Dietary intake of breastfeeding mothers in developed countries: a systematic review and results of the MEDIDIET study

Matteo Di Maso[1], Simone R. B. M. Eussen[2], Francesca Bravi[1], Guido E. Moro[3], Carlo Agostoni[4,5], Paola Tonetto[6], Pasqua Anna Quitadamo[7], Guglielmo Salvatori[8], Claudio Profeti[9], Iwona Kazmierska[10], Elisabetta Vacca[2], Adriano Decarli[1], Bernd Stahl[2,11], Enrico Bertino[12], Monica Ferraroni[1] on behalf of the MEDIDIET Working Group.

See the MEDIDIET Working Group members in statement of authors' contribution to the manuscript

[1]Department of Clinical Sciences and Community Health, Branch of Medical Statistics, Biometry and Epidemiology "G.A. Maccacaro", Università degli Studi di Milano, Milan, Italy; [2]Danone Nutricia Research, Utrecht, The Netherlands; [3]Italian Association of Human Milk Banks (AIBLUD), Milan, Italy; [4]Pediatric Intermediate Care Unit, Fondazione IRCCS Ospedale Cà Granda-Ospedale Maggiore Policlinico, Milan, Italy; [5]Department of Clinical Science and Community Health, Università degli Studi di Milano, Milan, Italy; [6]Neonatal Intensive Care Unit, City of Health and Science, University of Turin, Turin, Italy; [7]Neonatology – Neonatal Intensive Care Unit, IRCCS Casa Sollievo della Sofferenza, San Giovanni Rotondo, Italy; [8]Neonatal Intensive Care Unit, IRCCS Ospedale Pediatrico Bambino Gesù, Rome, Italy; [9]Azienda Ospedaliera Universitaria Meyer di Firenze, Florence, Italy; [10]Neonatal Intensive Care Unit, Ospedale Buccheri La Ferla Fatebenefratelli, Palermo, Italy; [11]Department of Chemical Biology & Drug Discovery, Utrecht Institute for Pharmaceutical Sciences, Faculty of Science, Utrecht University, Utrecht, The Netherlands; [12]Department of Public Health and Pediatrics, Neonatal Intensive Care Unit, Università degli Studi di Torino, Turin, Italy.

Sources of support

This study was sponsored by Danone Nutricia Research, Utrecht, The Netherlands. F.B. was supported by a grant of the Department of Clinical Sciences and Community Health of the University of Milan (PSR2015-1719FBRAV). M.D.M. was supported by an academic fellowship focusing on maternal nutrition.

Conflict of interest and Funding Disclosure

The statistical analyses were performed by the Department of Clinical Sciences and Community Health, Branch of Medical Statistics, Biometry and Epidemiology "G.A. Maccacaro", Università degli Studi di Milano, Milan, Italy (M.D.M., F.B., and M.F.) without involvement of the Sponsor. S.E., E.V., and B.S. are employees of Danone Nutricia Research, Utrecht, The Netherlands.

Corresponding author

Dr. Francesca Bravi, Department of Clinical Sciences and Community Health, Branch of Medical Statistics, Biometry and Epidemiology “G.A. Maccacaro”, Università degli Studi di Milano, Via Augusto Vanzetti 5, 20133 Milano, Italy. Phone: +39-02-50320874; e-mail: francesca.bravi@unimi.it

Word count: 7586

Number of figures: 2

Number of tables: 6

Supplementary material: PRISMA checklist

Running title

Nutritional intakes of breastfeeding mothers

Abbreviations

% En, % of total energy; % Fats, % of total fats; α-TE, α-tocopherol; ω-3 fatty acids, omega-3 fatty acids; ω-6 fatty acids, omega-6 fatty acids; AI, adequate intake; ALA, α-linolenic acid; AR, average requirement; ARA, arachidonic acid; DFE, dietary folate equivalent; DRVs, dietary reference values; EFSA, European Food Safety Authority; FFQ, food frequency questionnaire; LA, linoleic acid; NE, niacin equivalent; PRI, population reference intake; RAE, retinol activity equivalent; RI, reference intake range.

Abstract

Background

Lactation is a demanding period for women and good nutrition is crucial for optimal health of mothers and infants.

Objectives

To provide new data and summarize the overall evidence on maternal nutrient intakes during lactation in developed countries, we present a systematic review (SR) of the literature and concurrently original results of the Italian MEDIDIET study. We compared nutrient intakes with dietary reference values (DRVs) proposed by the European Food Safety Authority.

Methods

Studies were identified searching PubMed/Embase databases up to February 2020. Observational studies reporting at least energy and macronutrient intakes of healthy breastfeeding mothers who followed non-restricted and non-specific diets were included. Studies on populations with severe nutritional deficiencies were excluded. The MEDIDIET study enrolled 300 healthy breastfeeding mothers at 6±1 weeks postpartum. Usual diet was concomitantly evaluated through a validated and reproducible food frequency questionnaire. Nutrient intakes were estimated using a food composition database.

Results

Twenty-eight articles regarding 32 distinct study populations were included. Maternal nutrient intakes were generally in agreement across studies included in the SR and conforming to DRVs. Within micronutrients, vitamin D intake was below the recommendation. In the MEDIDIET study, mean intakes of energy (1950±445 kcal/day), carbohydrates (270±20.1 g/day), proteins (87.8±20.1 g/day) and fats (65.6±18.9 g/day) were similar to those observed in the SR. Moreover, observed intakes seemed to reflect the typical Mediterranean diet with low intakes of carbohydrates, saturated and polyunsaturated fatty acids and high monounsaturated fatty acids and vitamins. Conversely, protein intake was mainly derived from animal sources.

Conclusions

This SR showed that nutrient intakes of breastfeeding mothers in developed countries are generally in line with DRVs despite different dietary patterns worldwide. Some nutritional deficiencies emerged highlighting the need for additional nutritional advice. Mothers participating in the MEDIDIET study showed a nutritional profile in agreement with the Mediterranean diet.

Keywords: Maternal nutrient intakes; lactation; Mediterranean diet; nutritional epidemiology

Introduction

Adequate nutrition during breastfeeding is important for the health of both mothers and infants. The breastfeeding period is highly demanding for mothers with a nutritive need considerably greater than that of pregnancy for energy and most nutrients (1). For instance, the energy required to produce 1 L of milk is estimated to be approximately 700 kcal, and the milk secreted in 4 months of lactation represents the energy equivalent of the total energy requirement of pregnancy (2, 3).

Although even mothers who are not optimally nourished, can produce milk in appropriate quantity and quality (e.g. some micronutrients such as iron, zinc, and calcium are excreted in breast milk in adequate and constant amounts at the expense of maternal stores), deficiencies in mothers' dietary intake may influence the milk concentrations of several essential nutrients, such as water-soluble vitamins (4). The prevalence of maternal nutrient deficiencies may depend on geographical, cultural, dietary, and socioeconomic factors (5-8). For instance, infants of vegetarian and vegan mothers may have low vitamin B12 levels at birth, and this persists during lactation from B12-deficient mothers (9-11). In addition, mothers living in some areas (e.g. developing countries) have less access to foods known to be important during lactation than mothers living in industrialized areas (1). Dietary recommendations throughout the world provide different nutritional guidelines for lactating mothers. However, an European survey conducted by the World Health Organization on national recommendations for maternal nutrition and physical activity reported that only 62% of 51 participating Member States have implemented recommendations related to the postpartum and lactation periods (12). In addition, recommended nutrient intakes during lactation are based on limited data (13) and are often extrapolated from known secretion of nutrients in milk with adjustment for bioavailability (14).

Thus, tracking maternal dietary intake is an extremely important instrument in order to identify whether breastfeeding women consume the right amounts of essential nutrients during lactation. Accordingly, determining maternal dietary intake is important to design nutritional interventions to improve the nutritional status of breastfeeding women (5). One of the goals of the Italian MEDIDIET study was to evaluate nutritional intakes of breastfeeding mothers (15).

To provide new data and summarize the overall evidence on maternal diet in terms of nutrient intakes during lactation in developed countries, we present here a systematic review (SR) of the existing literature and concurrently original results of the Italian MEDIDIET study. We also compared nutrient intakes with dietary reference values (DRVs) proposed by the European Food Safety Authority (EFSA).

Methods

SR: search strategy

We performed a literature search up to February 2020 in the Medline/PubMed and Embase databases using the terms: "*maternal diet*", "*mother diet*", "*maternal food*", "*mother food*", "*maternal intake*", "*mother intake*", "*maternal nutrition*", "*mother nutrition*", "*maternal nutrient*", "*mother nutrient*", "*breastfeed*", "*breast feed*", "*breastfed*", "*breast fed*", "*lactation*", "*human milk*", "*breast milk*", "*maternal milk*", "*mother milk*" (see Appendix).

We followed the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) statement for SRs and reporting results for conducting the present study (**Supplementary Table 1**) (16, 17). Three authors (M.D.M., S.E., and M.F.) separately reviewed studies and discrepancies were discussed and solved. Studies were eligible for inclusion in the SR if they met the following criteria: a) the study had an observational design including healthy breastfeeding (any type) mothers with healthy infants born at term (i.e., ≥37 gestational weeks); b) the study enrolled breastfeeding mothers who followed a usual diet without any restrictions (e.g. specific diet, dietary interventions, use of dietary supplements); c) the study reported maternal diet either at a single point in time or repetitively between delivery and 12 months postpartum; d) the study reported at least energy and all 3 macronutrient intakes (i.e., carbohydrates, proteins, and fats) of breastfeeding mothers; e) the study reported means and SDs of maternal energy and nutrient intakes expressed as absolute values, percentage of total energy (% En) or percentage of total fats (% Fats). We included studies with any type of breastfeeding mothers because the SR aimed at assessing nutrient intakes of mothers without a formal evaluation of breast milk composition and infant outcomes.

Studies were excluded for one of the following reasons: a) the study focused on a population with severe nutritional deficiencies (e.g. Sub-Saharan African countries or rural areas of developing countries); b) the study enrolled breastfeeding mothers with major chronic diseases (e.g. diabetes, hypertension, or HIV/AIDS); c) the study enrolled children born preterm (i.e., <37 gestational weeks), children born at term with low birth weight (i.e., <2500 g), or children with problematic health conditions (e.g. atopic dermatitis or cystic fibrosis); d) the study had an experimental design evaluating the effects of dietary interventions (e.g. dietician counselling) and/or use of dietary supplements (e.g. iron or vitamin D supplements) even if participants belonging to the control arm followed an usual diet without any restrictions. We excluded experimental studies because the intervention setting may have somewhat modified usual maternal dietary behaviours making misleading comparisons with observational studies.

SR: data extraction

From each study, we extracted data on first author's surname, publication year, country, study design (i.e., cross-sectional or longitudinal), number and age of participants, dietary assessment tool (i.e., diary, dietary record, 24-h recall or FFQ), administration mode (i.e., interviewer-administered or self-administered), period of administration, and means ± SDs of maternal energy and nutrient intakes. We expressed energy intake in kcal/day for studies (18-22) that reported it in different units (i.e., MJ/day or kJ/day). When studies (18, 21, 23) reported SEM, we calculated SDs multiplying SEM by the square root of the sample size (i.e., the number of study participants). For studies (24-30) reporting maternal diet in strata of population (e.g. rural and urban areas of industrialized countries, physical activity levels of breastfeeding mothers), we calculated overall means and SDs using a weighted average of means and SDs, respectively. The overall SD is unbiased under the assumption of independence among strata and equal population variances (homogeneity) (31). Using the same method and under the same assumptions, we calculated overall means and SDs for studies (20, 32-35) that reported diet measured for the same mothers at different time points (e.g. first, third and sixth month postpartum) in order to have a more comprehensive description of maternal dietary intake during lactation.

MEDIDIET: study design, dietary assessment and estimation of energy and nutrient intakes

The MEDIDIET is an Italian observational study that mainly aimed to evaluate the role of maternal diet on breast milk composition. Study design, inclusion criteria, maternal diet assessment, milk collection and descriptive study characteristics are provided in detail elsewhere (15). Briefly, MEDIDIET study enrolled 300 healthy mothers with healthy term infants between October 2012 and June 2014 in five Italian maternity hospitals. All mothers were Caucasian aged 25-41 years old, free of disease (i.e., diabetes, autoimmune diseases, cardiovascular diseases, hypertension, and renal diseases), sero-negative for HBV/HCV/HIV, non-smokers, non-abusers of drugs or alcohol, and not severely obese (i.e., pre-pregnancy BMI<35 kg/m^2). Infants were born at term (i.e., ≥37 gestational weeks) with a birth weight of 2500-4500 g, a body length of 46-56 cm, and were exclusively breastfed (i.e., no other drink or food was given to infants) (36) from birth to the day of milk collection (i.e., 6 ± 1 weeks of age). All mothers signed an informed consent to participate to the study (15). The Ethics Committee of participating hospitals approved the study (protocol number: 31060 MD).

On the day of milk collection, mothers provided a sample of their breast foremilk (30-50 ml) expressed in the morning after breakfast and before lunch. The same day, trained interviewers administered a validated and reproducible quantitative food frequency questionnaire (FFQ) (37, 38) to assess maternal diet from delivery to the day of milk collection. The FFQ included information on weekly intake of 78 food items, recipes, and beverages according to the following sections: (1) milk, hot beverages and sweeteners; (2) bread, cereals and first courses; (3) second courses (e.g. meat and other main dishes); (4) side dishes (e.g. vegetables); (5) fruits; (6) sweets, desserts and soft drinks, and (7) alcoholic beverages. Serving size was defined either in "natural" unit (e.g. 1 cup of milk, 1 coffee spoonful of sugar, 1 egg, 1 apple, etc.) or as small, average/medium, or large according to an Italian average serving size (e.g. 80 g of pasta, 100 g of mixed salad, 175 g of potatoes, 150 g of beef). Other specific items investigated the fats (e.g. olive oil, seeds oil, butter) used for cooking or as seasoning. Seasonal variation in fruit and vegetable consumption was also considered to account for the fluctuations throughout the year. Occasional intakes (i.e., less than once a week, but greater than once per month) were coded as 0.5 per week. Lastly, dietary data collected by means of FFQ were used to estimate daily maternal energy and nutrient intakes using an Italian food composition database (39). In the nutrient intake estimation, information on fats used for cooking or as seasoning was used to weight the fat composition of each food or recipe.

Statistical analyses

We constructed the distribution of nutrient intakes using average intakes reported by studies included in the SR. It could be viewed as a "ranking system of mean value intakes" in order to easily compare intakes across studies and with those of the MEDIDIET study, as well as with the DRVs given by EFSA (40). Hereafter, we refer to average intake as intake. In the results section, we reported the minimum, the median and the maximum for each nutrient intake. We also reported the 25th and 75th percentile when more than half of included studies reported the intake.

Results

SR: paper selection

The literature search identified 3876 articles of which 3781 were excluded after review of title or abstract, leaving 95 articles assessed for eligibility (**Figure 1**). We selected 36 articles after the exclusion of 59 articles for at least one of the following reasons: not reporting at least maternal energy and all 3 macronutrient intakes (33 articles); not having an observational study design or mothers following a specific or restricted diet (12 articles); assessing diet during pregnancy or after 1 year postpartum (8 articles); enrolling infants born preterm or mothers from areas with severe nutritional deficiencies (3 articles); not reporting means and SDs for maternal nutrient intakes (3 studies). We excluded 10 additional articles that were duplicate reports of the same population (7 articles) or because nutrient intakes were evaluated in maternal plasma (3 articles). In addition, we included 2 articles identified from the reference list of the eligible pool.

