September 2024; Received in revised form 24 February 2025; Accepted 24 March 2025
Available online 25 March 2025

Overweight and obesity in childhood track to adulthood and are associated with a range of adverse outcomes including cardiovascular disease, types of cancer, diabetes and other non-communicable diseases (Kumar & Kelly, 2017; Sommer & Twig, 2018; Umer et al., 2017; World Obesity Federation, 2023). While the aetiology of childhood obesity is complex and involves multiple factors (Kumar & Kelly, 2017; Liao et al., 2019; Malacarne et al., 2022; Woo Baidal et al., 2016), how, what and when infants are fed plays an important role in the development and prevention of childhood obesity (Kumar & Kelly, 2017; López-Gil et al., 2023; Woo Baidal et al., 2016). The first year after birth is particularly important as children undergo rapid changes in feeding and developmental needs during this time (Taylor et al., 2017).

The World Health Organisation (WHO) recommends that infants are exclusively breastfed for at least the first 6 months of life, with continued breastfeeding to two years and that complementary foods are not introduced until at least 6 months of age (WHO, 2023a, 2023b). Breastfeeding is associated with reduced risk of childhood obesity even when accounting for confounding factors (Horta et al., 2023). However, prevalence of breastfeeding is low overall; for instance, on average, less than half of infants under 6 months are breastfed globally (Global Breastfeeding Global Breastfeedin Collective, 2023). While the choice to breastfeed can be influenced by multiple factors (Ejie et al., 2021; Hadisuyatmana et al., 2021; Patil et al., 2020), women's breastfeeding self-efficacy (i.e., a woman's confidence in her ability to breastfeed) (Dennis, 1999) is an important determinant (Borona et al., 2023; Chipojola et al., 2020; Dennis et al., 2024) with evidence demonstrating women with higher self-efficacy are more likely to initiate and continue breastfeeding (Chipojola et al., 2020). Consumption of commercial milk infant formula, and the type of formula fed (e.g., in relation to the casein/whey ratio), are also associated with childhood obesity, likely via rapid weight gain due to different nutrient profiles, including increased protein, in formula milk (Appleton et al., 2018; Blake-Lamb et al., 2016). Similarly, the timing of introduction of solid foods is associated with increased risk of obesity (Vazquez & Cubbin, 2020; Wang et al., 2016; Woo Baidal et al., 2016), yet there is evidence that infants are often introduced to solids early (i.e., before 6 months)(Arora et al., 2020; Chiang et al., 2023; Ferreira et al., 2023). Further, once complementary feeding is established, the type, and amount of foods fed to infants can influence development of childhood overweight and obesity (English et al., 2019; Rousham et al., 2022). Providing a healthy diet that includes age appropriate foods and beverages can therefore help to minimise risk of overweight and obesity (Hohman et al., 2017; Pearce & Langley-Evans, 2013; Rousham et al., 2022). Provision of appropriate portion sizes for infants can also reduce risk via development of child appetite and satiety regulation (Ferguson et al., 2019; Lioret et al., 2009).

Interventions that aim to improve diet-related factors in the first year of life demonstrate inconsistent effects, as confirmed by multiple systematic reviews (Flynn et al., 2004; Kerr et al., 2019; Lioret et al., 2023; Matvienko-Sikar et al., 2018; Patro-Gołąb et al., 2016; Whitehead et al., 2021). One potential reason for this inconsistency may be heterogeneity in what and how outcomes are measured across trials in this area (Matvienko-Sikar et al., 2019). Outcome heterogeneity limits evidence syntheses and ability to compare and contrast intervention outcomes to determine what interventions work, or not (Matvienko-Sikar et al., 2019; Williamson et al., 2017). To address this issue, a core outcome set (COS) for infant feeding interventions to prevent childhood obesity was previously developed by members of the study team (Matvienko-Sikar et al., 2020). A second complementary COS for trials of childhood obesity prevention interventions with children up to 5 years (EPOCH COS) was also developed by members of the study team (Brown et al., 2022a). COS include the most important outcomes to measure and report in trials in particular health areas (Matvienko-Sikar et al., 2019). These outcomes are not the only outcomes that can be measured in trials, but instead represent those that should be included at a minimum to enhance standardisation and evidence syntheses (Matvienko-Sikar et al., 2019). The infant feeding COS was developed following a systematic process (Williamson et al., 2017) involving evidence synthesis and international stakeholder engagement to determine what outcomes are most important to measure in trials of infant feeding interventions to prevent childhood obesity (Matvienko-Sikar et al., 2017, 2020). The infant feeding COS includes 26 outcomes, of which 13 (such as duration of exclusive breastfeeding, age of introduction of solids, and types of food consumed) are related to diet in the first year after birth (Matvienko-Sikar et al., 2020).

While the infant feeding COS usefully outlines what outcomes should be measured in trials of infant feeding interventions to prevent childhood obesity, it does not specify **how** best to measure these outcomes (Matvienko-Sikar et al., 2020, 2023). How such outcomes are measured is of importance because heterogeneity in outcome measurement instruments (OMIs) used can also limit evidence synthesis and examination of intervention effectiveness (Mokkink et al., 2016). In addition, not all OMIs are of good quality and use of poor-quality instruments can introduce bias and contribute to research waste (Mokkink et al., 2016). Thus, developing standardised approaches to measurement of diet-related infant feeding outcomes, which include appropriate and acceptable measurement instruments, ensures trial findings can be examined and synthesised to determine intervention effectiveness (Matvienko-Sikar et al., 2020, 2023). The first step in developing a standardised measurement set is to identify how outcomes are currently being measured in trials (Prinsen et al., 2016).

Previous reviews have identified a range of OMIs, such as food frequency questionnaires (Bryant et al., 2014; Burnett et al., 2020; Burrows et al., 2010, 2020), dietary recall (Bryant et al., 2014; Burnett et al., 2020; Burrows et al., 2010), biomarkers (Bryant et al., 2014), and image-based methods (Burrows et al., 2020) to measure child dietary outcomes. However, these reviews have examined OMIs in children over 1 year of age, thus representing an important gap in measurement of infant diet outcomes. In addition, these reviews have examined 'diet'/dietary intake (Bryant et al., 2014; Burnett et al., 2020), energy intake (Burrows et al., 2010, 2020), and breastfeeding outcomes (Sartorio et al., 2017) but not specifically outcomes included in the infant feeding COS. Further, infant diet-related outcomes are examined in trials across health areas, such as allergy (Brandwein et al., 2024), and so any examination of infant feeding OMIs should be similarly broad in scope. Determining how such outcomes are currently measured within and beyond the area of childhood obesity is therefore needed. Such an examination will provide a comprehensive overview of how diet-related outcomes are measured across child health trials more broadly, with potential implications for improving measurement of child diet-related outcomes across child health areas. As such, the aim of this review was to identify how 13 infant diet related outcomes from the infant feeding COS (Matvienko-Sikar et al., 2020) are currently measured in trials.

## 2. Methods

A scoping review was conducted and is reported in line with the Preferred Reporting Items for Systematic Review and Meta-Analysis extension for scoping reviews (PRISMA-ScR; Tricco et al., 2018). This review forms part of a larger search strategy to identify the OMIs currently used for all 26 outcomes included in the infant feeding COS as part of the Standardised measurement for Childhood Obesity Prevention (SCOPE) project (www.eiascope.com). The protocol for the overarching search is published (Matvienko-Sikar et al., 2023) and changes from the protocol are recorded in Supplementary File 1. For pragmatic reasons, and to ensure comprehensive reporting of OMIs, the full review was broken down into three reviews focused on infant diet-related outcomes; caregiver infant-feeding and environment outcomes; and child weight outcomes. This review focuses on diet-related outcomes only, and so only findings related to these outcomes are presented here.