Thus, the present SR included 28 articles regarding 32 distinct study populations as reported in **Table 1**. Hereafter, we refer to study population as study. Among 32 studies included in the SR, 5 studies (24, 26, 30, 34, 41) enrolled mothers from North America (i.e., US), 3 studies (25, 33, 42) from Central and South America (i.e., Mexico, Chile and Brazil), 1 study (18) from Oceania (i.e., Maori and Pacific Island ethnicity living in New Zealand), 9 studies (18, 19, 21, 23, 27, 43-45) from Asia (i.e., China, Japan, Philippine, South Korea, Thailand, and Asian ethnicity living in New Zealand); 3 studies (46-48) from Middle East (i.e., Iran and Turkey); 6 studies (18, 22, 23, 28, 35, 49) from North and Central Europe (i.e., Iceland, Poland, Sweden, and European ethnicity living in New Zealand), and 5 studies (20, 29, 32, 50, 51) from South Europe/Mediterranean Area (i.e., Croatia, Greece, Italy, and Spain).

SR: energy, macronutrients, cholesterol, and fiber

Table 2 provides means and SDs of maternal daily intakes for energy (kcal/day), carbohydrates (g/day and % En), proteins (g/day and % En), fats (g/day and % En), cholesterol (mg/day), and fibers (g/day).

Among the 32 studies included in the SR, the range for energy intake was 1411-2781 kcal/day with a median of 2111 kcal/day according to the energy intake distribution across studies. The 25th and 75th percentiles were 1949 and 2325 kcal/day, respectively. The average requirement (AR) for energy is nearly 2300 kcal/day which includes 500 additional kcal/day for lactation period beyond what is recommended for non-pregnant and/or non-lactating women (i.e., approximately 1800 kcal/day for women with low physical activity). The AR corresponded to the 75th percentile of energy distribution across studies included in the SR, however, the observed median intake was not far from the AR indicating a good adherence of breastfeeding mothers to the recommendation. Nevertheless, three studies (27, 35, 44) reported an intake lower than the recommendation for non-pregnant and/or non-lactating women (i.e., lower than 1800 kcal/day), whereas three studies (23, 28, 49) reported an intake greater than 2500 kcal/day indicating an exceedance of the AR by 200 kcal/day or more.

With regards to carbohydrates, 29 of 32 studies (18-26, 28-30, 33-35, 41-43, 45-51) reported the intake in g/day and 18 studies (18, 20-22, 24, 27, 29, 30, 32, 34, 35, 42, 44, 48, 50) in % En. Carbohydrate intake, expressed as g/day, ranged from 207 to 366 with a median of 274. Intakes corresponding to 25th and 75th percentiles were 250 and 316 g/day, respectively. When expressed as % En, carbohydrates ranged from 41.1 to 65.5 with a median of 49.5, whereas the 25th and 75th percentiles were 44.9 and 52.0, respectively. Two studies (29, 30) showed an intake lower (41.1 and 41.7% En) and one study (27) higher (65.5 % En) than the reference intake range (RI) of 45-60% En.

Twenty-nine studies (18-26, 28-30, 33-35, 41-43, 45-51) reported protein intake in terms of g/day and 18 studies (18, 20-22, 24, 27, 29, 30, 32, 34, 35, 42, 44, 48, 50) in terms of % En. The range of protein intake was 58.6-111 g/day, whereas the 25th, 50th and 75th percentiles were 78.9, 85.4, and 91.5 g/day, respectively. All studies reported an intake of proteins substantially higher than the corresponding AR of 53.5 g/day (calculated as the average of ARs for lactating women according to different postpartum periods and using 62.1 kg as the reference weight) (52). Moreover, the intake of protein was generally higher than the population reference intake (PRI) of 68.0 g/day (calculated using the same method as for the AR), except for few studies (23, 35, 42, 45, 48) that showed an intake slightly higher or close to this reference value. In terms of % En, protein intake ranged from 13.8 to 19.3. Intakes of 15.4, 15.8, and 16.8% En corresponded to the 25th, 50th and 75th percentile, respectively.

Also for fats, 29 studies (18-26, 28-30, 33-35, 41-43, 45-51) reported the intake as g/day and 18 studies (18, 20-22, 24, 27, 29, 30, 32, 34, 35, 42, 44, 48, 50) as % En. Fat intake ranged from 47.5 to 110 g/day (median 82.4 g/day). The 25th-75th percentile range was 62.7-97.0 g/day. When expressed as % En, fat intakes were 15.5 (minimum), 30.3 (25^{th} percentile), 34.5 (median), 36.7 (75^{th} percentile), and 42.4 (maximum). The minimum intake reported by Jiang et al. (27) was considerably lower, whereas the intakes reported by Sanchez et al. (29) and Sims (30) were considerably higher than the RI for fats (20-35% En).

Cholesterol was reported in 13 studies included in the SR (18, 19, 21, 25, 35, 43, 46, 47, 49, 50) with a range intake of 68.7-563 mg/day and a median of 276 mg/day. The minimum cholesterol intake was reported in the South Korean study of Kim et al. (19) and the highest one in the Mexican study of Caire-Juvera et al. (25).

Twelve studies (18, 21, 25, 26, 33, 35, 43, 49, 50) reported fiber intake. The range was 7.4-33.6 g/day with a median of 23.4 g/day which was close to the adequate intake (AI) of 25 g/day. In two studies (21, 26), intake levels were far lower (i.e., less than 11.1 g/day) than the AI; similarly two studies (18, 43) showed an intake of fiber higher (i.e., greater than 31.6) than the AI.

SR: fatty acids

Table 3 provides means and SDs of maternal daily intakes for SFA (g/day, % Fats, and % En), MUFA (g/day, % Fats, and % En), and PUFA (g/day, % Fats, and % En). **Table 4** provides the same figures for PUFA components. In particular, we presented total omega-6 fatty acids – ω-6 fatty acids (g/day, and % En) with parental compound linoleic acid – LA (g/day) and its major by-product arachidonic acid – ARA (g/day); and total omega-3 fatty acids – ω-3 fatty acids (g/day, and % En) with the parental compound α-linolenic acid – ALA (g/day) and its major by-products EPA (g/day) and DHA (g/day). For fatty acids, EFSA provided DRVs for SFA, LA, ALA and EPA+DHA. However, the recommendation for SFA was as low as possible, for LA and ALA was given in terms of % En whereas studies included in the SR reported the intake in absolute values (g/day). Thus, we report in table 4 only the recommendation for EPA+DHA.

Sixteen studies (18-20, 22, 23, 25, 33, 35, 46-49, 51) reported SFA intake as g/day, 5 studies (18, 32, 48) as % Fats, and 7 studies (18, 20, 22, 28, 50) as % En. The intake of SFA expressed as g/day ranged from 13.4 for Chinese mothers participating in the study of Xiang et al. (23) to 45.0 g/day for Icelanders mothers in the study of Olafsdottir et al. (22). The median intake of SFA distribution across studies was 33.7 g/day. In terms of % Fats and % En, intakes of SFA ranged from 13.1 to 46.7 and from 11.1 to 17.1, respectively.

As regards to MUFA, 16 studies (18-20, 22, 23, 25, 33, 35, 46-49, 51) reported the intake as g/day, 5 studies (18, 32, 48) as % Fats, and 3 studies (20, 22, 28) as % En. The minimum, median, and maximum intake of MUFA in terms of g/day were 16.0, 32.8, and 50.3, respectively. Among studies reporting the intake in terms of % Fats, the minimum was 16.2 and the maximum was 44.2. The intake of MUFA expressed in % En was 11.9 in the study of Olafsodottir et al. (22), 14.5 in the study of Mojska et al. (28), and 15.2 in the study of Kresic et al. (20).

Sixteen studies (18-20, 22, 23, 25, 33, 35, 46-49, 51) reported PUFA intake as g/day, 5 studies (18, 32, 48) as % Fats, and 4 studies (20, 22, 28, 50) as % En. The intake of PUFA ranged from 8.5 to 24.9 g/day and the median was 12.7 g/day. When expressed as % Fats, Antonakou et al. (32) reported a PUFA intake of 5.6 (minimum) for Greek mothers and Butts et al. (18) an intake of 18.6 (maximum) for Asian mothers. The intake expressed in terms of % En ranged from 3.2 to 6.7.

Four studies (19, 23, 33) reported ω-6 fatty acids as g/day and 1 study (48) as % En. Kim et al. (19) reported an intake of ω-6 fatty acids of 9.9 g/day, Xiang et al. (23) of 10.1 g/day for Swedish mothers and 14.1 g/day for Chinese mothers, and Barrera et al. (33) of 21.9 g/day. In terms of % En, Samur et al. (48) reported an intake of ω-6 fatty acids of 4.5% En.

Intake of LA was reported in 8 studies (23, 24, 33, 46-48, 51) with a range of 6.8-19.8 g/day (Scopesi et al. and Barrera et al., (33, 51) respectively) with a median of 9.9 g/day. Arachidonic acid (ARA) intake was reported in 5 studies (19, 23, 24, 33). The minimum, median and maximum intakes were 0.03 for Swedish mothers participating in the study of Xiang at al. (23), 0.05 for South Korean mothers in the study of Kim et al. (19), and 1.10 g/day for Chilean mothers in the study of Barrera et al. (33), respectively.

The ω-3 fatty acids were reported in 4 studies as g/day and in 1 study as % En. The lowest intake (1.2 g/day) was reported by Kim et al. (19), followed by Xiang et al. (23) (1.7 and 1.8 g/day for Swedish and Chinese mothers, respectively), whereas the highest intake (2.7 g/day) was reported by Barrera et al. (33). Samur et al. (48) reported an intake of ω-3 fatty acids of 0.6 % En.

Lastly, six studies reported ALA intake (23, 24, 33, 46, 48, 51), 6 studies reported EPA intake (19, 23, 24, 33, 46, 47) and 7 studies reported the intake of DHA (19, 23, 24, 33, 46, 47). The range of ALA was 0.2-2.6 g/day with a median of 1.2 g/day. The intake of EPA and DHA ranged from 0.02-0.09 g/day, and 0.01-0.14 g/day, respectively. Medians were 0.04 g/day (EPA) and 0.09 g/day (DHA).

SR: minerals

Maternal intake of calcium (mg/day), phosphorus (mg/day), potassium (mg/day), iron (mg/day), zinc (mg/day), and sodium (mg/day) are reported in **Table 5**.

Fourteen studies included in the SR reported the intake of calcium (18, 20, 21, 25, 26, 29, 30, 34, 35, 41, 43). Calcium intake ranged from 539 to 1636 with a median of 1001 mg/day. Three studies (21, 35, 43) reported a considerably lower calcium intake (i.e., less than 700 mg/day) than the AR of 805 mg/day (calculated as the average of ARs for lactating women according to different age groups). Likewise, three studies (25, 26, 41) reported an intake of calcium considerably higher (i.e., greater than 1300 mg/day) than the AR.

Twelve studies (18, 20, 21, 26, 29, 34, 35, 41, 43) reported an intake for phosphorus that ranged from 680.2 to 1736 mg/day. The median intake was 1465 mg/day. All studies reported an intake of phosphorus higher than the AI (550 mg/day). In particular, except for Thai mothers participating in the study of Leelahakul et al. (21) that showed an intake (680 mg/day) close to the AI, other studies reported an intake considerably higher (i.e., greater than 1200 mg/day).

Potassium intake was reported in 9 studies (18, 21, 25, 26, 35, 43). The minimum intake was 1677 mg/day, the median was 3063 mg/day, and the maximum was 4084 mg/day. Only one study

(43) reported an intake of potassium close to the corresponding AI (4000 mg/day). Leelahakul et al. (21) for Thai mothers and Caire-Juvera et al. (25) for Mexican ones reported an intake of potassium far lower (1677 and 2760 mg/day, respectively) than the AI and for the remaining studies the intake ranged from 3000 to 3650 mg/day.

All studies (18, 20, 21, 25, 26, 29, 30, 34, 35, 41, 43) reported an intake of iron higher than the AR of 7 mg/day. In particular, the intake ranged from 12.0-23.2 mg/day with a median of 14.8 mg/day.

Nine studies (18, 20, 21, 25, 35, 43) provided an intake for zinc. The range was 2.9-13.1 mg/day and the median was 10.0 mg/day which was close to the AR (approximately 10.6 mg/day which included an intake of 8.2 mg/day, calculated as the average of ARs for non-pregnant and non-lactating women according to different age groups and levels of phytate intake, and an additional intake of 2.4 mg/day for lactating women). In addition, Leelahakul et al. (21) for Thai mothers and Kresic et al. (20) for Croatian ones showed an intake of zinc considerably lower than the AR (2.9 mg/day and 5.2 mg/day, respectively).

For sodium, 9 studies (18, 21, 25, 26, 35, 43) provided the intake. Intakes of 899, 2579, and 6345.0 mg/day corresponded to the minimum, median and maximum, respectively. The minimum was observed for Thai mothers in the study of Leelahakul et al. (21) which was considerably lower than the AI of 2000 mg/day; conversely, the maximum was observed for South Korean mothers in the study of Choi et al. (43) which was more than three-fold higher than the AI.

SR: vitamins and β-carotene equivalent

Table 6 provides means and SDs of maternal daily intakes for vitamin A – retinol equivalent (μg RAE/day; RAE: retinol activity equivalent), thiamin (mg/day), riboflavin (mg/day), niacin equivalent (mg NE/day; NE: niacin equivalent), vitamin B6 (mg/day), folate (μg DFE/day; DFE: dietary folate equivalent), vitamin C (mg/day), vitamin D (μg/day), vitamin E (mg α-TE/day; α-TE: α-tocopherol), and β-carotene equivalent (mg/day).

Thirteen studies (18, 20, 21, 25, 26, 30, 34, 35, 43, 49) reported the vitamin A intake. The range was 262-3043 μg RAE/day and the median was 1132 μg RAE/day. Leelahakul et al. (21) for Thai mothers reported the minimum intake (262 μg RAE/day) which was considerably lower than the AR for vitamin A (1020 μg RAE/day); conversely four studies (25, 26, 30, 34) showed an intake considerably higher (i.e., greater than 2000.0 μg RAE/day) than the AR.

Eleven studies provided thiamin intake (18, 20, 21, 26, 30, 34, 35, 43). The minimum intake was 1.1 mg/day observed for Croatian mothers in the study of Kresic et al. (20), the median was 1.6 mg/day reported by Butts et al. for Asian mothers (18), and the maximum was 5.0 mg/day for Thai mothers participating in the study of Leelahakul et al. (21).

All studies showed an intake of riboflavin close or slightly higher than the corresponding AR of 1.7 mg/day. Among the 10 studies included in the SR (18, 21, 26, 30, 34, 35, 43) that reported riboflavin intake, the range was 1.6-2.6 mg/day and the median was 2.0 mg/day.