### 2.1. Eligibility criteria

Studies were eligible for inclusion in this review if they reported trials, conducted with full-term infants ≤1 year of age, and reported measuring at least one of the 13 diet-related outcome from the infant feeding COS (Matvienko-Sikar et al., 2020); see Table 1. All types of OMIs were eligible for inclusion (e.g., questionnaires, individual survey items, dietary recall, diary approaches, healthcare records, and direct observational methods). Outcomes could be measured and/or reported by caregivers, healthcare professionals, researchers, and/or childcare professionals, at any timepoint(s) in the first year after birth, and in any setting. Studies reporting on any trial design (e.g., randomised controlled trials (RCT), pilot trials) were eligible for inclusion. Studies were excluded if they examined outcomes in infants >1 year of age and/or did not report measurement of at least one of the 13 diet-related infant feeding outcomes from the COS. Protocols and non-trial designs (including reviews and observational studies) were not eligible for inclusion. Multiple studies from single trials could be included if different outcomes were measured and reported. There were no restrictions on language or location of publication, and non-English language studies were translated by native-language speakers prior to screening.

### 2.2. Search strategy

EMBASE, MEDLINE, CINAHL and PsycINFO were searched from inception to September 18, 2023. The search strategy was based on the population, construct, and measurement (see Supplementary File 2 for full search strategy). Two existing reviews of outcomes examined in infant feeding studies (Matvienko-Sikar et al., 2019) and childhood obesity prevention interventions up to 5 years of age (Brown et al., 2022b), and the TOPCHILD Collaboration registry of early obesity prevention interventions (Hunter et al., 2022) were crosschecked to supplement database searching. Reference lists of eligible studies were also checked.

**Table 1**
Diet-related outcomes and definitions from the infant feeding COS (Matvienko-Sikar et al., 2020).

| Outcomes | Definition |
|---|---|
| • Age of introduction of solids | • The infant's age when solids were introduced to the diet. Solids are considered any food or liquid substance, other than breast milk or formula milk. |
| • Duration breastfeeding from mother | • The length of time mothers breastfeeds their infants at the breast. This can include the length of time mothers exclusively breastfed their infants or the length of time before mothers ceased all breastfeeding. |
| • Duration of exclusive breastfeeding | • Feeding the infant only breast milk, without introducing solids or formula. |
| • Feeding method (breast milk, formula, solids, combination) | • The method by which the infant is fed. This can include single feeding approaches or a combination of feeding approaches. |
| • Amount/volume formula consumed | • The quantity of formula milk consumed, either per feed or per day. |
| • Type of commercial milk formula fed to infant | • The type of formula provided to infants. (e.g. early baby, hungry baby). |
| • Mother's breastfeeding self-efficacy | • How capable the mother feels about her ability to breastfeeding. |
| • Types of food consumed | • Relates to the different types of foodstuffs infants consume. This can include ever feeding, and/or the quantity of foods consumed, ranging from fruits and vegetables to sweet and savoury snacks. |
| • Portion size | • The size or amount of food provided to infants |
| • Offering age appropriate foods and beverages | • Whether the foods and beverages provided to infants are developmentally appropriate |
| • Infant eating ready-made food | • Infant consumption of commercial baby food; this includes pre-packaged, ready-made, or shop-bought foods. These foods can include cereals, fruit, vegetables, fish, meat, sweets and desserts. |
| • Infant eating homemade foods | • Infant consumption of food prepared by caregiver. This can include the type of food prepared by caregiver for infant. |
| • Type of 'other drinks' consumed | • Infant consumption of a range of non-milk drinks. These include water, sugar sweetened beverages, herbal drinks, tea/coffee, warm drinks (other than tea or coffee) |

### 2.3. Screening

Identified studies were imported to Rayyan (Ouzzani et al., 2016) and, following deduplication, all titles/abstracts were independently screened in duplicate for eligibility by two reviewers (KMS, RA, DD). Full texts were then screened independently in duplicate by at least two reviewers (KMS, RA, MD). Discrepancies were resolved by consensus and/or brought to a third reviewer.

### 2.4. Data extraction

The following data were extracted from eligible studies using a predefined data extraction form: author, title, year of publication, country of origin, design, setting, target population, infant feeding outcomes measured, name of OMI used, type of OMI, mode of administration, response format, number of items, timing of measurement, recall period, where measurement took place, who conducted and/or completed the measurement, child's age at measurement(s), and frequency of measurement. Four reviewers (KMS, RA, MD, EL) independently conducted pilot data extraction on five studies. Data were then extracted from all included studies independently in duplicate by two reviewers (RA, MD, EL), and checked by a third reviewer (KMS). Decisions about which diet-related outcome(s) were measured in studies were based on measurements explicitly reported as either outcomes, measures taken at baseline, or measures of covariates or confounding factors. Where explicit statements were not made but information provided in the methods and/or results indicated that diet-related outcome(s) from the infant feeding COS were measured, this was extracted and agreed upon by reviewers. Where information was absent or unclear in published studies, study authors were contacted via email for further information and/or clarification. Discrepancies were resolved by consensus discussion or brought to a third reviewer (KMS) as needed. Quality assessment was not conducted as the aim of the review was to identify what and how OMIs are used (Munn et al., 2018).

### 2.5. Data summary

Findings are presented narratively and in tabular format overall and for each of the 13 diet-related outcome from the COS. Narrative findings are presented in terms of the number of studies using an OMI and/or the number of OMIs used, as appropriate. Tables include information such as the type of OMI(s) used, mode of administration, response format, frequency, and setting of use. Where variability was observed in descriptions of measurement approaches across studies (e.g., one article reported use of a 12-question survey and another reported that 'survey questions' were asked), these were categorised for presentation in the narrative descriptions and/or tables. Where approaches were used to measure more than one feeding outcome (e.g., a single questionnaire measuring multiple dietary outcomes), this is also presented.

## 3. Results

Database searching and cross checking identified 16,029 studies, of which 157 met inclusion criteria; 136 studies reported on 133 trials measuring diet-related outcomes (Fig. 1).

Most studies were conducted in North America (n = 45, 33 %), followed by Europe (n = 36, 27 %); with studies also conducted in Asia (n

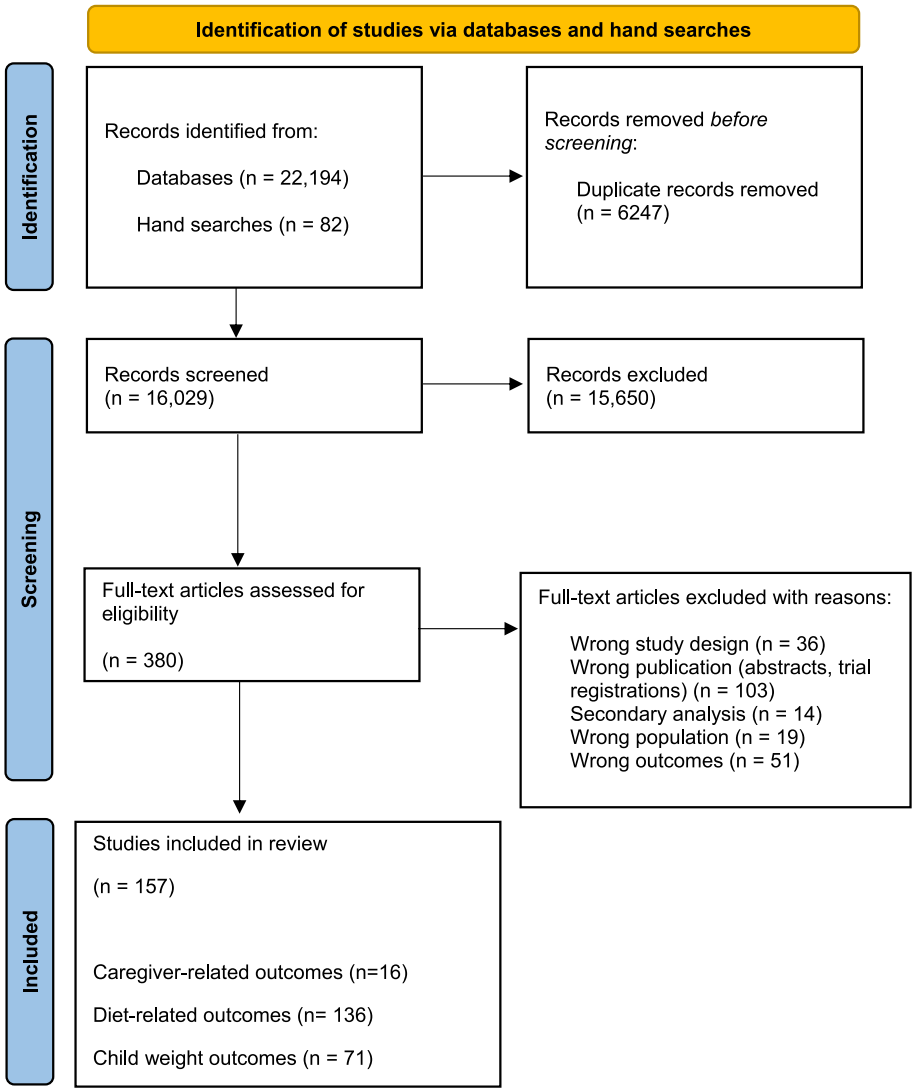


**Fig. 1.** Flow diagram of studies in the review.

= 23, 17 %), South America (n = 11, 8 %), Australasia (n = 10, 7 %), and Africa (n = 7, 5 %). The majority utilised a RCT design (n = 126, 93 %). Studies most frequently focused on breastfeeding (n = 64, 47 %), growth/obesity (n = 36, 26.47 %), feeding practices (n = 11, 8.1 %) and food intake (n = 10, 7.35 %). Studies were published between 1993 and 2023 and included between 59 and 5094 participants. The most measured diet-related outcomes were feeding method (n = 111, 82 %), types of food consumed (n = 39, 29 %) and age of introduction of solids (n = 36, 27 %). See Table 2 for summary study characteristics and Supplementary File 3 for full study characteristics.

### 3.1. Characteristics of identified outcome measurements

Across all studies the most commonly used OMI was questionnaires, with 66 different questionnaires reported in 70 studies. Of these, 35 were developed for the specific studies and 17 were existing measures or adapted versions of existing measures, including the Infant Feeding Practices Survey II (Fein et al., 2008) and the Breastfeeding Self-Efficacy Scale short form (Dennis, 2003; BSES-SF) which was used in 16 studies (Abbass-Dick, 2013; Abbass-Dick et al., 2020; Abuidhail et al., 2019; Cangöl & Şahin, 2017; Dodou et al., 2021; Javorski et al., 2018; Lutenbacher et al., 2023; McQueen, 2011; Noel-Weiss, 2005; Prasitwattanaseree et al., 2019; Puharić et al., 2020; Rodrigues et al., 2018; Scott et al., 2021; Vakilian et al., 2020; Wong & Chien, 2023; Yousefi et al., 2022). Information on whether 13 questionnaires in 12 studies (Abbass-Dick, 2013; Cloutier et al., 2018; Di Napoli et al., 2004; Gregson et al., 2016; Hoddinott et al., 2012; Javorski et al., 2018; Kramer et al., 2001; Maycock et al., 2013; McCormick et al., 2023; McQueen, 2011; Palacios et al., 2018; Vakilian et al., 2020) were existing, adapted, or developed specifically for the studies was unclear or not reported. Sixty-five different individual questions were used in 45 studies; 43 of these were developed for the specific studies, 18 were taken from previous research and existing surveys such as the German Health Survey for Children and Adolescents (KiGGS Study Group et al., 2014). Twenty-four different food diary/records were used in 21 studies, which ranged in duration from 1 day (Kattelmann et al., 2001) to 'monthly' (Tang et al., 2018), with 3-day diaries/records most frequently used in 11 studies (Daniels et al., 2018; He et al., 2022; Kattelmann et al., 2001; Kouwenhoven et al., 2020; Krebs et al., 2012; Niinikoski et al., 1997; Singhal et al., 2010; Specker et al., 1997; Tang et al., 2018; Williams Erickson et al., 2018; Woźniak et al., 2022). Information about duration was not reported or unclear for diaries and food records in seven studies (Borschel et al., 2014; Gijsbers et al., 2006; Kalhoff et al., 2021; Lagström, 1997; Liotto et al., 2018; Prasitwattanaseree et al., 2019; Shah et al., 2014). Eleven studies used 24-hour dietary recall; seven of these were explicitly reported as being multiple pass recalls (Atkins et al., 2016; Campbell et al., 2013; L. A. Daniels et al., 2014; Kong et al., 2022; Sangalli et al., 2021; Thomson et al., 2018; Watt et al., 2008), which

**Table 2**
Summary Study and OMI characteristics.

| | N studies (%) | |
|---|---|---|
| **Location** | | |
| Africa | 7 (5.1 %) | |
| Asia | 23 (16.9 %) | |
| Australasia | 10 (7.4 %) | |
| Europe | 36 (26.5 %) | |
| North America | 45 (33.1 %) | |
| South America | 11 (8.1 %) | |
| Multiple countries | 4 (2.9 %) | |
| **Trial Design** | | |
| RCT | 126 (92.6 %) | |
| Clinical Trial | 2 (1.4 %) | |
| Randomised intervention trial | 1 (0.8 %) | |
| Controlled, non-randomised trial | 1 (0.8 %) | |
| Randomised, community-based intervention trial | 1 (0.8 %) | |
| Pre-intervention/post-intervention trial | 2 (1.4 %) | |
| Non-randomised clinical trial | 1 (0.8 %) | |
| Randomised crossover trial | 1 (0.8 %) | |
| Laboratory-based within-subject experimental trial | 1 (0.8 %) | |
| **Core Outcomes Measured** | | |
| Duration of breastfeeding from mother | 8 (5.9 %) | |
| Duration of exclusive breastfeeding | 26 (19.1 %) | |
| Feeding method | 111 (81.6 %) | |
| Amount/volume of commercial formula milk fed to infant | 16 (11.8 %) | |
| Type of commercial milk formula fed to infant | 1 (0.7 %) | |
| Breastfeeding self-efficacy | 22 (16.2 %) | |
| Age of introduction of solids | 36 (26.5 %) | |
| Types of food consumed | 39 (28.7 %) | |
| Portion size | 23 (16.9 %) | |
| Offering age-appropriate foods and beverages | 2 (1.5 %) | |
| Infant eating home-made food | 3 (2.2 %) | |
| Infant eating ready-made foods | 4 (2.9 %) | |
| Types of 'other' drinks consumed | 33 (24.3 %) | |
| | **N studies (%)** | **N OMIs (%)** |
| **OMI Type** | | |
| Questionnaire | 70 (51.5 %) | 66 (31.6 %) |
| Individual items | 45 (33.1 %) | 65 (31.1 %) |
| 24-h dietary recall | 11 (8.1 %) | 11 (5.3 %) |
| Diary/record approach | 21 (15.4 %) | 24 (11.5 %) |
| Healthcare record data | 6 (4.4 %) | 6 (2.9 %) |
| Other | 8 (5.9 %) | 9 (4.3 %) |
| Unclear/not reported | 18 (13.2 %) | 28 (13.4 %) |
| **Who administered** | | |
| Self-administered (by caregiver) | 51 (37.5 %) | 60 (28.7 %) |
| Researcher administered | 60 (44.1 %) | 78 (37.3 %) |
| HCP administered | 18 (13.2 %) | 23 (11.0 %) |
| Other | 11 (8.1 %) | 17 (8.1 %) |
| Unclear/not reported | 40 (29.4 %) | 51 (24.4 %) |
| **Where administered** | | |
| Home/own determined location | 100 (73.5 %) | 129 (61.7 %) |
| Healthcare setting | 38 (27.9 %) | 43 (20.6 %) |
| Other | 3 (2.2 %) | 3 (1.4 %) |
| Unclear/not reported | 35 (25.7 %) | 54 (25.8 %) |

HCP= Healthcare professional; OMI= Outcome measurement instrument; RCT = Randomised Clinical Trial.

involves collecting data over multiple passes, for instance in terms of generating quick list, followed by more detailed descriptions and data collection. Healthcare record data were used in 6 studies (Gagnon et al., 1997; Gregson et al., 2016; Hartley, 1996; Kramer et al., 2001; Linares et al., 2019; Serwint et al., 1996). Five studies reported use of weighed measurement approaches (Fildes et al., 2015; Krebs et al., 2012; Paul et al., 2011; Shah et al., 2014; Williams Erickson et al., 2018) including, for instance, pre and post weights for food consumption (Paul et al., 2011). Weighed approaches were conducted using standardised scales by researchers in one study (Paul et al., 2011), in participants home-s/own determined locations (Fildes et al., 2015; Williams Erickson et al., 2018), and/or in a healthcare setting (Fildes et al., 2015; Shah et al., 2014). One study included a 'text message' asking about infant feeding method but without specification of further detail (Bender et al., 2022). Another included use of study formula tins for measurement and deuterium dilution, which involves ingesting a small dose of deuterium-labelled water and then measuring the concentration of deuterium in a biological sample to estimate total body water and lean mass (Kouwenhoven et al., 2020). See Table 3 for OMI summary characteristics and Supplementary Files 4 and 5 for full OMI characteristics, including details of what OMI was used, mode of administration, response format, number of items, timing of completion, recall period, and measurement setting.