Also for niacin, 10 studies (18, 21, 26, 30, 34, 35, 43) reported the intake. Intakes of 14.1, 20.6, and 42.4 mg NE/day corresponded to the minimum, the median, and the maximum, respectively. The lowest intake was reported by Leelahakul et al. for Thai mothers (21), the median was reported in the South Korean study of Choi et al. (43), and the maximum by Butts et al. (18) for New Zealand European mothers.

Only 3 studies reported vitamin B6 intake. Kresic et al. (20) showed an intake of 1.6 mg/day for Croatian mothers which was lower that the corresponding AR of 2.2 mg/day. Bzikowska-Jura et al. (35) reported an intake of 2.5 mg/day for Polish mothers, and Choi et al. (43) of 2.5 mg/day for South Korean mothers close to this recommendation.

Folate intake was reported by 7 studies (18, 20, 25, 35, 43). The minimum intake corresponding to 105 µg DFE/day was reported by Kresic et al. (20), the median (312 µg DFE/day) was reported by Caire-Juvera et al. (25), and the maximum (587 µg DFE/day) by Choi et al. (43).

Eleven studies (18, 21, 25, 26, 30, 34, 35, 43) provided intakes for vitamin C with a range of 84.4-178 mg/day and a median of 122 mg/day. As regards to the AR for vitamin C (145 mg/day), Leelahakul et al. (21) for Thai mothers and Butts et al. (18) for mothers of Maori and Pacific Islands ethnicity reported an intake far lower (i.e., 84.4 and 87.9 mg/day, respectively).

All vitamin D intakes of breastfeeding mothers included in the SR were considerably lower than the corresponding AI of 15 µg/day. Among the 6 studies (18, 20, 29, 35) that reported the intake of vitamin D, it ranged from 1.6 to 4.4 µg/day with a median of 3.1 µg/day.

Nine studies (18, 25, 32, 35, 43, 46, 49) provided vitamin E intake. The minimum intake of 3.2 mg α-TE/day was observed in the study of Iranpour et al. (46), the median intake of 10 mg α-TE/day was reported by Butts et al. for Maori and Pacific Island mothers, and the maximum intake of 27.9 mg α-TE/day by Choi et al. (43). The minimum and maximum intakes observed were far from the AI of 11 mg α-TE/day.

Seven studies gave intakes of β–carotene equivalents (18, 21, 43, 49). The intake ranged from 1240 to 6331 mg/day and the median was 3584 mg/day.

MEDIDIET study: participants' characteristics

Mothers participating in the MEDIDIET study were enrolled from the cities of Turin in Northern Italy (110 mothers), Florence and Rome in Central Italy (23 and 46 mothers, respectively), and San Giovanni Rotondo and Palermo in Southern Italy (101 and 20 mothers, respectively). The mean age was 33 ± 4.1 years and the mean pre-pregnancy BMI was 22.3 ± 3.22, data shown in (15).

MEDIDIET study: energy, macronutrients, cholesterol, and fiber

Figure 2 shows box-whiskers plots for energy (kcal/day) and macronutrient (expressed both in g/day and % En) intakes of studies included in the SR, the intake of MEDIDIET study, and the corresponding DRVs.

In the MEDIDIET study, the energy intake was 1950 kcal/day which corresponded to approximately the 25th percentile of the distribution among the included studies in the SR. This intake was close to that reported in the Greek study of Antonakou et al. (32) but was lower than other studies (20, 29, 50, 51) enrolling mothers in countries bordering the Mediterranean Sea. In addition, mothers participating in the MEDIDIET study showed an energy intake lower than the recommendation (AR=2300 kcal/day; figure 2.A).

Mothers participating in the MEDIDIET study had an intake of carbohydrates of 269.8 g/day which was close to the median intake (i.e., 270 g/day; figure 2.B) across studies included in the SR and close to intakes reported by Kresic et al. (20) and Scopesi et al. (51) for Croatian (261 g/day) and Italian (280 g/day) mothers, respectively. In addition, Spanish breastfeeding women in the study of Sanchez at al. (29) showed a carbohydrate intake slightly lower than mothers in the MEDIDIET study, whereas Italian women in the study of Giammarioli et al. (50) showed a higher intake. With 54.8% En, the MEDIDIET study showed an intake conforming to the RI (figure 2.C).

The protein intake was higher than the AR of 53.5 g/day but close to the median of the protein intake distribution (MEDIDIET=87.8 g/day vs median=85.4 g/day; figure 2.D) and similar to those (from 79.2 to 96.7 g/day) observed in countries belonging to the Mediterranean area (20, 29, 50, 51) (table 2). The protein intake expressed as % En was 18.2 peaking MEDIDIET study close to the maximum (figure 2.E).

With a fat intake of 65.6 g/day, MEDIDIET was lower than the 25th percentile of fat intake distribution and the lowest intake among Mediterranean studies (20, 29, 50, 51). In terms of % En, the intake of mothers participating in the MEDIDIET was 30.2% En conforming to the RI (figure 2.F).

The cholesterol intake was 298 mg/day which was lower than that reported by the Italian study of Giammarioli et al. (50) but slightly higher than the median (i.e., 276 mg/day) of the cholesterol intake distribution of the SR.

As regards to fiber, the MEDIDIET study showed an intake of 14.8 g/day which was below the AI of 25 g/day, the median intake distribution of 23.4 g/day observed in the SR, and the intake of 20 g/day reported by the Italian study of Giammarioli et al. (50).

MEDIDIET study: fatty acids

Italian mothers participating in the MEDIDIET study had an intake of SFA (23.5 g/day; table 3) far below the median of SFA intake distribution (33.7 g/day). In addition, MEDIDIET showed an intake of SFA considerably lower than those of other countries (20, 51) bordering the Mediterranean Sea i.e., 31.7 g/day in the study of Kresic et al. (20) and 41.0 g/day in the study of Scopesi et al. (51). Likewise, MUFA intake of 29.4 g/day was lower than the median of MUFA intake distribution (32.8 g/day) according to studies included in the SR and the lowest intake among Mediterranean studies (20, 51). In addition, the MEDIDIET study showed the lowest intake of PUFA (8.1 g/day) which was close to the Italian study of Scopesi et al. (8.6 g/day) (51), but far lower than 15.4 g/day observed in the Croatian study of Kresic et al. (20).

The MEDIDIET study showed the lowest intake for ω-6 fatty acids (6.7 g/day and 3.1 % En) and LA (6.4 g/day) compared to studies included in the SR (table 4). Conversely, with an intake of 0.26 g/day, Italian mothers showed an ARA intake considerably higher than other studies but far lower than that (1.10 g/day) reported by Barrera et al. (33) for Chilean mothers. The intake of ω-3 fatty acids of the MEDIDIET study was 1.4 g/day. In terms of % En, the intake was 0.7 close to the intake of 0.6 reported by Samur et al. (48). With 1.1 g/day, ALA intake was slightly lower than the intake reported by Scopesi et al. (51) (1.5 g/day) but close to the median of ALA intake distribution (1.2 g/day). The MEDIDIET study showed the highest values for EPA and DHA with intakes of 0.13

g/day (EPA) and 0.17 g/day (DHA). Interestingly, only mothers participating in the MEDIDIET study had intakes close to the recommendation for EPA and DHA (AI for EPA+DHA=0.25 g/day).

MEDIDIET study: minerals

The intake of calcium (792 mg/day; table 5) observed in the MEDIDIET study was in accordance to the corresponding AR of 805 mg/day. In addition, MEDIDIET study showed a calcium intake lower than those reported by Mediterranean studies of Kresic et al. (20) and Sanchez et al. (29). The intake of phosphorus was 1358 mg/day which was close to that reported by Kresic et al. (20) but lower than that of Sanchez et al. (29). Similar to studies included in the SR, also MEDIDIET study showed an intake considerably higher than the AI of 550 mg/day. As regards to potassium, in the MEDIDIET study the intake was 3304 mg/day which was higher than the median (3063 mg/day) of potassium intake distribution but lower than the AI (4000 mg/day). Mothers participating in the MEDIDIET study had the lowest intake of iron (10.8 mg/day), not so far from the intakes observed in the studies of Kresic et al. (20) and Sanchez et al. (29) (12.0 and 15.2 mg/day, respectively). However, the intake observed in the MEDIDIET study was higher than the AR for iron of 7 mg/day. With 11.4 mg/day, the intake of zinc was slightly higher than both the median observed in the SR (10.0 mg/day) and the corresponding recommendation (AR=10.6 mg/day). The intake of sodium for mothers participating in the MEDIDIET study was 1903 mg/day in accordance with the AI of 2000.0 mg/day.

MEDIDIET study: vitamins and β-carotene equivalent

Mothers of the MEDIDIET study showed an intake of vitamin A of 1143 μg RAE/day (table 6) which was close to the median intake distribution (1132 μg RAE/day) across studies included in the SR and close to the AR (1020 μg RAE/day). As regards to thiamin, the MEDIDIET study reported an intake of 1.0 mg/day which was the lowest intake compared to those in the SR but it was close to that reported by Kresic et al. (20) for Croatian mothers. Likewise, the riboflavin intake of 1.6 mg/day in the MEDIDIET study was the lowest intake; however, it was close to the corresponding AR of 1.7 mg/day. The intake of niacin equivalent for mothers participating in the MEDIDIET study was 18.9 mg/day that was close to the median of niacin equivalent intake distribution (20.6 mg/day). The MEDIDIET study showed a vitamin B6 intake of 2.2 mg/day close to those reported by Choi et al. (43) and Bzikowska-Jura et al. (35) (2.5 mg/day for both studies), but higher than that reported by Kresic et al. (20) (1.6 mg/day). The folate intake of 330 µg DFE/day was slightly higher than the median observed in SR of 312 µg DFE/day and slightly lower than the AR of 380 µg DFE/day. With 184 mg/day, the MEDIDIET study showed the highest intake of vitamin C. As regards to vitamin D, the MEDIDIET study showed an intake (2.6 mg/day) far below the AI=15 mg/day as observed for all studies included in the SR. However, this intake was in line with that (2.2 mg/day) reported by Sanchez et al. (29) for Spanish mothers and higher than that (1.6 mg/day) reported by Kresic et al. (20). Conversely, the intake of vitamin E was close to the recommendation (MEDIDET=9.9 mg α-TE/day; AI=11 mg α-TE/day). Lastly, the MEDIDIET study showed an intake of 4242 mg/day which was far higher than the median of β–carotene equivalent intake distribution (3584 mg/day).

Discussion

In this work, we reviewed the literature on energy, nutrient intakes, and food components of breastfeeding mothers in developed countries and also presented original results of the Italian MEDIDIET study within this reviewing framework. Although some differences in maternal nutrient intake emerged, likely depending on different dietary behaviours across geographical area, populations and over time, findings of the present SR showed a substantial agreement worldwide on nutritional intake levels and a good adherence to the corresponding DRVs. In particular, the intakes of energy, carbohydrates, and fats agreed with the recommendations, whereas protein intake was generally higher. In addition, our findings showed higher intakes for phosphorus, iron and vitamin B6 than the DRVs. Phosphorus intake was two- or three-fold higher than the AI of 550 mg/day. However, based on data from 13 dietary surveys conducted in 9 European Union Countries, EFSA reported a mean phosphorus intake range from 1000 to 1767 mg/day in adults aged >18 years (men and women combined) which is in line with our results (40). In addition, EFSA's scientific panel of experts concluded that the available data are not sufficient to establish a Tolerable Upper Intake Level and no adverse effect have been observed in longer term with dosages of phosphorus up to 3000 mg/day (53). All studies included in the SR showed an intake of iron higher than the AR. In particular, the study of Choi et al. (43) showed an intake of iron (23.2 mg/day) considerably higher than the AR as well as higher than the corresponding PRI of 16 mg/day. Few studies reported the intake of vitamin B6 which was slightly higher than the recommendation. Conversely, the intakes of potassium and vitamin D were lower than the DRVs (AIs of 4000 mg/day and 15 μg/day, respectively). Both cohort studies and randomised controlled trials suggested that an intake of potassium below 3500 mg/day was associated with adverse health outcomes, particularly cardiovascular diseases (54). Only few studies included in the SR (18, 26, 43) showed an intake of potassium higher than 3500 mg/day; whereas mothers participating in the MEDIDIET study were slightly lower than this threshold (3304.3 mg/day). Maternal vitamin D deficiency during lactation has been the subject of intensive research assessing the relationship between adequate vitamin D level in maternal serum and infant growth and development. Low vitamin D serum level of breastfeeding women is essentially related to lack of sun exposure and minimal intake of vitamin D from diet (55). In 2013, a SR of experimental studies showed a strong positive association between maternal vitamin D supplementation during lactation and infant serum 25-hydroxyvitamin D level. The authors concluded that "when maternal vitamin D is sufficient, vitamin D transfer via breast milk is adequate to meet infant needs" (56). Accordingly, it is recommended for women to continue to take a dietary vitamin D supplement while they are breastfeeding (57).

Nutrient intakes of mothers in the MEDIDIET study generally reflected the typical Mediterranean diet, a plant-based dietary pattern which is characterized by high consumption of vegetables, fruit and nuts, legumes, and unprocessed cereals; moderate consumption of fish and poultry; low consumption of red meat and dairy products; and olive oil as the principal source of fat

(58, 59). The intakes of carbohydrates and fats in the MEDIDIET study could be consistent with the Mediterranean diet according to the above definition. In contrast to this dietary pattern, the elevated intake of protein derived mainly from animal sources, especially the consumption of poultry and meat (data not shown). Moreover, the low intake of MUFA expressed in g/day was attributable to the low energy intake observed in the MEDIDIET study. In terms of % Fats, however, mothers in the MEDIDIET study showed the highest level of MUFA likely deriving from the high use of olive oil in the Mediterranean area. Olive oil is a rich source of MUFA typically in the form of oleic acid (60). Similar to MUFA, the low energy intake in the MEDIDIET study was also responsible for the low PUFA intake (g/day). Among the studies that reported PUFA, the lowest PUFA intake in the MEDIDIET study likely resulted in a moderate consumption of fish (data not shown), a rich source of ω-3 fatty acids. In addition, levels of ω-3 fatty acids are generally more elevated in fish from cold waters, such as oceans or the North Sea, than from warm waters of the Mediterranean Sea (61). Surprisingly, the MEDIDIET study showed the highest intake of EPA and DHA, and it was the only study in which EPA and DHA intakes were in line with the recommendation. Conversely, a recent review of studies reporting plasma levels of ω-3 fatty acids, DHA, and EPA in healthy adults found very low blood levels of DHA+EPA for Italy and in general for countries bordering the Mediterranean Sea compared with other geographic areas (62). Nevertheless, a French study showed a positive, although weak, correlation between DHA and EPA levels and adherence to the Mediterranean diet (63). As regards to mineral and vitamin intakes, mothers in the MEDIDIET study showed levels of these nutrients consistent with a typical Mediterranean diet (64). MEDIDIET showed the highest intake of vitamin C, but a direct comparison with studies belonging to the Mediterranean area was not possible because they did not report such intake. Nevertheless, the vitamin C intake observed for mothers participating in the MEDIDIET study was similar to the intake reported for non-pregnant and non-lactating women aged 20-50 years enrolled in the Mediterranean Healthy Eating, Ageing, and Lifestyle (MEAL) study (65). In addition, Castro-Quezada et al. (66) reviewed the evidence on nutritional adequacy of the Mediterranean diet and the Western dietary pattern showing that people who followed the Mediterranean pattern were more likely to achieve adequate intake of several micronutrients, including vitamin C. Although we did not formally assess the adherence to the Mediterranean diet using one of the proposed scores, nutritional intakes reported by mothers participating in the MEDIDIET study seemed to follow a typical Mediterranean nutritional profile.