Issues encountered when synthesising data on OMIs included questions used not being specified in studies (n = 119, 88 %), and lack of clarity or reporting in studies on the response formats used (n = 109, 80 %), the number of questions asked (n = 107, 79 %), recall periods (n = 81, 60 %), days for dietary recalls (n = 6, 55 % of studies using dietary recalls) and food diaries (n = 7, 33 % of studies using food diaries), and by whom (n = 40, 29 %), where (n = 35, 26 %), and how (16 %, n = 22 %) OMIs were administered/completed. See Supplementary File 6.

**Table 3**
Summary of OMIs by core outcome.

| Core Outcome Set outcome | N studies | | | | | | |
|---|---|---|---|---|---|---|---|
| | Questionnaire | Individual Items | Dietary recall | Diary/record approach | Healthcare record data | Other | Unclear/not reported |
| **Duration of breastfeeding from mother** | 4 | 3 | | | | | 1 |
| **Duration of exclusive breastfeeding** | 13 | 7 | 1 | 1 | | | 5 |
| **Feeding method** | 49 | 42 | 3 | 5 | 6 | 1 | 13 |
| **Amount/volume of commercial milk formula fed to infant** | 3 | 1 | 1 | 10 | | 2 | 1 |
| **Type of commercial milk formula fed to infant** | | | | 1 | | | |
| **Breastfeeding self-efficacy** | 21 | 2 | | | | | |
| **Age of introduction of solids** | 7 | 17 | 3 | 1 | | | 8 |
| **Types of food consumed** | 12 | 2 | 11 | 14 | | | |
| **Portion size** | 4 | | 6 | 9 | | 4 | |
| **Offering age-appropriate foods and beverages** | | | 2 | | | | |
| **Infant eating home-made food** | 2 | 1 | | | | | |
| **Infant eating ready-made foods** | 2 | 1 | | 1 | | | |
| **Types of 'other' drinks consumed** | 13 | 8 | 7 | 5 | | | |

Note. Please see Supplementary File 5 for summary characteristics of where and by whom OMIs were administered.

### 3.2. Duration of breastfeeding from mother

Eight studies measured duration of breastfeeding from mother, predominantly using questionnaires (n = 4 studies) (Abbass-Dick, 2013; Araban et al., 2018; Brent, 1995, 1995ağan & Genç, 2023) or individual questions (n = 3 studies) (Kluka, 2009; Lutenbacher et al., 2023; Noel-Weiss, 2005). Three different questionnaires were developed specifically for the purposes of the studies (Araban et al., 2018; Brent, 1995, 1995ağan & Genç, 2023); one study (Çağan & Genç, 2023) also included an existing tool, the LATCH breastfeeding assessment tool (Adams & Hewell, 1997); this information was unclear in one study (Abbass-Dick, 2013). The number of items related to duration of breastfeeding from mother in questionnaires was unclear or not reported in all studies. Individual questions, that were developed specifically for the study, were used as part of larger questionnaires in three studies (Kluka, 2009; Lutenbacher et al., 2023; Noel-Weiss, 2005). Of these, questions in one study (Lutenbacher et al., 2023) were developed from the Perinatal Risk Assessment Monitory System Survey (Shulman et al., 2018) and National Survey of Children's Health (Data Resource Center for Child and Adolescent Health, 2018). The type of OMI used in one study was unclear (Albernaz et al., 2003).

### 3.3. Duration of exclusive breastfeeding

Twenty-six studies used 28 different OMIs to measure duration of exclusive breastfeeding. The most used type of OMI was a questionnaire (n = 13 studies). Seven different questionnaires were designed for the specific study (Ara et al., 2018; Babakazo et al., 2015; De Oliveira et al., 2012; Nikodem et al., 1993; Sevda & Sevil, 2023; Wong & Chien, 2023, 2023ağan & Genç, 2023); one study (Lewkowitz et al., 2020) used a questionnaire based on the Infant Feeding Practices study II (Fein et al., 2008); one study (Çağan & Genç, 2023) included an existing tool, the LATCH breastfeeding assessment tool (Adams & Hewell, 1997); and two studies (Gijsbers et al., 2006; M'Liria et al., 2020) used existing questionnaires (Gijsbers et al., 2005). Three studies (McQueen, 2011; Palacios et al., 2018; Vakilian et al., 2020) reported using questionnaires but did not provide further information. In addition to a questionnaire, a diary approach (Schönberger et al., 2004) was used in one study (Gijsbers et al., 2006). Individual questions were used in seven studies (Abdulahi et al., 2021; Cattaneo et al., 2016; Hoffmann et al., 2019; Lutenbacher et al., 2023; Noel-Weiss, 2005; Parat et al., 2019; Scott et al., 2021); of these, questions were developed specifically for the study in four studies (Abdulahi et al., 2021; Noel-Weiss, 2005; Parat et al., 2019; Scott et al., 2021). An example of a question used is *"for how many months did you exclusively breastfeed (child's name)"*(Abdulahi et al., 2021). Questions from existing surveys, the KiGGS (KiGGS Study Group et al., 2014), the Perinatal Risk Assessment Monitory System Survey (Shulman et al., 2018) and National Survey of Children's Health (Data Resource Center for Child and Adolescent Health, 2018), were used/adapted in two studies (Hoffmann et al., 2019; Lutenbacher et al., 2023). No further information was presented for the question(s) used in one study (Cattaneo et al., 2016). The number of individual questions used was unclear in most studies; of the studies that reported the number of questions used, these ranged from 3 to 6 questions. A 24-hour multiple pass recall approach was used in one study (Watt et al., 2008). The OMI used in five studies was unclear (Carlsen et al., 2013; Curro et al., 1997; Johansson et al., 2023; Prasitwattanaseree et al., 2019; Rzehak et al., 2009).

### 3.4. Feeding method

One hundred and twenty-two different OMIs were used to measure feeding method in 111 studies. Ten studies (Abbott et al., 2019; Gagnon et al., 1997; Gijsbers et al., 2006; Gregson et al., 2016; Hoddinott et al., 2012; Javorski et al., 2018; Kramer et al., 2001; Linares et al., 2019; Reifsnider et al., 2018; Serwint et al., 1996) used more than one OMI, typically a combination of questionnaire and review of medical records. The most used OMI was a questionnaire, with 52 different questionnaires used in 49 studies. Of the questionnaires used, 26 were developed specifically for the study; 7 existing questionnaires, such as the Infant Feeding Practices Survey II (Fein et al., 2008) were used in seven studies (Abbott et al., 2019; Bonuck et al., 2014, 2014ağan & Genç, 2023; Cangöl & Şahin, 2017; Gijsbers et al., 2006; M'Liria et al., 2020; Schroeder et al., 2015); five questionnaires were adapted from existing questionnaires (Adams et al., 2019; Azimi & Nasiri, 2020; Black et al., 2001; Kong et al., 2022; Lewkowitz et al., 2020), predominantly the Infant Feeding Practices Survey II (Fein et al., 2008); and it was unclear whether 14 questionnaires were existing or developed specifically for the study (Abbass-Dick, 2013; Cloutier et al., 2018; Di Napoli et al., 2004; Gregson et al., 2016; Hoddinott et al., 2012; Javorski et al., 2018; Kramer et al., 2001; Maycock et al., 2013; McCormick et al., 2023; McQueen, 2011; Moghaddam et al., 2021; Palacios et al., 2018; Vakilian et al., 2020). Individual questions were reported to be used in 41 studies. Of these, questions were developed specifically for 26 studies and were pre-existing questions (Forster et al., 2019; Graffy, 2004; Hoffmann et al., 2019; Lakshman et al., 2018; Lutenbacher et al., 2023; Martinez-Brockman et al., 2018; Messito et al., 2020; Wen, 2011; Wen et al., 2020) or questions based on pre-existing (Addicks, 2018; Hoffmann et al., 2021) questions such as the Infant Feeding Practices Survey II (Fein et al., 2008), in 11 studies. It was unclear if items were developed or existing in four studies (Abuidhail et al., 2019; Cattaneo et al., 2016; Hoddinott et al., 2012; Reifsnider et al., 2018). An example of a

questions asked is "*Are you currently breastfeeding or feeding pumped milk to your new baby?*" (Lutenbacher et al., 2023). The number of items used, as either individual questions or in questionnaires, ranged from 1 to 12; though the number of questions used was unclear or not reported in 66 studies. Review of medical records was used in 6 studies (Gagnon et al., 1997; Gregson et al., 2016; Hartley, 1996; Kramer et al., 2001; Linares et al., 2019; Serwint et al., 1996). A food diary or record was used in five studies (Gijsbers et al., 2006; Paul et al., 2011; Prasitwattanaseree et al., 2019; Specker et al., 1997; Woźniak et al., 2022) in the form of 3-day diet records (Specker et al., 1997) or food diary (Gijsbers et al., 2006; Woźniak et al., 2022), a 'food record form' (Prasitwattanaseree et al., 2019), or a 96-hour diary card (Paul et al., 2011). Twenty-four-hour recall was used in three studies (Atkins et al., 2016; Watt et al., 2008; Zhang et al., 2009). A text message approach to measurement was used in one study (Bender et al., 2022); while measurement was unclear in 13 studies (Aghababaei et al., 2022; Albernaz et al., 2003; Balaguer Martínez et al., 2018; Carlsen et al., 2013; Curro et al., 1997; De Vries et al., 2015; French et al., 2012; Johansson et al., 2023; Kalhoff et al., 2021; Kemp et al., 2011; Lana et al., 2004; Reifsnider et al., 2018; Serwint et al., 1996).

### 3.5. Amount/volume of commercial milk formula fed to infant

The amount/volume of commercial milk formula fed to the infant was measured using 20 different OMIs in 16 studies. Eleven different diary/record approaches were used (Borschel et al., 2014; L. Daniels et al., 2018; He et al., 2022; Kouwenhoven et al., 2020; Liotto et al., 2018; Singhal et al., 2010; Specker et al., 1997; Tang et al., 2018; Williams Erickson et al., 2018; Woźniak et al., 2022), with seven explicitly reported as a 3-day diary/record (Daniels et al., 2018; He et al., 2022; Kouwenhoven et al., 2020; Singhal et al., 2010; Specker et al., 1997; Tang et al., 2018; Woźniak et al., 2022). One of these studies also used measurements from specifically designed formula tins, and deuterium dilution (Kouwenhoven et al., 2020). Three different questionnaires were developed specifically for use in three studies (French et al., 2012; Ventura & Hernandez, 2019; Ziegler et al., 2015); the number of items included in these questionnaires was not reported. One study used individual questions, such as "*In a typical 24- hour period, how much formula milk does your baby have?*"(Lakshman et al., 2018). A 24-hour dietary recall, using the U.S. Department of Agriculture Automated Multiple-Pass method, was used in one study (Kong et al., 2022); while the OMI used in another study was unclear (Reifsnider et al., 2018).

### 3.6. Type of commercial milk formula fed to infant

The type of commercial milk formula fed to infant was measured in one study only using 3-day diet records designed for the study that were completed by caregivers in their own home and/or own determined location (Specker et al., 1997).

### 3.7. Breastfeeding self-efficacy

Five different OMIs were used across 22 studies to measure breastfeeding self-efficacy. The Breastfeeding Self-Efficacy Scale (BSES) (Dennis & Faux, 1999), which comprises 33 items measured on a 5-point Likert scale, from 1 (not at all confident) to 5 (always confident), was used in three studies (Aghababaei et al., 2022; Kluka, 2009; Yesil et al., 2023); with one of these adapted for Turkey (Eksioglu & Ceber, 2011; Yesil et al., 2023). The Breastfeeding Self-Efficacy Scale Short Form (BSES-SF) (Dennis, 2003) comprising 14 items measured on the same 5-point Likert scale was used in 16 studies (Abbass-Dick, 2013; Abbass-Dick et al., 2020; Abuidhail et al., 2019; Cangöl & Şahin, 2017; Dodou et al., 2021; Javorski et al., 2018; Lutenbacher et al., 2023; McQueen, 2011; Noel-Weiss, 2005; Prasitwattanaseree et al., 2019; Puharić et al., 2020; Rodrigues et al., 2018; Scott et al., 2021; Vakilian et al., 2020; Wong & Chien, 2023; Yousefi et al., 2022), while one further study adapted the BSES-SF by removing an item to create a 13 item scale (Araban et al., 2018). The BSES-SF was adapted for use in different cultural contexts in nine studies, including use of a Persian version (Araban et al., 2018; Vakilian et al., 2020; Yousefi et al., 2022), a Turkish version (Cangöl & Şahin, 2017), a Croatian version (Puharić et al., 2020), a Thai version (Prasitwattanaseree et al., 2019), a Hong Kong Chinese version (Wong & Chien, 2023) and a version adapted for Brazil (Dodou et al., 2021; Javorski et al., 2018). One studies also included a question in a scale developed specifically for the study (Cangöl & Şahin, 2017); one study used questions from a previous study (Gijsbers et al., 2006); and one used a questionnaire developed specifically for the study, though the number of items included in this questionnaire was not specified (Zhang et al., 2009).

### 3.8. Age of introduction of solids

Thirty-six different OMIs were used to measure the age of introduction of solids in 36 studies in this review. Seventeen individual questions were used in 17 studies. Of these, questions were developed specifically for ten studies (Abdulahi et al., 2021; Abiyu & Belachew, 2020; Aidam et al., 2005; Fildes et al., 2015; Linares et al., 2019; McEachan et al., 2016; Morandi et al., 2019; Parat et al., 2019; Rosenstock et al., 2021; Scott et al., 2021). Pre-existing questions from previous research, such as the German Health Survey for Children and Adolescents (KiGGS Study Group et al., 2014) and the Infant Feeding Practices Survey II (Fein et al., 2008), were used in seven studies (Forster et al., 2019; Gijsbers et al., 2006; Hoffmann et al., 2021; Lakshman et al., 2018; Ventura et al., 2022; Wen, 2011; Wen et al., 2020). An example question used is "*how old was your child when you first introduced solids?*" (Gijsbers et al., 2006). Seven different questionnaires were used in seven studies (Babakazo et al., 2015; Black et al., 2001; Cloutier et al., 2018; De Oliveira et al., 2012; Kong et al., 2022; Palacios et al., 2018; Ventura & Hernandez, 2019). Of the questionnaires used, three were developed specifically for the study (Babakazo et al., 2015; De Oliveira et al., 2012; Ventura & Hernandez, 2019); two existing questionnaires, including a shortened version of the Infant Feeding Practices Study II (Fein et al., 2008), were used in two studies (Black et al., 2001; Kong et al., 2022). This information was not reported or was unclear in two studies (Cloutier et al., 2018; Palacios et al., 2018). The number of questions used in studies, as individual questions or questionnaires, ranged from 1 to 2; this information was not reported in 12 studies (Aidam et al., 2005; Babakazo et al., 2015; Black et al., 2001; Cloutier et al., 2018; De Oliveira et al., 2012; Forster et al., 2019; Hoffmann et al., 2021; Kong et al., 2022; Palacios et al., 2018; Parat et al., 2019; Rosenstock et al., 2021; Scott et al., 2021). Three studies used 24-hour dietary recalls (Thomson et al., 2018; Watt et al., 2008; Zhang et al., 2009), and one study used a 3-day dietary intake diary (Singhal et al., 2010). In eight studies the OMI used was unclear (Carlsen et al., 2013; L. Daniels et al., 2018; Kalhoff et al., 2021; Kemp et al., 2011; Kouwenhoven et al., 2020; Paul et al., 2011; Reifsnider et al., 2018; Rzehak et al., 2009).