The use of different tools for collecting dietary data (i.e., diary, dietary record, 24-h recall, and FFQ) among studies included in the SR could have impacted on maternal nutrient estimations introducing a bias in the comparison of nutrient intakes. Another limitation comprises the assessment of maternal diet in different time periods (e.g. 1st month, 3rd month, 6th month or later postpartum). Indeed, for studies comprised in the SR that have investigated the usual diet within same mothers at different time periods, we observed a decreasing amount of energy (slightly) and nutrient intakes from delivery onwards. We tried to mitigate this problem by putting together nutrient intakes for these studies in order to have a more stable estimation of usual maternal dietary intakes. With reference to the overall SD calculated for studies reporting maternal diet at different times, however, we introduced some bias because we could not take into account the within-subject correlation. Since higher within-subject correlation leads to lower variance, we overestimated the overall SD because we assumed independence (i.e., within-subject correlation equal to zero) (31). In addition, studies included in the present SR were conducted in a very wide interval time (i.e., the oldest was published in 1978 and the latest in 2018). It is well-known that dietary behaviours change over time introducing a further source of variability in the maternal nutrient intakes. The limited sample size (i.e., lower than 50) of several studies (18, 21, 23, 29, 34, 35, 41, 49) included in the SR should be counted as another limitation. In addition, some studies reported a SD for nutrient intake considerably lower or higher than those of the other studies. Different populations with different dietary behaviours could partially explain these different SDs, however, we cannot exclude some bias in collecting and reporting dietary information for these studies. Lastly, this SR provided detailed descriptions of macronutrient intakes of breastfeeding women according to available evidence. Nonetheless, the descriptions of other nutrient intakes were based on limited and scattered information. The same problem emerged in a previous review on maternal nutrition (13). Although including 36 studies, the authors were unable to draw a comprehensive picture because "the available data on this topic is scarce and diversified". As regards to the MEDIDIET study, the FFQ used to collect dietary information was validated in an Italian sample of healthy adult population which could substantially differ from lactating women population (i.e., it included men and women older than breastfeeding mothers) and this should be accounted as a limitation.

One of the strengths of the present SR was the comprehensive picture on the evaluation of maternal diet worldwide, especially for the intake of macronutrients. Second, we identified a well-defined study population, i.e., healthy breastfeeding mothers not following a specific or restricted diet with healthy infants born at term. Although we used in the MEDIDIET study an FFQ not specifically validated for lactating women, our research group investigated for long time Italian dietary behaviour in adults by means of this tool (67, 68), strengthening reliability of dietary information collected. Lastly, the relatively large sample size of the MEDIDIET study (i.e., 300 mothers) guaranteed a precise estimate of nutritional intakes.

Conclusions

This review showed that energy and nutrient intakes of breastfeeding mothers worldwide are generally in line with the DRVs despite different dietary patterns, nutritional sources, and foods consumed. Some nutritional deficiencies emerged highlighting the need for additional nutritional advice or strengthening the existing ones. Lastly, mothers in the MEDIDIET study follow the nutritional profile of the typical Mediterranean diet that is a well-known recommended dietary pattern. The adherence to this dietary pattern may not only be beneficial to the mother but may also play a positive influential role in the composition and quality of human milk and therefore for the infant growing.

Appendix

("maternal diet*" OR "mother* diet*" OR "maternal food*" OR "mother* food*" OR “maternal intake*” OR “mother* intake*” OR "maternal nutrition*" OR "mother* nutrition*" OR “maternal nutrient*” OR “mother* nutrient*”) AND (breastfeed* OR "breast feed*" OR breastfed* OR "breast fed*" OR lactat* OR "human milk" OR "breast milk" OR breastmilk OR "maternal milk" OR "mother* milk").

The following limits were applied. Publication date: 01/31/2020; species: Humans; language: English.

Acknowledgments

The authors wish to thank Prof. M. Parpinel for her valuable comments. The authors wish to thank Dr. Frank Wiens who was former project leader of the MEDIDIET study for Danone Nutricia Research.

Authors’ contributions

M.F. and E.V. designed the research. M.D.M., S.E., and M.F. conducted the research (reviewed the literature). M.D.M. analysed the data and performed statistical analysis. M.D.M wrote paper. M.D.M. had primary responsibility for the final content. M.F., E.S., C.A., and F.B. contributed to the results’ interpretation. G.M. directed data acquisition for the MEDIDIET study. P.T., P.A.Q., G.A., C.P., I.K. managed data acquisition for the MEDIDIET study.

All authors have read and approved the final version of the manuscript.

Full list of the MEDIDIET Working Group members includes also the following investigators (in alphabetical order): Ansaldi Giulia (Neonatal Care Unit of the University, City of Health and Science Hospital, Turin, Italy); Amadio Patrizia (Ospedale Pediatrico Bambino Gesù, Rome, Italy); Chester Elena (Neonatal Care Unit of the University, City of Health and Science Hospital, Turin, Italy); Di

Nicola Paola (Neonatal Care Unit of the University, City of Health and Science Hospital, Turin, Italy); Monzali Francesca (Azienda Ospedaliera Universitaria Meyer, Florence, Italy); Palumbo Giuseppina ("Casa Sollievo della Sofferenza" Foundation, San Giovanni Rotondo, Italy); Roselli Elena (Azienda Ospedaliera Universitaria Meyer, Florence, Italy); Siemens Louise (Ospedale Buccheri La Ferla, FBF, Palermo, Italy); Sottemano Stefano (Neonatal Care Unit of the University, City of Health and Science Hospital, Turin, Italy); Villani Antonio ("Casa Sollievo della Sofferenza" Foundation, San Giovanni Rotondo, Italy).

References

1. Hall Moran V, Lowe N, Crossland N, Berti C, Cetin I, Hermoso M, Koletzko B, Dykes F. Nutritional requirements during lactation. Towards European alignment of reference values: the EURRECA network. Matern Child Nutr. 2010 Oct;6 Suppl 2:39-54.
2. Cervera P, Ngo J. Dietary guidelines for the breast-feeding woman. Public Health Nutr. 2001 Dec;4:1357-62.
3. Picciano MF. Pregnancy and lactation: physiological adjustments, nutritional requirements and the role of dietary supplements. J Nutr. 2003 Jun;133:1997S-2002S.
4. Ares Segura S, Arena Ansotegui J, Diaz-Gomez NM, en representacion del Comite de Lactancia Materna de la Asociacion Espanola de P. [The importance of maternal nutrition during breastfeeding: Do breastfeeding mothers need nutritional supplements?]. An Pediatr (Barc). 2016 Jun;84:347 e1-7.
5. Subcommittee for a Clinical Application Guide, Committee on Nutritional Status During Pregnancy and Lactation, Food and Nutrition Board, Institute of Medicine, National Academy of Sciences. Nutrition during pregnancy and lactation. An implementation guide. Washington, DC: National Academy Press. 1992.
6. The Standing Committee on the Scientific Evaluation of Dietary Reference Intakes and its Panels on Folate, Other B Vitamins, Maternal nutrition needs during breastfeeding and Choline and Subcommittee on Upper Reference Levels of Nutrients, Food and Nutrition Board. Dietary reference intakes for thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid, biotin, and choline. Institute of Medicine Washington, DC: The National Academies Press. 1998.
7. Michaelsen KF, Larsen PS, Thomsen BL, Samuelson G. The Copenhagen Cohort Study on Infant Nutrition and Growth: breast-milk intake, human milk macronutrient content, and influencing factors. Am J Clin Nutr. 1994 Mar;59:600-11.

8. Picciano MF. Nutrient composition of human milk. Pediatr Clin North Am. 2001 Feb;48:53-67.

9. Baatenburg de Jong R, Bekhof J, Roorda R, Zwart P. Severe nutritional vitamin deficiency in a breast-fed infant of a vegan mother. Eur J Pediatr. 2005 Apr;164:259-60.

10. Specker BL, Black A, Allen L, Morrow F. Vitamin B-12: low milk concentrations are related to low serum concentrations in vegetarian women and to methylmalonic aciduria in their infants. Am J Clin Nutr. 1990 Dec;52:1073-6.

11. Weiss R, Fogelman Y, Bennett M. Severe vitamin B-12 deficiency in an infant associated with a maternal deficiency and a strict vegetarian diet. J Pediat Hematol Onc. 2004 Apr;26:270-1.

12. WHO. Good maternal nutrition: the best start in life. WHO Regional Office for Europe. 2016.

13. Bravi F, Wiens F, Decarli A, Dal Pont A, Agostoni C, Ferraroni M. Impact of maternal nutrition oh breast-milk composition: a systematic review. American Journal of Clinical Nutrition. 2016 Sep;104:646-62.

14. Atkinson SA, Koletzko B. Determining life-stage groups and extrapolating nutrient intake values (NIVs). Food Nutr Bull. 2007 Mar;28:S61-S76.

15. Moro GE, Bertino E, Bravi F, Tonetto P, Gatta A, Quitadamo PA, Salvatori G, Profeti C, Di Nicola P, Decarli A, et al. Adherence to the Traditional Mediterranean Diet and Human Milk Composition: Rationale, Design, and Subject Characteristics of the MEDIDIET Study. Front Pediatr. 2019;7:66.

16. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart LA, Group P-P. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev. 2015 Jan 1;4:1.

17. Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart LA, Group P-P. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ. 2015 Jan 2;350:g7647.

18. Butts CA, Hedderley DI, Herath TD, Paturi G, Glyn-Jones S, Wiens F, Stahl B, Gopal P. Human Milk Composition and Dietary Intakes of Breastfeeding Women of Different Ethnicity from the Manawatu-Wanganui Region of New Zealand. Nutrients. 2018 Sep 4;10.
19. Kim H, Kang S, Jung BM, Yi H, Jung JA, Chang N. Breast milk fatty acid composition and fatty acid intake of lactating mothers in South Korea. Br J Nutr. 2017 Feb;117:556-61.
20. Kresic G, Dujmovic M, Mandic ML, Redzic D. [Dietary intake of Croatian lactating women]. Croat J Food Sci Technol. 2012;4:46-53.
21. Leelahakul V, Tanaka F, Sinsuksai N, Vichitsukon K, Pinyopasakul W, Kido N, Inukai S. Comparison of the protein composition of breast milk and the nutrient intake between Thai and Japanese mothers. Nurs Health Sci. 2009 Jun;11:180-4.
22. Olafsdottir AS, Thorsdottir I, Wagner KH, Elmadfa I. Polyunsaturated fatty acids in the diet and breast milk of lactating icelandic women with traditional fish and cod liver oil consumption. Ann Nutr Metab. 2006;50:270-6.
23. Xiang M, Harbige LS, Zetterstrom R. Long-chain polyunsaturated fatty acids in Chinese and Swedish mothers: diet, breast milk and infant growth. Acta Paediatr. 2005 Nov;94:1543-9.
24. Bopp M, Lovelady C, Hunter C, Kinsella T. Maternal diet and exercise: effects on long-chain polyunsaturated fatty acid concentrations in breast milk. J Am Diet Assoc. 2005 Jul;105:1098-103.
25. Caire-Juvera G, Ortega MI, Casanueva E, Bolanos AV, de la Barca AM. Food components and dietary patterns of two different groups of Mexican lactating women. J Am Coll Nutr. 2007 Apr;26:156-62.
26. Finley DA, Dewey KG, Lonnerdal B, Grivetti LE. Food choices of vegetarians and nonvegetarians during pregnancy and lactation. J Am Diet Assoc. 1985 Jun;85:678-85.
27. Jiang JJ, Wu KJ, Yu ZX, Ren YP, Zhao YM, Jiang Y, Xu XF, Li W, Jin YX, Yuan J, et al. Changes in fatty acid composition of human milk over lactation stages and relationship with dietary intake in Chinese women. Food Funct. 2016;7:3154-62.

28. Mojska H, Socha P, Socha J, Soplinska E, Jaroszewska-Balicka W, Szponar L. Trans fatty acids in human milk in Poland and their association with breastfeeding mothers' diets. Acta Paediatr. 2003 Dec;92:1381-7.

29. Sanchez CL, Rodriguez AB, Sanchez J, Gonzalez R, Rivero M, Barriga C, Cubero J. [Analisi nutricional en el aporte del mineral calcio en mujeres con lactancia]. Archivios Latinoamericanos de nutrition. 2008;58:371-7.

30. Sims LS. Dietary status of lactating women. I. Nutrient intake from food and from supplements. J Am Diet Assoc. 1978 Aug;73:139-46.

31. Snedecor GW, Cochran WG. Statistical Methods, 8th Edition. West Press and Iowa: Iowa State University Press. 1991.

32. Antonakou A, Chiou A, Andrikopoulos NK, Bakoula C, Matalas AL. Breast milk tocopherol content during the first six months in exclusively breastfeeding Greek women. Eur J Nutr. 2011 Apr;50:195-202.

33. Barrera C, Valenzuela R, Chamorro R, Bascunan K, Sandoval J, Sabag N, Valenzuela F, Valencia MP, Puigrredon C, Valenzuela A. The Impact of Maternal Diet during Pregnancy and Lactation on the Fatty Acid Composition of Erythrocytes and Breast Milk of Chilean Women. Nutrients. 2018 Jun 28;10.

34. Butte NF, Garza C, Stuff JE, Smith EO, Nichols BL. Effect of maternal diet and body composition on lactational performance. Am J Clin Nutr. 1984 Feb;39:296-306.

35. Bzikowska-Jura A, Czerwonogrodzka-Senczyna A, Oledzka G, Szostak-Wegierek D, Weker H, Wesolowska A. Maternal Nutrition and Body Composition During Breastfeeding: Association with Human Milk Composition. Nutrients. 2018 Sep 27;10.

36. Celebrating The Innocenti Declaration on the Protection, Promotion and Support of Breastfeeding : Past Achievements, Present Challenges and Priority Actions for Infant and Young Child Feeding. Florence: UNICEF Innocenti Research Centre. 2006.

37. Decarli A, Franceschi S, Ferraroni M, Gnagnarella P, Parpinel MT, La Vecchia C, Negri E, Salvini S, Falcini F, Giacosa A. Validation of a food-frequency questionnaire to assess dietary intakes in cancer studies in Italy. Results for specific nutrients. Ann Epidemiol. 1996 Mar;6:110-8.

38. Franceschi S, Barbone F, Negri E, Decarli A, Ferraroni M, Filiberti R, Giacosa A, Gnagnarella P, Nanni O, Salvini S, et al. Reproducibility of an Italian food frequency questionnaire for cancer studies. Results for specific nutrients. Ann Epidemiol. 1995 Jan;5:69-75.