### 3.9. Types of food consumed

Forty-one different OMIs were used to measure types of food consumed in 39 studies. The most common OMI used for this outcome was food diaries or records, 16 of which were used in 14 studies (Daniels et al., 2018; Johansson et al., 2023; Kattelmann et al., 2001; Krebs et al., 2012; Lagström, 1997; Lakshman et al., 2018; Niinikoski et al., 1997; Prasitwattanaseree et al., 2019; Shah et al., 2014; Singhal et al., 2010; Specker et al., 1997; Tang et al., 2018; Williams Erickson et al., 2018; Woźniak et al., 2022). Ten 3-day food diaries/records were used (Daniels et al., 2018; Kattelmann et al., 2001; Krebs et al., 2012; Lagström, 1997; Niinikoski et al., 1997; Singhal et al., 2010; Specker et al., 1997; Tang et al., 2018; Williams Erickson et al., 2018; Woźniak et al., 2022); two were explicitly reported as weighed food diaries (Daniels et al., 2018; Williams Erickson et al., 2018), three specified

including one weekend day (Daniels et al., 2018; Williams Erickson et al., 2018; Woźniak et al., 2022), and two specified 3 consecutive days (Lagström, 1997; Niinikoski et al., 1997). One of these studies also reported inclusion of a 1-day diet record (Kattelmann et al., 2001). One study included a 4-day diet diary (Lakshman et al., 2018), one included a 5-day food record (Johansson et al., 2023), one reported using a 'food record' of unspecified duration (Prasitwattanaseree et al., 2019), and one reported using a 'monthly calendar' (Tang et al., 2018). Twenty-four-hour recalls were used in 11 studies (Atkins et al., 2016; Campbell et al., 2013; Daniels et al., 2014; Iannotti et al., 2017; Johnson et al., 1993; Kong et al., 2022; Sangalli et al., 2021; Talavera et al., 2014; Thomson et al., 2018; Watt et al., 2008; Zhang et al., 2009) with seven of these studies explicitly reporting that multiple pass 24-hour recall was used (Atkins et al., 2016; Campbell et al., 2013; Daniels et al., 2014; Kong et al., 2022; Sangalli et al., 2021; Thomson et al., 2018; Watt et al., 2008). Three studies specified that recall was conducted over two weekdays and one weekend day (Atkins et al., 2016; Campbell et al., 2013; Kong et al., 2022). Twelve different questionnaires, including six food frequency questionnaires (Beinert et al., 2017; Black et al., 2001; Helle et al., 2019; McEachan et al., 2016; Schroeder et al., 2015; Wall et al., 2019), were used in 12 studies (Baratto et al., 2021; Beinert et al., 2017; Black et al., 2001; De Oliveira et al., 2012; French et al., 2012; Helle et al., 2019; McEachan et al., 2016; Messito et al., 2020; Moreira et al., 2022; Schroeder et al., 2015; Wall et al., 2019; Ziegler et al., 2015). Of these, seven were developed specifically for the study (Baratto et al., 2021; De Oliveira et al., 2012; French et al., 2012; Helle et al., 2019; Moreira et al., 2022; Schroeder et al., 2015; Ziegler et al., 2015); one existing questionnaire, the Infant Feeding Practices Survey II (Fein et al., 2008) was reported to be used in one study (Messito et al., 2020); one questionnaire was adapted from a questionnaire used in previous research (Black et al., 2001); and it was unclear whether three questionnaires were existing or developed specifically for the study (Beinert et al., 2017; McEachan et al., 2016; Wall et al., 2019). Individual questions were reported to be used in two studies (Aidam et al., 2005; Hoffmann et al., 2021), with these questions either developed specifically for the study (Aidam et al., 2005) or taken from a pre-existing survey in one study (Hoffmann et al., 2021). Where reported, the number of questions asked in studies ranged from 7 to 13, though this was not reported in 12 studies (Aidam et al., 2005; Baratto et al., 2021; De Oliveira et al., 2012; French et al., 2012; Helle et al., 2019; Hoffmann et al., 2021; McEachan et al., 2016; Messito et al., 2020; Moreira et al., 2022; Schroeder et al., 2015; Wall et al., 2019; Ziegler et al., 2015).

### 3.10. Portion size

Portion size outcome was measured by 25 different OMIs in 23 studies. A food diary or record was used in nine studies (Daniels et al., 2018; Johansson et al., 2023; Kalhoff et al., 2021; Kattelmann et al., 2001; Lagström, 1997; Niinikoski et al., 1997; Tang et al., 2018; Williams Erickson et al., 2018; Woźniak et al., 2022). Six 3-day food diaries/records were used in six studies (Daniels et al., 2018; Kattelmann et al., 2001; Niinikoski et al., 1997; Tang et al., 2018; Williams Erickson et al., 2018; Woźniak et al., 2022); of these, two were reported as weighed food diaries (Daniels et al., 2018; Williams Erickson et al., 2018), three explicitly reported including one weekend day (Daniels et al., 2018; Williams Erickson et al., 2018; Woźniak et al., 2022), three included 3 consecutive days (Kattelmann et al., 2001; Lagström, 1997; Niinikoski et al., 1997), and two referred to use of household measures to guide portion sizes (Kattelmann et al., 2001; Niinikoski et al., 1997). In addition to 3-day diet records, a 1-day record was used in one study (Kattelmann et al., 2001) and a 'monthly calendar' was used in another study (Tang et al., 2018). A 5-day food record was used in one study (Johansson et al., 2023), and duration was unspecified in two studies (Kalhoff et al., 2021; Lagström, 1997). Twenty-four-hour dietary recall was used in six studies (Atkins et al., 2016; Campbell et al., 2013; Daniels et al., 2014; Johnson et al., 1993; Sangalli et al., 2021; Watt et al., 2008), with five explicitly reported as multiple pass recalls (Atkins et al., 2016; Campbell et al., 2013; Daniels et al., 2014; Sangalli et al., 2021; Watt et al., 2008), and two reported as involving 3 days, including one weekend day (Atkins et al., 2016; Campbell et al., 2013). Weighed approaches were used in four studies (Fildes et al., 2015; Krebs et al., 2012; Paul et al., 2011; Shah et al., 2014). These included the amount of weighed food in a taste test in one study (Fildes et al., 2015), weighed duplicate meals adjusted for plate waste in one study (Krebs et al., 2012), pre and post meal weights for vegetables consumed in one study (Paul et al., 2011), and weighing food containers pre-feed and post-feeding (Shah et al., 2014). Four different questionnaires, including three food frequency questionnaires (Beinert et al., 2017; Schroeder et al., 2015; Wall et al., 2019) were used in four studies (Baratto et al., 2021; Beinert et al., 2017; Schroeder et al., 2015; Wall et al., 2019); three of these were developed specifically for the studies (Baratto et al., 2021; Beinert et al., 2017; Schroeder et al., 2015) and this information was not reported for the fourth questionnaire (Wall et al., 2019). The number of items included in questionnaires was only reported in one study as having 27 food types and 7 drinks (Beinert et al., 2017). Household measurements were explicitly referred to in two studies (Baratto et al., 2021; Schroeder et al., 2015) as guiding measurement of portion size.

### 3.11. Offering age-appropriate foods and beverages

Offering age-appropriate foods and beverages was measured using 24-hour recalls in two studies (Daniels et al., 2014; Zhang et al., 2009). In one study, a three-pass 24-hour dietary recall was administered by a dietician via telephone (Daniels et al., 2014). In the other study, the 24-hour dietary recall was administered by a researcher via telephone, though further details are not provided (Zhang et al., 2009).