39. Gnagnarella P, Parpinel M, Salvini S, Franceschi S, Palli D, Boyle P. The update of the Italian Food Composition Database. J Food Compos Anal. 2004 Jun-Aug;17:509-22.

40. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). Dietary Reference Values for nutrients. Summary Report; 2017.

41. Stuff JE, Garza C, Smith EO, Nichols BL, Montandon CM. A comparison of dietary methods in nutritional studies. Am J Clin Nutr. 1983 Feb;37:300-6.

42. da Cunha J, Macedo da Costa TH, Ito MK. Influences of maternal dietary intake and suckling on breast milk lipid and fatty acid composition in low-income women from Brasilia, Brazil. Early Hum Dev. 2005 Mar;81:303-11.

43. Choi YK, Kim JM, Lee JE, Cho MS, Kang BS, Choi H, Kim Y. Association of Maternal Diet With Zinc, Copper, and Iron Concentrations in Transitional Human Milk Produced by Korean Mothers. Clin Nutr Res. 2016 Jan;5:15-25.

44. Quinn EA, Largado F, Power M, Kuzawa CW. Predictors of breast milk macronutrient composition in Filipino mothers. Am J Hum Biol. 2012 Jul-Aug;24:533-40.

45. Tiangson CL, Gavino VC, Gavino G, Panlasigui LN. Docosahexaenoic acid level of the breast milk of some Filipino women. Int J Food Sci Nutr. 2003 Sep;54:379-86.

46. Iranpour R, Kelishadi R, Babaie S, Khosravi-Darani K, Farajian S. Comparison of long chain polyunsaturated fatty acid content in human milk in preterm and term deliveries and its correlation with mothers' diet. J Res Med Sci. 2013 Jan;18:1-5.

47. Kelishadi R, Hadi B, Iranpour R, Khosravi-Darani K, Mirmoghtadaee P, Farajian S, Poursafa P. A study on lipid content and fatty acid of breast milk and its association with mother's diet composition. Journal of Research in Medical Sciences. 2012 Sep;17:824-7.

48. Samur G, Topcu A, Turan S. Trans fatty acids and fatty acid composition of mature breast milk in turkish women and their association with maternal diet's. Lipids. 2009 May;44:405-13.

49. Duda G, Nogala-Kalucka M, Karwowska W, Kupczyk B, Lampart-Szczapa E. Influence of the lactating women diet on the concentration of the lipophilic vitamins in human milk. Pak J Nutr. 2009;8:629-43.

50. Giammarioli S, Sanzini E, Ambruzzi AM, Chiarotti F, Fasano G. Nutrient intake of Italian women during lactation. Int J Vitam Nutr Res. 2002 Oct;72:329-35.

51. Scopesi F, Ciangherotti S, Lantieri PB, Risso D, Bertini I, Campone F, Pedrotti A, Bonacci W, Serra G. Maternal dietary PUFAs intake and human milk content relationships during the first month of lactation. Clin Nutr. 2001 Oct;20:393-7.

52. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). Agostoni C, Bresson JL, Fairweather-Tait S, Flynn A, Golly I, Korhonen H, Lagiou P, Løvik M, Marchelli R, Martin A, et al. Scientific opinion on dietary reference values for protein. EFSA Journal. 2012;10:2257.

53. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). Agostoni C, Berni Canani R, S Fairweather-Tait S, Heinonen M, Korhonen H, La Vieille S, Marchelli R, Martin A, Naska A, Neuhäuser-Berthold M, et al. Scientific opinion on dietary reference values for phosphorus. EFSA Journal. 2015;13:4185.

54. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). Turck D, Bresson JL, Burlingame B, Dean T, Fairweather-Tait S, Heinonen M, Ildico Hirsch-Ernst K, Mangelsdorf I, McArdle H, Neuh M. Dietary reference values for potassium. EFSA Journal. 2016;14:4592.

55. Wagner CL, Taylor SN, Johnson DD, Hollis BW. The role of vitamin D in pregnancy and lactation: emerging concepts. Womens Health (Lond). 2012 May;8:323-40.

56. Thiele DK, Senti JL, Anderson CM. Maternal vitamin D supplementation to meet the needs of the breastfed infant: a systematic review. J Hum Lact. 2013 May;29:163-70.

57. Kominiarek MA, Rajan P. Nutrition Recommendations in Pregnancy and Lactation. Med Clin N Am. 2016 Nov;100:1199-+.

58. Trichopoulou A, Martinez-Gonzalez MA, Tong TYN, Forouhi NG, Khandelwal S, Prabhakaran D, Mozaffarian D, de Lorgeril M. Definitions and potential health benefits of the Mediterranean diet: views from experts around the world. Bmc Med. 2014 Jul 24;12.

59. Willett WC, Sacks F, Trichopoulou A, Drescher G, Ferroluzzi A, Helsing E, Trichopoulos D. Mediterranean Diet Pyramid - a Cultural Model for Healthy Eating. American Journal of Clinical Nutrition. 1995 Jun;61:1402s-6s.

60. Olives and Olive Oil in Health and Disease Prevention. Olives and Olive Oil in Health and Disease Prevention. 2010:1-1479.

61. Galli C, Marangoni F. N-3 fatty acids in the Mediterranean diet. Prostag Leukotr Ess. 2006 Sep;75:129-33.

62. Stark KD, Van Elswyk ME, Higgins MR, Weatherford CA, Salem N. Global survey of the omega-3 fatty acids, docosahexaenoic acid and eicosapentaenoic acid in the blood stream of healthy adults. Prog Lipid Res. 2016 Jul;63:132-52.

63. Feart C, Peuchant E, Letenneur L, Samieri C, Montagnier D, Fourrier-Reglat A, Barberger-Gateau P. Plasma eicosapentaenoic acid is inversely associated with severity of depressive symptomatology in the elderly: data from the Bordeaux sample of the Three-City Study. American Journal of Clinical Nutrition. 2008 May;87:1156-62.

64. The Mediterranean Diet. An Evidence-Based Approach, Second Edition; 2020.

65. Castiglione D, Platania A, Conti A, Falla M, D'Urso M, Marranzano M. Dietary Micronutrient and Mineral Intake in the Mediterranean Healthy Eating, Ageing, and Lifestyle (MEAL) Study. Antioxidants-Basel. 2018 Jul;7.

66. Castro-Quezada I, Roman-Vinas B, Serra-Majem L. The Mediterranean Diet and Nutritional Adequacy: A Review. Nutrients. 2014 Jan;6:231-48.

67. Di Maso M, Talamini R, Bosetti C, Montella M, Zucchetto A, Libra M, Negri E, Levi F, La Vecchia C, Franceschi S, et al. Red meat and cancer risk in a network of case-control studies focusing on cooking practices. Ann Oncol. 2013 Dec;24(12):3107-12.

68. Bosetti C, Filomeno M, Riso P, Polesel J, Levi F, Talamini R, Montella M, Negri E, Franceschi S, La Vecchia C. Cruciferous vegetables and cancer risk in a network of case-control studies. Ann Oncol. 2012 Aug;23(8):2198-2203.

Table 1 Characteristics of observational studies included in the systematic review on nutrient intakes of breastfeeding mothers.

Author, year	Country	Study design	Participants, n Age[1], y	Tool used for diet assessment	Nutrient intake, unit/day
North America					
Bopp et al., 2005 (24)	US	Cross-sectional	23 mothers with a low physical activity Age: mean ± SD=31.5 ± 4.8; 30 mothers with a consistent physical activity Age: mean ± SD=31.5 ± 3.3	3 days diary at 12 weeks postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), LA (g), ARA (g), ALA (g), EPA (g), and DHA (g)
Butte et al., 1984 (34)	US	Longitudinal	45 mothers at 1, 2, 3, and 4 months postpartum Age: mean ± SD=28.0 ± 3.1	3 consecutive dietary record (2 weekdays and 1 weekend day) at 1, 2, 3, and 4 months postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), calcium (mg), phosphorus (mg), iron (mg), vitamin A – retinol equivalent (µg RAE), thiamin (mg), riboflavin (mg), niacin (mg), and vitamin C (mg)
Finley et al., 1985 (26)	US	Longitudinal	60 mothers Age: mean=29.0	A 24-h dietary recall at the enrolment (in the first 2 months postpartum) and 2-day diet record monthly (up to 18 months postpartum)	Energy (kcal), carbohydrates (g), proteins (g), fats (g), fibers (g), calcium (mg), phosphorus (mg), potassium (mg), iron (mg), sodium (mg), vitamin A – retinol equivalent (µg RAE), thiamin (mg), riboflavin (mg), niacin equivalent (mg NE), and vitamin C (mg)
Sims, 1978 (30)	US	Cross-sectional	61 mothers at 1-6 months postpartum Age: mean=28.0 (50 mothers taking supplements 11 mothers taking no supplements)	3-day dietary record administered by mail	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), calcium (mg), iron (mg), vitamin A – retinol equivalent (mg), thiamin (mg), riboflavin (mg), niacin equivalent (mg NE), and vitamin C (mg)
Stuff et al., 1983 (41)	US	Cross-sectional	40 mothers at 3-6 weeks postpartum Age: not reported	7-day dietary record and an FFQ at 3-6 months postpartum	Energy (kcal), carbohydrates (g), proteins (g), fats (g), calcium (mg), phosphorus (mg), and iron (mg)
Central and South America					
Barrera et al., 2018 (33)	Chile	Longitudinal	50 pregnant mothers at 22-25 weeks of gestation Age: 20-33; mean ± SD=29.4 ± 6.2	FFQ administered by trained dietitians at 1 and 6 months postpartum	Energy (kcal), carbohydrates (g), proteins (g), fats (g), fibers (g), SFA (g), MUFA (g), PUFA(g), ω-6 fatty acids (g), LA (g), ARA (g), ω-3 fatty acids (g), ALA (g), EPA (g), and DHA (g)
Caire-Juvera et al., 2007 (25)	Mexico	Cross-sectional	60 mothers at 1-2 days postpartum Age: 15-35; mean ± SD=19.8 ± 4.4	Two 24-h recalls administered by interviewers at 15-30 days postpartum	Energy (kcal), carbohydrates (g), proteins (g), fats (g), cholesterol (mg), fibers (g), SFA (g), MUFA (g), PUFA (g), calcium (mg), potassium (mg), iron (mg), zinc (mg), sodium (mg), vitamin A – retinol equivalent (µg RAE), folate (µg DFE), vitamin C (mg), and vitamin E (mg α-TE)

da Cunha et al., 2005 (42)	Brazil	Cross-sectional	77 mothers at 15 days postpartum Age: 18-39; mean ± SD =23.6 ± 4.5	24-h dietary recall at 15 ± 1 days postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), and fats (g and % En)
Oceania					
Butts et al., 2018 (18)	New Zealand	Cross-sectional	17 Maori and Pacific Island mothers at 6-8 weeks postpartum; Age: 19-42; mean ± SD=31.2 ± 1.5	3-day food diaries (2 week days and 1 weekend day) at 6-8 weeks postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), cholesterol (mg), fibers (g), SFA (g, % Fats, and % En), MUFA (g and % Fats), PUFA (g and % Fats), calcium (mg), phosphorus (mg), potassium (mg), iron (mg), zinc (mg), sodium (mg), vitamin A – retinol equivalent (μg RAE), thiamin (mg), riboflavin (mg), niacin equivalent (mg NE), folate (μg DFE), vitamin C (mg), vitamin D (μg), vitamin E (mg α-TE), and β-carotene equivalents (μg)
Asia					
Butts et al., 2018 (18)	New Zealand	Cross-sectional	8 Asian mothers at 6-8 weeks postpartum; Age: 19-42; mean ± SD=30.4 ± 1.2	3-day food diaries (2 week days and 1 weekend day) at 6-8 weeks postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), cholesterol (mg), fibers (g), SFA (g, % Fats, and % En), MUFA (g and % Fats), PUFA (g and % Fats), calcium (mg), phosphorus (mg), potassium (mg), iron (mg), zinc (mg), sodium (mg), vitamin A – retinol equivalent (μg RAE), thiamin (mg), riboflavin (mg), niacin equivalent (mg NE), folate (μg DFE), vitamin C (mg), vitamin D (μg), vitamin E (mg α-TE), and β-carotene equivalents (μg)
Choi et al., 2016 (43)	South Korea	Cross-sectional	96 mothers at 5-15 days postpartum Age: mean ± SD=31.8 ± 3.9	3-day dietary record	Energy (kcal), carbohydrates (g), proteins (g), fats (g), cholesterol (mg), fibers (g), calcium (mg), phosphorus (mg), potassium (mg), iron (mg), zinc (mg), sodium (mg), vitamin A – retinol equivalent (μg RAE), thiamin (mg), riboflavin (mg), niacin equivalent (mg NE), vitamin B6 (mg), folate (μg DFE), vitamin C (mg), vitamin E (mg α-TE), and β-carotene equivalent (μg)
Jiang et al., 2016 (27)	China	Longitudinal	202 mothers from Hangzhou; 133 mothers from Bejing; 142 mothers from Lanzhou Age: mean ± SD=28.3 ± 3.6	Three self-administered 24-h dietary recall at 1, 14, and 42 days postpartum	Energy (kcal), carbohydrate (% En), proteins (% En), and fats (% En)
Kim et al., 2017 (19)	South Korea	Cross-sectional	238 mothers Age: 21-45; mean ± SD=31.6 ± 3.2	A food record for 3 consecutive days (2 weekdays and 1 weekend day). This dietary protocol was completed before and after 1 week of milk collection	Energy (kcal), carbohydrates (g), proteins (g), fats (g), cholesterol (mg), SFA (g), MUFA (g), PUFA (g), ω-6 fatty acids (g), ARA (g), ω-3 fatty acids (g), EPA (g), and DHA (g)

Leelahakul et al., 2009 (21)	Japan and Thailand	Cross-sectional	14 Japanese mothers in postpartum period Age: mean ± SD=30.5 ± 4.9	24-h dietary records at 2-4 days postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), cholesterol (mg), fibers (g), vitamin A – retinol equivalent (µg RAE), thiamin (mg), riboflavin (mg), niacin equivalent (mg NE), vitamin C (mg), calcium (mg), phosphorus (mg), potassium (mg), iron (mg), zinc (mg), sodium (mg), and β-carotene equivalent (µg)
Leelahakul et al., 2009 (21)	Japan and Thailand	Cross-sectional	15 Thai mothers in postpartum period Age: mean ± SD=26.0 ± 5.4	24-h dietary records at 2-4 days postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), cholesterol (mg), fibers (g), vitamin A – retinol equivalent (µg RAE), thiamin (mg), riboflavin (mg), niacin equivalent (mg NE), vitamin C (mg), calcium (mg), phosphorus (mg), potassium (mg), iron (mg), zinc (mg), sodium (mg), and β-carotene equivalent (µg)
Quinn et al., 2012 (44)	Philippines	Cross-sectional	102 mothers who breastfed less than 18 months Age: 23-24; mean ± SD=23.8 ± 0.3	A single dietary recall with measuring cups to prompt portion sizes	Energy (kcal), carbohydrates (% En), proteins (% En), and fats (% En)
Tiangson et al., 2003 (45)	Philippines	Cross-sectional	100 mothers at 2-4 months postpartum Age: 16-40; mean ± SD=28.4 ± 6.0	3-day dietary record at 2-4 months postpartum (2 weekdays and 1 weekend day) and an FFQ at 2-4 months postpartum	Energy (kcal), carbohydrates (g), proteins (g), and fats (g)
Xiang et al., 2005 (23)	China and Sweden	Cross-sectional	23 Chinese mothers at 3 months postpartum Age: mean ± SD=27.4 ± 0.8	3-day dietary record at 3 months postpartum	Energy (kcal), carbohydrates (g), proteins (g), fats (g), SFA (g), MUFA (g), PUFA (g), ω-6 fatty acids (g), LA (g), ARA (g), ω-3 fatty acids (g), ALA (g), EPA (g), and DHA (g)
Middle East					
Iranpour et al., 2013 (46)	Iran	Cross-sectional	59 mothers Age: 18-30	A questionnaire at 3 days postpartum assessing diet of the previous day	Energy (kcal), carbohydrates (g), proteins (g), fats (g), cholesterol (g), SFA (g), MUFA (g), PUFA (g), LA (g), ALA (g), EPA (g), DHA (g), and vitamin E (mg α-TE)
Kelishadi et al., 2012 (47)	Iran	Cross-sectional	86 mothers at 8-72 hours after delivery Age: mean ± SD=28.4 ± 5.6	1-day food record questionnaire at 8-72 hours postpartum	Energy (kcal), carbohydrates (g), proteins (g), fats (g), cholesterol (mg), SFA (g), MUFA (g), PUFA (g), LA (g), EPA (g), and DHA (g)
Samur et al., 2009 (48)	Turkey	Cross-sectional	50 mothers at 12-16 weeks postpartum Age: 17-39; mean ± SD=26.2 ± 5.5	3-day dietary record at 12-16 weeks postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), SFA (g and % Fats), MUFA (g and % Fats), PUFA (g and % Fats), ω-6 (% En), LA (g), ω-3 (% En), and ALA (g)
North and Central Europe					

Butts et al., 2018 (18)	New Zealand	Cross-sectional	53 New Zealand European mothers at 6-8 weeks postpartum Age: 19-42; mean ± SD=30.7 ± 0.7	3-day food diaries (2 week days and 1 weekend day) at 6-8 weeks postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), cholesterol (mg), fibers (g), SFA (g, % Fats, and % En), MUFA (g and % Fats), PUFA (g and % Fats), calcium (mg), phosphorus (mg), potassium (mg), iron (mg), zinc (mg), sodium (mg), vitamin A – retinol equivalent (µg RAE), thiamin (mg), riboflavin (mg), niacin equivalent (mg NE), folate (µg DFE), vitamin C (mg), vitamin D (µg), vitamin E (mg α-TE), and β-carotene equivalents (µg)
Bzikowska-Jura et al., 2018 (35)	Poland	Longitudinal	40 mothers at 1 month postpartum Age: mean ± SD=31.1 ± 4.4	3-day self-administered dietary record checked by a qualified dietitian at 1 (n=40), 3 (n=22), and 6 (n=15) months postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), cholesterol (mg), fibers (g), SFA (g), MUFA (g), PUFA (g), calcium (mg), phosphorus (mg), potassium (mg), iron (mg), zinc (mg), sodium (mg), vitamin A – retinol equivalent (µg RAE), thiamin (mg), riboflavin (mg), niacin equivalent (mg NE), vitamin B6 (mg), folate (µg DFE), vitamin C (mg), vitamin D (µg), and vitamin E (mg α-TE)
Duda et al., 2009 (49)	Poland	Cross-sectional	30 mothers at 1-12 months postpartum Age: 25-37; mean ± SD=28.7 ± 3.0	24-h dietary recall administered by expert interviews for 3 consecutive days at 1-12 months postpartum	Energy (kcal), carbohydrates (g), proteins (g), fats (g), cholesterol (mg), fibers (g), SFA (g), MUFA (g), PUFA (g), vitamin A – retinol equivalent (µg RAE), vitamin E (mg α-TE), and β-carotene equivalent (µg)
Mojska et al., 2003 (28)	Poland	Longitudinal	34 mothers enrolled at delivery in Spring season Age: mean ± SD=26.2 ± 3.9; 35 mothers enrolled at delivery in Autumn season Age: mean ± SD=26.2 ± 4.3	7-day dietary record at 9-10 weeks postpartum	Energy (kcal), carbohydrates (g), proteins (g), fats (g), SFA (% En), MUFA (% En), and PUFA (% En)
Olafsdottir et al., 2006 (22)	Iceland	Cross-sectional	77 mothers at 2-4 months postpartum Age: mean ± SD=31.0 ± 4.0 (18 mothers consuming cod liver oil; 59 mothers not consuming cod liver oil)	24-h dietary recall at 2-4 months postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), SFA (g and % En), MUFA (g and % En), and PUFA (g and % En)
Xiang et al., 2005 (23)	China and Sweden	Cross-sectional	17 Swedish mothers at 3 months postpartum Age: mean ± SD=29.5 ± 1.0	3-day dietary record at 3 months postpartum	Energy (kcal), carbohydrates (g), proteins (g), fats (g), SFA (g), MUFA (g), PUFA (g), ω-6 fatty acids (g), LA (g), ARA (g), ω-3 fatty acids (g), ALA (g), EPA (g), and DHA (g)
South Europe/Mediterranean area					

Antonakou et al., 2011 (32)	Greece	Longitudinal	64 mothers at 1 month postpartum; 39 mothers at 3 months postpartum; 23 mothers at 6 months postpartum Age: 25-39; mean ± SD=32.5 ± 3.1	3-day dietary record (2 consecutive weekdays and 1 weekend day) at 1, 3, and 6 months postpartum reviewed by an expert	Energy (kcal), carbohydrates (% En), proteins (% En), fats (% En), SFA (% Fats), MUFA (% Fats), PUFA (% Fats), and vitamin E (mg α-TE)
Giammarioli et al., 2002 (50)	Italy	Cross-sectional	125 mothers Age: 27-36; mean ± SD=31.3 ± 4.5	Two self-administrated consecutive 24-h dietary recall	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), cholesterol (mg), fibers (g), SFA (% En), and PUFA (% En)
Kresic et al., 2012 (20)	Croatia	Longitudinal	83 mothers at 1, 3, and 6 months postpartum Age: 19-40	Two consecutive 24-h dietary recall at 1, 3, and 6 months postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), SFA (g and % En), MUFA (g and % En), PUFA (g and % En), calcium (mg), phosphorus (mg), iron (mg), zinc (mg), vitamin A – retinol equivalent (µg RAE), thiamin (mg), vitamin B6 (mg), folate (µg DFE), and vitamin D (µg)
Sanchez et al., 2008 (29)	Spain	Cross-sectional	39 mothers at 1 month postpartum Age: 18-40; mean ± SD=34.3 ± 5.2	24-h dietary recall at 1 month postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), fats (g and % En), calcium (mg), phosphorus (mg), iron (mg), and vitamin D (µg)
Scopesi et al., 2001 (51)	Italy	Cross-sectional	34 mothers at delivery were consecutively enrolled Age: 25-35	Food records at 1 day postpartum, and 4, 7, 14, 21, and 28 days after colostrum appearance	Energy (kcal), carbohydrates (g), proteins (g), fats (g), SFA (g), MUFA (g), PUFA (g). LA (g), and ALA (g)

Abbreviations: % En, % of total energy; % Fats, % of total fats; α-TE, α-tocopherol; ω-3 fatty acids, omega-3 fatty acids; ω-6 fatty acids, omega-6 fatty acids; ALA, α-linolenic acid; ARA, arachidonic acid; DFE, dietary folate equivalent; LA, linoleic acid; NE, niacin equivalent; RAE, retinol activity equivalent.

[1]Values are mean or mean ± SD.

Table 2 Energy, macronutrient, cholesterol and fiber intakes of breastfeeding mothers of studies included in the systematic review and in the MEDIDIET study.

Author, year	**Participants, n**	**Energy**	**Carbohydrates**		**Proteins**		**Fats**		**Cholesterol**	**Fibres**
		kcal/day[1]	**g/day[1]**	**% En[1]**	**g/day[1]**	**% En[1]**	**g/day[1]**	**% En[1]**	**mg/day[1]**	**g/day[1]**
North America										
Bopp et al., 2005 (24)	53	2200 ± 527	309 ± 84.9	55.6 ± 8.8	83.9 ± 20	15.6 ± 5.2	73.8 ± 26	30.3 ± 5.2	-	-
Butte et al., 1984 (34)	45	2182 ± 563	265 ± 72.2	46.3 ± 6.8	91.4 ± 25.3	17 ± 3.5	89.5 ± 30.6	36.7 ± 5.3	-	-
Finley et al., 1985 (26)	60	2200 ± 587	274 ± 89	-	86 ± 30	-	88 ± 32	-	-	7.4 ± 4.2
Sims, 1978 (30)	61	2076 ± 525	215 ± 55	41.7 ± 5.4	86 ± 27	16.7 ± 3.7	99 ± 31	42.3 ± 5.6	-	-
Stuff et al., 1983 (41)	40	2206 ± 478	247 ± 77	-	93.7 ± 20	-	88.7 ± 34.1	-	-	-
Central and South America										
Barrera et al., 2018 (33)	50	2134 ± 255	270 ± 58.6	-	84 ± 31.2	-	84.5 ± 27.5	-	-	24 ± 10.1
Caire-Juvera et al., 2007 (25)	60	2325 ± 1267	291 ± 126	-	89 ± 60	-	94.9 ± 68.4	-	563 ± 754	25.5 ± 17.5
da Cuhna et al., 2005 (42)	77	1816 ± 651	218 ± 89	49.5 ± 10.1	70 ± 32	16.3 ± 5.8	69 ± 31	34.1 ± 9	-	-
Oceania										
Butts et al., 2018 (18), Maori & PI	17	2145 ± 577	244 ± 78.3	44.9 ± 5.4	82.5 ± 20.6	15.8 ± 2.1	88.9 ± 24.7	36.6 ± 4.5	286 ± 128	26 ± 8.3
Asia										
Butts et al., 2018 (18), Asian	8	2390 ± 816	275 ± 102	45.8 ± 6.8	85.4 ± 17.8	15.3 ± 3.1	100 ± 39.6	36.4 ± 6.2	313 ± 90.5	33.6 ± 16.4
Choi et al., 2016 (43)	96	2092 ± 315	325 ± 292	-	91.5 ± 18.3	-	74.5 ± 33.6	-	405 ± 1116	31.6 ± 7
Jiang et al., 2016 (27)	477	1659 ± 300	-	65.5 ± 7.9	-	18.4 ± 2.4	-	15.5 ± 2.1	-	-
Kim et al., 2017 (19)	238	1952 ± 422	285 ± 64.5	-	77.8 ± 21.2	-	57.2 ± 18.9	-	68.7 ± 54.1	-
Leelahakul et al., 2009 (21), Japanese	14	2098 ± 213	325 ± 30.7	61.9 ± 1.3	83.1 ± 9.3	15.8 ± 0.6	52.1 ± 7.3	22.3 ± 1.4	276 ± 48.3	17.5 ± 1.9
Leelahakul et al., 2009 (21), Thai	15	2070 ± 290	266 ± 42.5	51.3 ± 3.4	78.9 ± 9.8	15.4 ± 2.2	77 ± 14.2	33.3 ± 2.7	235 ± 85.2	11.1 ± 2.5
Quinn et al., 2012 (44)	102	1411 ± 720	-	50 ± 10	-	19.3 ± 5	-	19.3 ± 13	-	-
Tiangson et al., 2003 (45)	100	1949 ± 416	316 ± 86.6	-	63.8 ± 25	-	51.5 ± 21.1	-	-	-
Xiang et al., 2005 (23), Chinese	23	2016 ± 427	342 ± 74.3	-	58.6 ± 16.8	-	47.5 ± 24	-	-	-
Middle East										
Iranpour et al., 2013 (46)	59	1945 ± 262	288 ± 85.9	-	86.2 ± 28.3	-	55.7 ± 24.3	-	255 ± 146	-
Kelishadi et al., 2012 (47)	86	1948 ± 648	315 ± 226	-	84.9 ± 30.7	-	56.9 ± 25.8	-	252 ± 148	-
Samur et al., 2009 (48)	50	1939 ± 555	241 ± 85.9	50.7 ± 8.4	70.9 ± 31.6	14.8 ± 4.6	74.2 ± 26.5	34.5 ± 7.6	-	-
North and Central Europe										
Butts et al., 2018 (18), NZ European	53	2418 ± 496	272 ± 72.8	44.2 ± 6.6	97.8 ± 21.8	16.6 ± 2.9	99.2 ± 27.7	36.1 ± 5.8	301 ± 109	27.1 ± 8.6
Bzikowska-Jura et al., 2018 (35)	40	1783 ± 448	250 ± 64.9	52 ± 6.9	74.7 ± 20.5	17 ± 3.1	62.7 ± 21.6	31 ± 6.1	259 ± 125	21.6 ± 7.9
Duda et al., 2009 (49)	30	2576 ± 803	366 ± 132	-	92.8 ± 28.9	-	91.1 ± 33.6	-	479 ± 271	23.4 ± 9.4
Mojska et al., 2003 (28)	69	2693 ± 651	362 ± 92.1	-	91.7 ± 18.9	-	107 ± 31	-	-	-
Olafsdottir et al., 2006 (22)	77	2314 ± 746	267 ± 109	45.8 ± 8.5	93 ± 26	16.8 ± 4.6	97 ± 38	37.5 ± 8	-	-
Xiang et al., 2005 (23), Swedish	17	2781 ± 862	352 ± 144	-	111 ± 38.8	-	102 ± 32.2	-	-	-
South Europe/Mediterranean area										
Antonakou et al., 2011 (32)	64	1994 ± 518	-	45.2 ± 6.9	-	15.7 ± 3.2	-	38.5 ± 6.7	-	-
Giammarioli et al., 2002 (50)	125	2365 ± 597	324 ± 94.4	52 ± 6.6	91.3 ± 27.6	15.5 ± 2.9	82.4 ± 24.9	31.8 ± 5.8	362 ± 191	20 ± 6.5
Kresic et al., 2012 (20)	83	2112 ± 588	261 ± 77.1	50.7 ± 6.6	79.2 ± 24.2	13.8 ± 3.5	79.9 ± 22.6	36 ± 6.4	-	-
Sanchez et al., 2008 (29)	39	2341 ± 624	207 ± 40.2	41.1 ± 7.1	96.7 ± 31.1	16.5 ± 5.2	110 ± 18.1	42.4 ± 7.1	-	-
Scopesi et al., 2001 (51)	34	2365 ± 645	280 ± 89.6	-	90.4 ± 28.4	-	97.1 ± 30.4	-	-	-
MEDIDIET, Moro et al.	300	1950 ± 445	270 ± 69.4	54.8 ± 5.9	87.8 ± 20.1	18.2 ± 2.3	65.6 ± 18.9	30.2 ± 4.8	298 ± 84.9	14.8 ± 5[2]
EFSA's DRVs, 2017 (40)		AR=2300	-	RI=45-60	AR=53.5; PRI=68	-	-	AR=20-35	-	AI=25

Abbreviations: % En, % of total energy; AI, adequate intake; AR, average requirement; DRVs, Dietary reference values; EFSA, European Food Safety Authority; PRI, population reference intake, RI, reference intake range.