### 3.12. Infant eating home-made food

Three different OMIs were used to measure infant consumption of home-made food in three studies (Beinert et al., 2017; Helle et al., 2019; McEachan et al., 2016). Items from food frequency questionnaires were used in two studies (Beinert et al., 2017; Helle et al., 2019). One study used an individual question designed for the study: "*At home, which of the following do you normally give (child's name)*" and was followed by response options related to homemade and commercial foods (McEachan et al., 2016).

### 3.13. Infant eating ready-made foods

Four different OMIs were used to measure infant consumption of ready-made foods in four studies (Beinert et al., 2017; Helle et al., 2019; McEachan et al., 2016; Woźniak et al., 2022). One study (McEachan et al., 2016) used a single question, which was the same question used for the outcome 'infant eating home-made food' (McEachan et al., 2016). One study used a 3-day food diary that was developed specifically for the study and was self-administered by caregivers over three days which included one weekend day (Woźniak et al., 2022).

### 3.14. Types of 'other' drinks consumed

Thirty-four different OMIs were used to measure types of 'other' drinks consumed in 33 studies. Thirteen different questionnaires, including five food frequency questionnaires (Beinert et al., 2017; Black et al., 2001; Helle et al., 2019; McEachan et al., 2016; Schroeder et al., 2015), were reported to be used in 13 studies. Of these, seven were developed specifically for the study (Ara et al., 2018; Baratto et al., 2021; French et al., 2012; Helle et al., 2019; Langer et al., 1998; Moreira et al., 2022; Schroeder et al., 2015); two existing questionnaires were reported to be used in two studies (McEachan et al., 2016; Messito et al., 2020); two questionnaires were adapted from questionnaires used in

previous research (Black et al., 2001; Rosenstock et al., 2021) such as the Pre-School Beverage Intake Questionnaire (BEVQ-PS; Lora et al., 2016); and it was unclear whether two questionnaires were existing or developed specifically for the study (Beinert et al., 2017; Cloutier et al., 2018). Individual questions were reported to be used in eight studies (Aidam et al., 2005; Cattaneo et al., 2016; Hoffmann et al., 2021; Linares et al., 2019; Martinez-Brockman et al., 2018; Morandi et al., 2019; Wen et al., 2020; Wu et al., 2023), with these questions either developed specifically for the study (Aidam et al., 2005; Linares et al., 2019; Morandi et al., 2019; Wu et al., 2023) or taken from a pre-existing survey in three studies (Hoffmann et al., 2021; Martinez-Brockman et al., 2018; Wen et al., 2020). The number of items was not reported or unclear for the majority of studies using questionnaires or individual questions. Six food diaries/records were used in five studies (Daniels et al., 2018; Johansson et al., 2023; Kattelmann et al., 2001; Williams Erickson et al., 2018; Woźniak et al., 2022). Four 3-day food diaries/records were used (Daniels et al., 2018; Kattelmann et al., 2001; Williams Erickson et al., 2018; Woźniak et al., 2022), two of which were explicitly reported as being weighed food diaries (Daniels et al., 2018; Williams Erickson et al., 2018) and three of which specified inclusion of one weekend day (Daniels et al., 2018; Williams Erickson et al., 2018; Woźniak et al., 2022). One of these studies also included a 1-day diet record (Kattelmann et al., 2001), and one study reported use of a 5-day food record (Johansson et al., 2023). Twenty-four-hour recalls were used in seven studies (Atkins et al., 2016; Campbell et al., 2013; L. A. Daniels et al., 2014; Iannotti et al., 2017; Kong et al., 2022; Sangalli et al., 2021; Zhang et al., 2009). Five of these were reported as being multiple pass recalls (Atkins et al., 2016; Campbell et al., 2013; L. A. Daniels et al., 2014; Kong et al., 2022; Sangalli et al., 2021) and three studies specified that recall was conducted over two weekdays and one weekend day (Atkins et al., 2016; Campbell et al., 2013; Kong et al., 2022).

## 4. Discussion

To ultimately reduce heterogeneity in measurement of infant diet-related outcomes and to improve synthesis and evaluation of obesity prevention interventions, this scoping review identified what OMIs have been used to measure 13 infant diet-related outcomes from a COS for infant feeding interventions (Matvienko-Sikar et al., 2020), and how these OMIs have been used. Questionnaires, individual questions, dietary recall, food diaries/records, healthcare records, weighed approaches, and deuterium dilution were used in reviewed studies. These OMIs were predominantly administered by caregivers, researchers, and healthcare professionals, and were typically completed in participants homes, a location of their choosing, or healthcare settings.

The findings of this review highlight heterogeneity in measurement of core diet-related infant feeding outcomes (Matvienko-Sikar et al., 2020), including the many different types of OMIs used. Such heterogeneity has been noted in previous reviews related to diet OMIs used with older children (Bryant et al., 2014; Burnett et al., 2020; Burrows et al., 2020). Questionnaires were reported as the most used OMI for diet-related outcomes across studies included in this review, followed by the use of individual questions. Questionnaires and individual questions can provide a valuable approach to data collection that can be used in person or remotely (Bailey, 2021; Foster & Bradley, 2018; Hooson et al., 2020) and so their inclusion in the reviewed studies is not surprising. However, in the reviewed studies, there was variability in terms of whether questionnaires and individual questions were developed specifically for the studies, were existing OMIs or adapted versions of existing OMIs. Some studies reported using existing and adapted versions of questionnaires, and/or individual questions, which allows for some comparison across studies. More often however, questionnaires and questions were developed specifically for the study in which they were used and only appear to be used in that study, which can contribute to research waste (Prinsen et al., 2016; Whitford et al., 2018; Williamson et al., 2017). The observed heterogeneity is also problematic as it reduces the ability to compare across studies to determine intervention effectiveness and the usefulness and appropriateness of the questionnaires used (Prinsen et al., 2016). A further limiting factor in synthesising the OMIs used in the reviewed studies is that, in many instances, details about questionnaires and questions used were not reported. As such we cannot accurately determine the content of many of the questionnaires and questions used in the reviewed studies. It is also unclear how many questions in questionnaires related to the specific core outcome being measured, and how many individual questions were used to measure outcomes in some studies.

Other common OMIs used in the reviewed studies were food diary/record approaches and 24-hour dietary recall. This is similar to previous reviews which also identified food diaries/records and dietary recall as commonly used diet OMIs in older children (Bryant et al., 2014; Burrows et al., 2010, 2020). Food diaries/records and dietary recalls in this review varied in terms of the duration and specified days of data collection. It is important that diary and recall methods capture data over a sufficient duration to be meaningful and minimise bias (Bailey, 2021; Foster & Bradley, 2018; Ortega, 2015). For instance, single day data provision is not likely to capture day to day variability (Matvienko-Sikar, Kelly, et al., 2018) and thus may not provide a comprehensive and/or accurate representation of an infants' diet (Burrows et al., 2010; Foster & Bradley, 2018). Similarly, using average frequency of dietary intake, as was identified in a review of OMIs for pre-school age children, rather than repeated 24-hour recall fails to capture child diet comprehensively (Burnett et al., 2020). The duration of a food diary/record or dietary recall must also not be so long that they are burdensome to participants (Bailey, 2021; Ortega, 2015), as this may influence retention and the quality of data provided (Foster & Bradley, 2018). It is important that there is some degree of standardisation in duration of information collected so that findings can be compared across and within studies. In the reviewed studies most diaries/records and dietary recalls included multiple days, with most specifying 3-days, to account for this (Burrows et al., 2010; Foster & Bradley, 2018; Ortega, 2015).

Standardisation is also important in terms of the days specified for data collection because what an infant, and families more generally, eat on weekdays and weekends can differ (Esposito et al., 2022; Molitor & Doerr, 2021; Rothausen et al., 2012). In the reviewed studies, some diaries/records were specified to include two weekdays and a weekend day, which is important to capture this potential variability (Burrows et al., 2010; Foster & Bradley, 2018; Hooson et al., 2020; Ortega, 2015). However, many did not report accounting for this potential variability and/or did not articulate the specified days, thus limiting our ability to evaluate these OMIs. In addition, data collection using dietary recall and/or diaries/records can require specialized training and/or resources to complete (Bailey, 2021; Foster & Bradley, 2018). Thus, despite their potential usefulness and comprehensiveness there is potential for researcher and/or caregiver burden in completing such OMIs.

Hospital/medical record data, including primary care data, was less frequently used in reviewed studies and was only used for measurement of feeding method. Despite the WHO and UNICEF suggesting standardised infant feeding data collection methods, routine collection of feeding data is rarely or poorly recorded and differs across and within countries (Whitford et al., 2018). Lack of use of healthcare record data for assessment of outcomes other than feeding method also speaks to a gap in practice, whereby important infant feeding outcomes are likely not recorded or monitored by healthcare professionals (Whitford et al., 2018). There is evidence that healthcare professionals such as midwives, general practitioners, and nurses see infant feeding as part of their role (Baker et al., 2021; Toomey et al., 2020). As such, collection of such information in healthcare settings may be feasible, provided healthcare professionals are provided appropriate training and supports to do so (Baker et al., 2021). Doing so could also enhance the reliability of such data and facilitate greater accessibility of data and data-linkage for

research purposes.

The variability in where OMIs were administered and by whom in the reviewed studies highlights the diversity in where and how measurement of infant diet-related outcomes can occur. This is a positive finding, as trials of infant feeding interventions often occur in the community, participants homes, and/or healthcare settings (Denova-Gutiérrez et al., 2023; Matvienko-Sikar, Kelly, et al., 2018; Redsell et al., 2016) and so having available OMIs that can be used in these contexts is beneficial. In this review, OMIs were commonly self-administered by caregivers and completed in their own homes or a location of their choosing. This flexibility enables caregivers to provide data in a manner that may best suit them, potentially increasing engagement and data provision. More frequently in reviewed studies, researchers also administered OMIs for diet-related outcomes and were particularly involved in assessments such as dietary-recall and use of food frequency questionnaires. Researcher collection of diet-related outcome data is suggested to minimise risks of missing dietary data and improve precision (Hooson et al., 2020). The feasibility of such an approach requires further investigation. Further, many OMIs were completed in multiple locations, with many OMIs being completed in more than one location or being administered by more than one person in the same trial. This speaks to the flexibility of many of the OMIs used in this review, particularly the use of questionnaires and individual questions. However, observed variability in timing of measurement across studies limits comparability, particularly given infants rapid changing feeding needs in their first year (Taylor et al., 2017).

This review used a comprehensive search strategy that identified studies representing a wide geographical range and are published over a 30-year period. Presentation of OMIs overall and by diet-related outcome also provides comprehensive information on use of OMIs that can guide future OMI use. This review had limitations. For instance, in this review we examined OMIs used to measure only those diet-related outcomes included in the infant feeding COS (Matvienko-Sikar et al., 2020), which means examining how other diet-related outcomes are measured is outside the remit of this review. For instance, we examined measurement of duration of exclusive breastfeeding and duration of breastfeeding from mother but did not examine duration of *any* breastfeeding up to 2 years. As such, the findings of this review are limited to the infant feeding COS outcomes only. That said, the approach to measurement of these outcomes are likely applicable to other breastfeeding and broader infant feeding outcomes also. The search approach was revised from a focus solely on childhood obesity prevention trials to include other child health areas also. This change ensured that OMIs which may be applicable to childhood obesity prevention, but have not yet been examined in this context were identified.

An important limitation of the reviewed literature is that some OMIs used were either not reported or details for reported OMIs were unclear or absent. While authors were contacted for additional details in the review, this limits assessment of what OMIs are used due to lack of full and clear reporting in studies. Further, the inclusion and translation of non-English studies in this review, though a strength in terms of inclusivity of evidence, may contribute to some loss of information, particularly in relation to use of questionnaires. Despite this, the review findings provide a comprehensive overview of OMIs reported to be used for infant diet-related outcomes. Further, evidence of poor reporting of OMI detailed in this review emphasises the need for improved outcome reporting in this area. We recommend that future trials clearly report what OMIs were used to measure all outcomes reported, how many questions were asked where relevant, OMI response formats, recall periods, measurement timing, and how, where and by whom OMIs were administered/completed. If such reporting is not feasible due to journal word counts, authors should use supplementary files and/or open repositories (such as the Open Science Framework) to make this information and/or the OMIs used available.

## 5. Conclusion

This review identified a range of OMIs for diet-related outcomes. Observed heterogeneity in the types of OMIs identified, and where, when and by whom they were administered, highlights the need for increased standardisation of how infant diet-related outcomes are measured in trials of childhood obesity and more broadly. Such standardisation must recognize the need for some flexibility in how infant-feeding questions may need to be asked with different populations and in different contexts however, due to potential differences in perceptions and experiences of infant feeding (MacMillan Uribe et al., 2022; Marvin-Dowle et al., 2021). Further, increased standardisation does not preclude researchers from choosing their own and/or additional OMIs to use in trials but use of standardised OMIs will maximise comparability across studies, enhance evidence synthesis, and minimise research waste (Prinsen et al., 2016; Whitford et al., 2018; Williamson et al., 2017). There is also a need for clear and complete reporting of OMIs used in studies to measure diet-related outcomes in infants. Full reporting will enable evaluation of OMI measurement properties required to assess the quality of questionnaires and guide decisions about their use in future trials (Mokkink et al., 2016). The findings of this review will inform development of a standardized set of OMIs for the previously developed infant feeding COS (Matvienko-Sikar et al., 2020) as part of the Standardised measurement for Childhood Obesity Prevention (SCOPE) project. The next step of this process is to evaluate the measurement properties and feasibility of the identified OMIs (Matvienko-Sikar et al., 2023). Identifying feasible, good quality OMIs for use in future trials of infant feeding interventions to prevent childhood obesity will enable enhanced evidence syntheses and examination of what works, or not, to improve infants' diet-behaviours and to support child health, growth and wellbeing.

## CRediT authorship contribution statement

**Karen Matvienko-Sikar:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Moira Duffy:** Writing – review & editing, Formal analysis, Data curation. **Eibhlín Looney:** Writing – review & editing, Formal analysis, Data curation. **Reindolf Anokye:** Writing – review & editing, Data curation. **Catherine S. Birken:** Writing – review & editing, Methodology. **Vicki Brown:** Writing – review & editing, Methodology. **Darren Dahly:** Writing – review & editing, Methodology, Conceptualization. **Ann S. Doherty:** Writing – review & editing, Methodology. **Dimity Dutch:** Writing – review & editing, Methodology. **Rebecca Golley:** Writing – review & editing, Methodology, Conceptualization. **Brittany J. Johnson:** Writing – review & editing, Methodology. **Patricia Leahy-Warren:** Writing – review & editing, Methodology. **Marian McBride:** Writing – review & editing, Methodology, Conceptualization. **Elizabeth McCarthy:** Writing – review & editing, Methodology. **Andrew W. Murphy:** Writing – review & editing, Methodology, Conceptualization. **Sarah Redsell:** Writing – review & editing, Methodology, Conceptualization. **Caroline B. Terwee:** Writing – review & editing, Methodology, Conceptualization.

## Ethical statement

Ethical approval was not obtained as this is a review and thus does not require ethical approval.

This manuscript has not been published previously in any form, is not under consideration for publication elsewhere, and will not be published elsewhere if accepted. All authors made substantial contributions to the manuscript, and all authors approve the articles publication. The authors have no conflicts of interest to declare.

## Funding sources

This work is supported by a Health Research Board Emerging Investigator Award (HRB-EIA-2022-005).

DD is supported by the EPOCH-Translate Centre for Research Excellence (GNT2006999). BJJ is supported by The Hospital Research Foundation Early-Mid Career Fellowship.

## Declaration of competing interest

The authors have no conflicts of interest to declare.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2025.107980.

## Data availability

No data was used for the research described in the article.

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