[1]Values are mean ± SD.

[2]Calculated according to the Englyst method.

Table 3 Fatty acid intakes of breastfeeding mothers of studies included in the systematic review and in the MEDIDIET study.

Author, year	Participants, n	SFA			MUFA			PUFA		
-----		g/day[1]	% Fats[1]	% En[1]	g/day[1]	% Fats[1]	% En[1]	g/day[1]	% Fats[1]	% En[1]
North America										
Bopp et al., 2005 (24)	53	-	-	-	-	-	-	-	-	-
Butte et al., 1984 (34)	45	-	-	-	-	-	-	-	-	-
Finley et al., 1985 (26)	60	-	-	-	-	-	-	-	-	-
Sims, 1978 (30)	61	-	-	-	-	-	-	-	-	-
Stuff et al., 1983 (41)	40	-	-	-	-	-	-	-	-	-
Central and South America										
Barrera et al., 2018 (33)	50	33.7 ± 3.4	-	-	24.3 ± 2.9	-	-	24.9 ± 7.4	-	-
Caire-Juvera et al., 2007 (25)	60	38.2 ± 31.5	-	-	35.6 ± 33	-	-	21.2 ± 21.7	-	-
da Cuhna et al., 2005 (42)	77	-	-	-	-	-	-	-	-	-
Oceania										
Butts et al., 2018 (18), Maori & PI	17	37.3 ± 9.5	45.3 ± 6.6	15 ± 1.6	32.7 ± 11.5	39 ± 4.9	-	12.8 ± 5.4	15.7 ± 6.6	-
Asia										
Butts et al., 2018 (18), Asian	8	34.6 ± 26	37.2 ± 13.3	11.9 ± 4.5	38.9 ± 17	44.2 ± 9.6	-	16.4 ± 7.1	18.6 ± 5.1	-
Choi et al., 2016 (43)	96	-	-	-	-	-	-	-	-	-
Jiang et al., 2016 (27)	477	-	-	-	-	-	-	-	-	-
Kim et al., 2017 (19)	238	13.5 ± 6	-	-	16 ± 6.6	-	-	11 ± 4.6	-	-
Leelahakul et al., 2009 (21), Japanese	14	-	-	-	-	-	-	-	-	-
Leelahakul et al., 2009 (21), Thai	15	-	-	-	-	-	-	-	-	-
Quinn et al., 2012 (44)	102	-	-	-	-	-	-	-	-	-
Tiangson et al., 2003 (45)	100	-	-	-	-	-	-	-	-	-
Xiang et al., 2005 (23), Chinese	23	13.4 ± 8.8	-	-	17.2 ± 11	-	-	15.9 ± 7.5	-	-
Middle East										
Iranpour et al., 2013 (46)	59	21 ± 0.02	-	-	50.3 ± 234	-	-	8.5 ± 4.9	-	-
Kelishadi et al., 2012 (47)	86	22.1 ± 12	-	-	39.5 ± 190	-	-	8.9 ± 5.4	-	-
Samur et al., 2009 (48)	50	23.3 ± 9.2	31.6 ± 6.3	-	32 ± 12.5	43.4 ± 8.7	-	13.9 ± 10.4	18.1 ± 9.5	-
North and Central Europe										
Butts et al., 2018 (18), NZ European	53	41.7 ± 12.4	46.7 ± 8	15.2 ± 2.9	35.7 ± 12.4	39.5 ± 5.1	-	12.7 ± 7.3	13.9 ± 4.4	-
Bzikowska-Jura et al., 2018 (35)	40	22.8 ± 10.3	-	-	23.7 ± 9.2	-	-	11.4 ± 7.5	-	-
Duda et al., 2009 (49)	30	34.8 ± 13.1	-	-	34.9 ± 13.1	-	-	13.1 ± 8	-	-
Mojska et al., 2003 (28)	69	-	-	12.6 ± 1.6	-	-	14.5 ± 1.7	-	-	5.7 ± 1.1
Olafsdottir et al., 2006 (22)	77	45 ± 22	-	17.1 ± 5.4	31 ± 15	-	11.9 ± 3.8	9 ± 7	-	3.9 ± 3
Xiang et al., 2005 (23), Swedish	17	41.3 ± 14	-	-	32.9 ± 12.4	-	-	11.7 ± 4.4	-	-
South Europe/Mediterranean area										
Antonakou et al., 2011 (32)	64	-	13.1 ± 2.9	-	-	16.2 ± 4.3	-	-	5.6 ± 2.2	-
Giammarioli et al., 2002 (50)	125	-	-	11.1 ± 3.2	-	-	-	-	-	3.2 ± 3
Kresic et al., 2012 (20)	83	31.7 ± 9.1	-	14 ± 2.6	32.8 ± 9.6	-	15.2 ± 3.6	15.4 ± 8.2	-	6.7 ± 2.8
Sanchez et al., 2008 (29)	39	-	-	-	-	-	-	-	-	-
Scopesi et al., 2001 (51)	34	41 ± 15.5	-	-	44.4 ± 14.3	-	-	8.6 ± 4	-	-

MEDIDIET, Moro et al.	300	23.5 ± 7.4	35.7 ± 3.7	10.8 ± 2.1	29.4 ± 9.2	44.7 ± 3.7	13.5 ± 2.7	8.1 ± 2.3	12.4 ± 1.7	3.7 ± 0.6

[1]Values are mean ± SD.

Abbreviations: % En, % of total energy; % Fats, % of total fats.

Table 4 Polyunsaturated fatty acids component intakes of breastfeeding mothers of studies included in the systematic review and in the MEDIDIET study.

------		PUFA component								
Author, year	**Participants, n**	**ω-6 fatty acids**				**ω-3 fatty acids**				
		g/day[1]	**% En[1]**	**LA**	**ARA**	**g/day[1]**	**% En[1]**	**ALA**	**EPA**	**DHA**
				g/day[1]	**g/day[1]**			**g/day[1]**	**g/day[1]**	**g/day[1]**
North America										
Bopp et al., 2005 (24)	53	-	-	10.1 ± 5.9	0.08 ± 0.05	-	-	0.9 ± 0.5	0.03 ± 0.05	0.05 ± 0.10
Butte et al., 1984 (34)	45	-	-	-	-	-	-	-	-	-
Finley et al., 1985 (26)	60	-	-	-	-	-	-	-	-	-
Sims, 1978 (30)	61	-	-	-	-	-	-	-	-	-
Stuff et al., 1983 (41)	40	-	-	-	-	-	-	-	-	-
Central and South America										
Barrera et al., 2018 (33)	50	21.9 ± 2.6	-	19.8 ± 2.2	1.10 ± 0.04	2.7 ± 0.5	-	2.6 ± 0.5	0.02 ± 0.01	0.04 ± 0.01
Caire-Juvera et al., 2007 (25)	60	-	-	-	-	-	-	-	-	-
da Cuhna et al., 2005 (42)	77	-	-	-	-	-	-	-	-	-
Oceania										
Butts et al., 2018 (18), Maori & PI	17	-	-	-	-	-	-	-	-	-
Asia										
Butts et al., 2018 (18), Asian	8	-	-	-	-	-	-	-	-	-
Choi et al., 2016 (43)	96	-	-	-	-	-	-	-	-	-
Jiang et al., 2016 (27)	477	-	-	-	-	-	-	-	-	-
Kim et al., 2017 (19)	238	9.9 ± 4.3	-	-	0.05 ± 0.04	1.2 ± 0.9	-	-	0.07 ± 0.15	0.14 ± 0.32
Leelahakul et al., 2009 (21), Japanese	14	-	-	-	-	-	-	-	-	-
Leelahakul et al., 2009 (21), Thai	15	-	-	-	-	-	-	-	-	-
Quinn et al., 2012 (44)	102	-	-	-	-	-	-	-	-	-
Tiangson et al., 2003 (45)	100	-	-	-	-	-	-	-	-	-
Xiang et al., 2005 (23), Chinese	23	14.1 ± 7	-	14.1 ± 7	0.03 ± 0.05	1.8 ± 0.5	-	-	-	0.01 ± <0.01
Middle East										
Iranpour et al., 2013 (46)	59	-	-	7.3 ± 6.2	-	-	-	0.2 ± 0.2	0.04 ± 0.09	0.12 ± 0.25
Kelishadi et al., 2012 (47)	86	-	-	7.6 ± 6.1	-	-	-	-	0.08 ± 0.40	0.09 ± 0.21
Samur et al., 2009 (48)	50	-	4.5 ± 3.3	10.7 ± 10.1	-	-	0.6 ± 0.2	1.2 ± 0.2	-	-
North and Central Europe										
Butts et al., 2018 (18), NZ European	53	-	-	-	-	-	-	-	-	-
Bzikowska-Jura et al., 2018 (35)	40	-	-	-	-	-	-	-	-	-
Duda et al., 2009 (49)	30	-	-	-	-	-	-	-	-	-
Mojska et al., 2003 (28)	69	-	-	-	-	-	-	-	-	-
Olafsdottir et al., 2006 (22)	77	-	-	-	-	-	-	-	-	-
Xiang et al., 2005 (23), Swedish	17	10.1 ± 4.1	-	9.9 ± 4	0.08 ± 0.04	1.7 ± 0.5	-	1.4 ± 0.5	0.09 ± 0.10	0.12 ± 0.08
South Europe/Mediterranean area										
Antonakou et al., 2011 (32)	64	-	-	-	-	-	-	-	-	-
Giammarioli et al., 2002 (50)	125	-	-	-	-	-	-	-	-	-
Kresic et al., 2012 (20)	83	-	-	-	-	-	-	-	-	-
Sanchez et al., 2008 (29)	39	-	-	-	-	-	-	-	-	-
Scopesi et al., 2001 (51)	34	-	-	6.8 ± 3.6	-	-	-	1.5 ± 0.5	-	-
MEDIDIET, Moro et al.	300	6.7 ± 2	3.1 ± 0.6	6.4 ± 1.9	0.26 ± 0.09	1.4 ± 0.4	0.7 ± 0.1	1.1 ± 0.3	0.13 ± 0.06	0.17 ± 0.08

EFSA's DRVs, 2017 (40)	AI=250[2]

[1]Values are mean ± SD; [2]Value refers to EPA+DHA.

Abbreviations: % En, % of total energy; ω-3 fatty acids, omega-3 fatty acids; ω-6 fatty acids, omega-6 fatty acids; AI, adequate intake; ALA, α-linolenic acid; ARA, arachidonic acid; DRVs, Dietary reference values; EFSA, European Food Safety Authority; LA, linoleic acid.

Table 5 Mineral intakes of breastfeeding mothers of studies included in the systematic review and in the MEDIDIET study.

Author, year	Participants, n	Calcium mg/day[1]	Phosphorus mg/day[1]	Potassium mg/day[1]	Iron mg/day[1]	Zinc mg/day[1]	Sodium mg/day[1]
North America							
Bopp et al., 2005 (24)	53	-	-	-	-	-	-
Butte et al., 1984 (34)	45	1072 ± 488	1540 ± 479	-	14.4 ± 3.9	-	-
Finley et al., 1985 (26)	60	1350 ± 594	1736 ± 584	3540 ± 1230	16 ± 6.3	-	2425 ± 1087
Sims, 1978 (30)	61	1066 ± 627	-	-	12.2 ± 2.8	-	-
Stuff et al., 1983 (41)	40	1337 ± 465	1699 ± 399	-	16.3 ± 4.5	-	-
Central and South America							
Barrera et al., 2018 (33)	50	-	-	-	-	-	-
Caire-Juvera et al., 2007 (25)	60	1636 ± 1910	-	2760 ± 1841	16.1 ± 13.4	11.6 ± 8.4	2579 ± 1912
da Cuhna et al., 2005 (42)	77	-	-	-	-	-	-
Oceania							
Butts et al., 2018 (18), Maori & PI	17	758 ± 231	1356 ± 346	2971 ± 837	13.3 ± 4.1	10.7 ± 2.9	2914 ± 969
Asia							
Butts et al., 2018 (18), Asian	8	736 ± 458	1489 ± 481	3609 ± 1624	16.1 ± 5.4	11 ± 2.5	3138 ± 1366
Choi et al., 2016 (43)	96	660 ± 172	1287 ± 266	4084 ± 846	23.2 ± 15.5	12.5 ± 2.2	6345 ± 1334
Jiang et al., 2016 (27)	477	-	-	-	-	-	-
Kim et al., 2017 (19)	238	-	-	-	-	-	-
Leelahakul et al., 2009 (21), Japanese	14	1001 ± 120	1311 ± 133	3365 ± 310	17 ± 2.1	9.8 ± 1	3802 ± 350
Leelahakul et al., 2009 (21), Thai	15	539 ± 224	680 ± 161	1677 ± 475	13.5 ± 5.5	2.9 ± 0.7	899 ± 545
Quinn et al., 2012 (44)	102	-	-	-	-	-	-
Tiangson et al., 2003 (45)	100	-	-	-	-	-	-
Xiang et al., 2005 (23), Chinese	23	-	-	-	-	-	-
Middle East							
Iranpour et al., 2013 (46)	59	-	-	-	-	-	-
Kelishadi et al., 2012 (47)	86	-	-	-	-	-	-
Samur et al., 2009 (48)	50	-	-	-	-	-	-
North and Central Europe							
Butts et al., 2018 (18), NZ European	53	1041 ± 386	1648 ± 359	3551 ± 1267	14.8 ± 5.1	13.1 ± 3.6	2889 ± 946
Bzikowska-Jura et al., 2018 (35)	40	691 ± 315	1290 ± 347	3063 ± 838	12.6 ± 8	10 ± 3.3	2482 ± 836
Duda et al., 2009 (49)	30	-	-	-	-	-	-
Mojska et al., 2003 (28)	69	-	-	-	-	-	-
Olafsdottir et al., 2006 (22)	77	-	-	-	-	-	-
Xiang et al., 2005 (23), Swedish	17	-	-	-	-	-	-
South Europe/Mediterranean area							
Antonakou et al., 2011 (32)	64	-	-	-	-	-	-
Giammarioli et al., 2002 (50)	125	-	-	-	-	-	-
Kresic et al., 2012 (20)	83	994 ± 3140	1465 ± 450	-	12 ± 5	5.2 ± 2.2	-
Sanchez et al., 2008 (29)	39	1102 ± 226	1612 ± 421	-	15.2 ± 6.2	-	-
Scopesi et al., 2001 (51)	34	-	-	-	-	-	-
MEDIDIET, Moro et al.	300	792 ± 265	1358 ± 319	3304 ± 846	10.8 ± 3	11.4 ± 2.8	1903 ± 587
EFSA's DRVs, 2017 (40)		AR=805	AI=550	AI=4000	AR=7	AR=10.6	AI=2000

[1]Values are mean ± SD.

Abbreviations: AI, adequate intake; AR, average requirement; DRVs, Dietary reference values; EFSA, European Food Safety Authority.

Table 6 Vitamin and β-carotene equivalent intakes of breastfeeding mothers of studies included in the systematic review and in the MEDIDIET study.

Author, year	**Participants, n**	**Vitamin A retinol equivalent**	**Thiamin**	**Riboflavin**	**Niacin equivalent**	**Vitamin B6**	**Folate**	**Vitamin C**	**Vitamin D**	**Vitamin E**	**β-carotene equivalent**
		µg RAE/day[1]	**mg/day[1]**	**mg/day[1]**	**mg NE/day[1]**	**mg/day[1]**	**µg DFE/day[1]**	**mg/day[1]**	**mg/day[1]**	**mg α-TE/day[1]**	**mg/day[1]**
North America											
Bopp et al., 2005 (24)	53	-	-	-	-	-	-	-	-	-	-
Butte et al., 1984 (34)	45	2676 ± 1666	1.6 ± 0.7	2.2 ± 0.9	21.2 ± 6.9	-	-	126 ± 77.5	-	-	-
Finley et al., 1985 (26)	60	3043 ± 1932	1.5 ± 0.9	2.3 ± 0.9	17 ± 6.9	-	-	152 ± 120	-	-	-
Sims, 1978 (30)	61	2085 ± 1448	1.6 ± 0.9	2 ± 1.1	16.3 ± 2.6	-	-	108 ± 45	-	-	-
Stuff et al., 1983 (41)	40	-	-	-	-	-	-	-	-	-	-
Central and South America											
Barrera et al., 2018 (33)	50	-	-	-	-	-	-	-	-	-	-
Caire-Juvera et al., 2007 (25)	60	2204 ± 4615	-	-	-	-	312 ± 304	103 ± 153	-	12.9 ± 15	-
da Cuhna et al., 2005 (42)	77	-	-	-	-	-	-	-	-	-	-
Oceania											
Butts et al., 2018 (18), Maori & PI	17	937 ± 330	1.9 ± 0.8	2 ± 0.6	35.4 ± 10.8	-	273 ± 103	87.9 ± 74.3	3.5 ± 2.1	10 ± 3.4	3584 ± 1905
Asia											
Butts et al., 2018 (18), Asian	8	1583 ± 1047	1.6 ± 0.7	2.1 ± 0.9	37.3 ± 10	-	395 ± 190	157 ± 70.7	3.8 ± 3	13.4 ± 6.5	5483 ± 5317
Choi et al., 2016 (43)	96	1132 ± 355	4.4 ± 20.6	1.6 ± 0.6	20.6 ± 4.6	2.5 ± 3.2	587 ± 144	122 ± 75.5	-	27.9 ± 6.7	6138 ± 1998
Jiang et al., 2016 (27)	477	-	-	-	-	-	-	-	-	-	-
Kim et al., 2017 (19)	238	-	-	-	-	-	-	-	-	-	-
Leelahakul et al., 2009 (21), Japanese	14	1351 ± 148	1.2 ± 0.2	1.6 ± 0.6	22 ± 14.4	-	-	178 ± 25	-	-	6331 ± 845
Leelahakul et al., 2009 (21), Thai	15	262 ± 152	5 ± 2.8	2.6 ± 1	14.1 ± 3.3	-	-	84.4 ± 32.3	-	-	1240 ± 1098
Quinn et al., 2012 (44)	102	-	-	-	-	-	-	-	-	-	-
Tiangson et al., 2003 (45)	100	-	-	-	-	-	-	-	-	-	-
Xiang et al., 2005 (23), Chinese	23	-	-	-	-	-	-	-	-	-	-
Middle East											
Iranpour et al., 2013 (46)	59	-	-	-	-	-	-	-	-	3.2 ± 1.7	-
Kelishadi et al., 2012 (47)	86	-	-	-	-	-	-	-	-	-	-
Samur et al., 2009 (48)	50	-	-	-	-	-	-	-	-	-	-
North and Central Europe											
Butts et al., 2018 (18), NZ European	53	988 ± 459	1.8 ± 0.7	2.3 ± 0.8	42.4 ± 14.9	-	285 ± 94.6	119 ± 66.3	4.4 ± 3.6	11.9 ± 7.7	3389 ± 2271
Bzikowska-Jura et al., 2018 (35)	40	1233 ± 911	1.3 ± 0.5	1.7 ± 0.6	16.4 ± 6.7	2.5 ± 3.7	342 ± 150	137 ± 98.6	3.1 ± 2.6	10.8 ± 6.1	-
Duda et al., 2009 (49)	30	1012 ± 735	-	-	-	-	-	-	-	7.7 ± 3.4	2096 ± 2465
Mojska et al., 2003 (28)	69	-	-	-	-	-	-	-	-	-	-
Olafsdottir et al., 2006 (22)	77	-	-	-	-	-	-	-	-	-	-
Xiang et al., 2005 (23), Swedish	17	-	-	-	-	-	-	-	-	-	-
South Europe/Mediterranean area											
Antonakou et al., 2011 (32)	64	-	-	-	-	-	-	-	-	7.8 ± 4	-
Giammarioli et al., 2002 (50)	125	-	-	-	-	-	-	-	-	-	-
Kresic et al., 2012 (20)	83	898 ± 834	1.1 ± 1.1	-	-	1.6 ± 1.8	105 ± 39	-	1.6 ± 2.7	-	-
Sanchez et al., 2008 (29)	39	-	-	-	-	-	-	-	2.2 ± 1.7	-	-
Scopesi et al., 2001 (51)	34	-	-	-	-	-	-	-	-	-	-
MEDIDIET, Moro et al.	300	1143 ± 911	1 ± 0.2	1.6 ± 0.4	18.9 ± 4.9	2.2 ± 0.5	330 ± 110	184 ± 78	2.6 ± 0.9	9.9 ± 3.2	4242 ± 2610
EFSA's DRVs, 2017 (40)		AR=1020	-	AR=1.7	-	AR=2.2	AR=380	AR=145	AI=15	AI=11	-

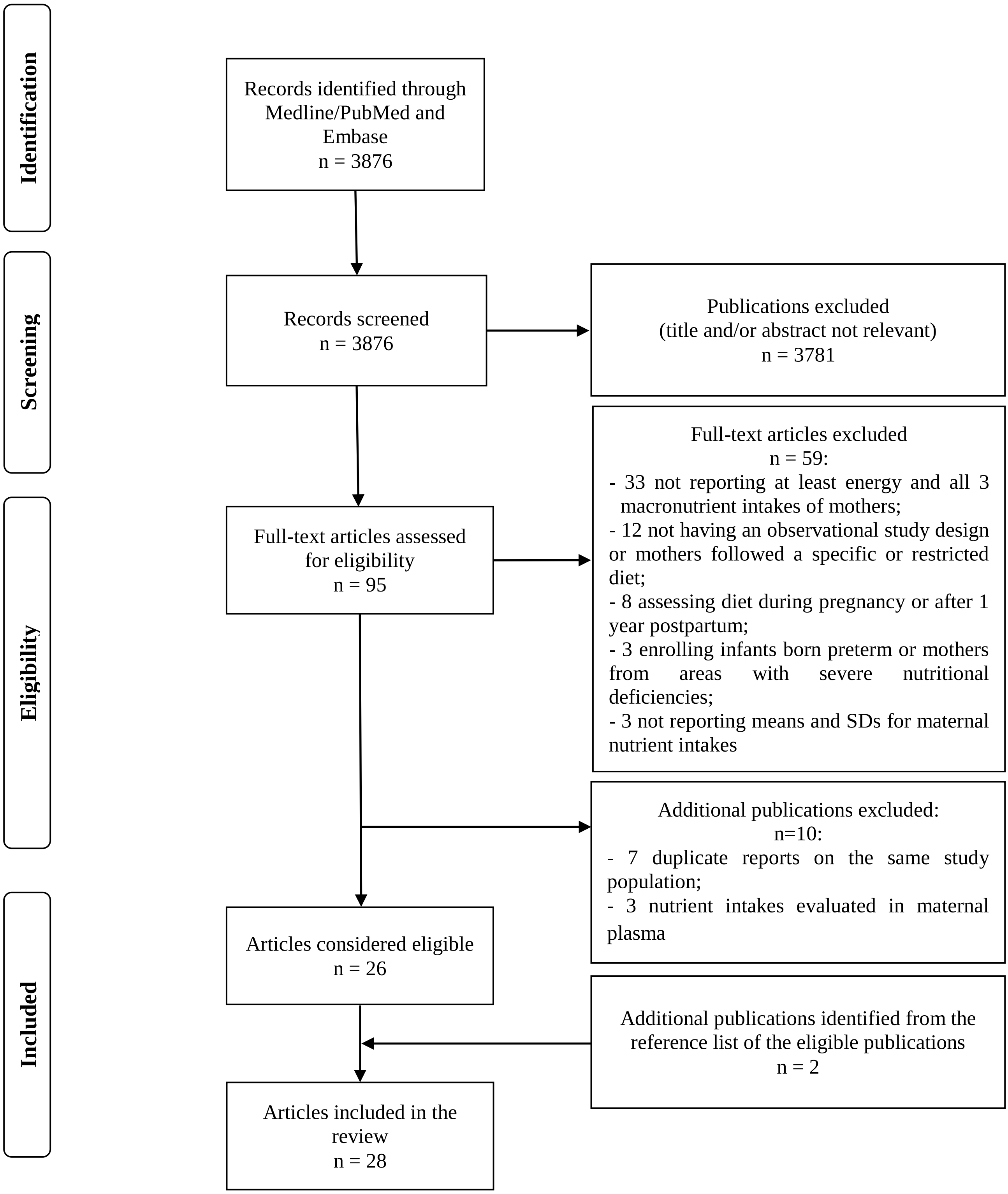
[1]Values are mean ± SD.

Abbreviations: α-TE, α-tocopherol; AI, adequate intake; AR, average requirement; DFE, dietary folate equivalent; DRVs, Dietary reference values; EFSA, European Food Safety Authority; NE, niacin equivalent; RAE, retinol activity equivalent.

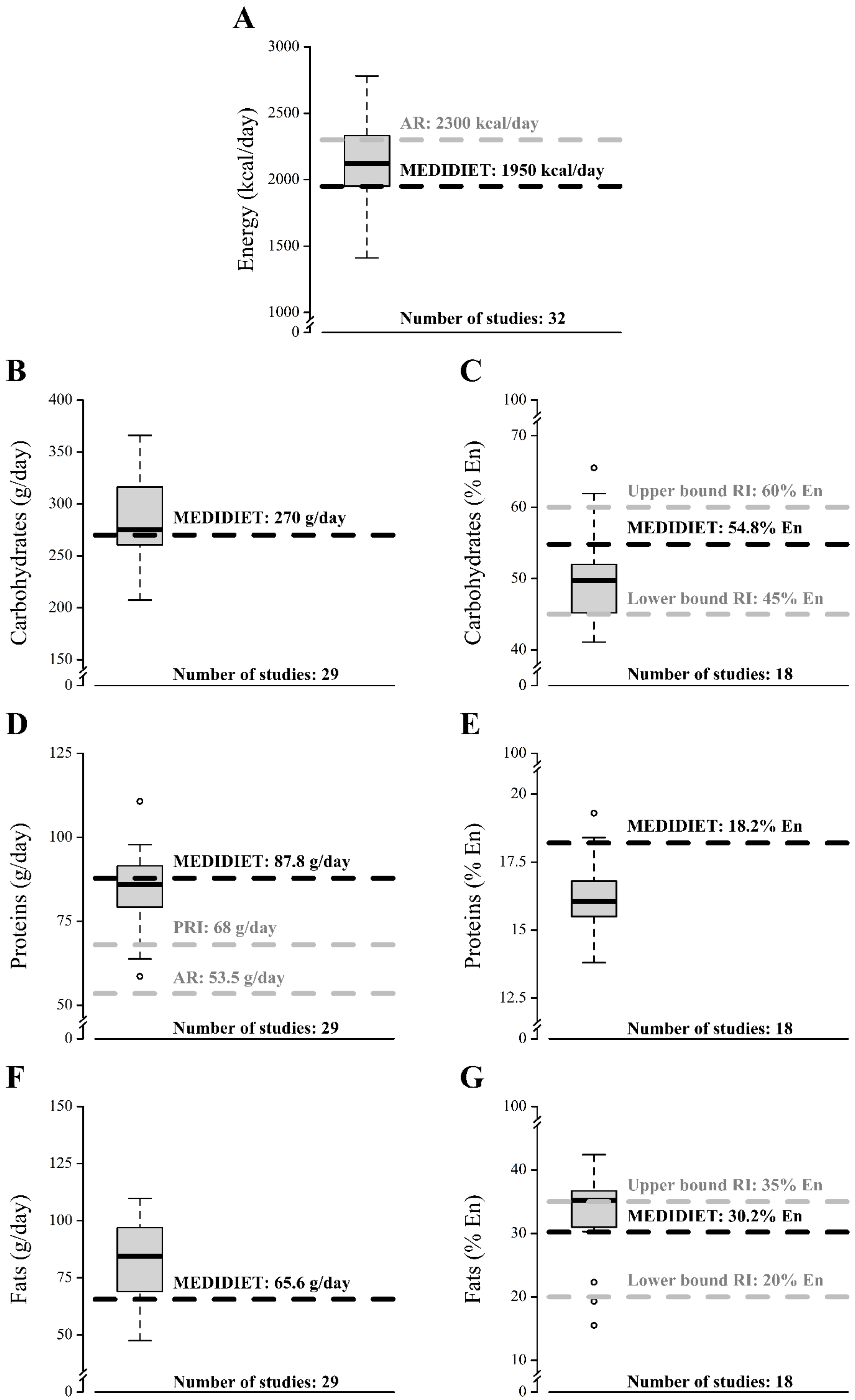
Figure 1 Flow-chart of study selection on dietary intake of breastfeeding mothers.

Figure 2 Box-whiskers plots of energy (kcal/day; A), carbohydrate (g/day – B; % En – C), protein (g/day – D; % En – E) and fat (g/day – F; % En – G) intake distributions of breastfeeding mothers for studies included in the systematic review and in the MEDIDIET study, and the corresponding dietary reference values.

Abbreviations: % En, % of total energy; AR, average requirement; DRVs, Dietary reference values; EFSA, European Food Safety Authority; PRI, population reference intake; RI, reference intake range.
The black thick dotted lines indicate the intake of the MEDIDIET study; the grey thick dotted lines indicate the EFSA's DRVs (40).



Identification
Screening
Eligibility
Included
Records identified through Medline/PubMed and Embase n = 3876
Records screened n = 3876
Publications excluded (title and/or abstract not relevant) n = 3781
Full-text articles assessed for eligibility n = 95
Full-text articles excluded n = 59:
- 33 not reporting at least energy and all 3 macronutrient intakes of mothers;
- 12 not having an observational study design or mothers followed a specific or restricted diet;
- 8 assessing diet during pregnancy or after 1 year postpartum;
- 3 enrolling infants born preterm or mothers from areas with severe nutritional deficiencies;
- 3 not reporting means and SDs for maternal nutrient intakes
Additional publications excluded: n=10:
- 7 duplicate reports on the same study population;
- 3 nutrient intakes evaluated in maternal plasma
Articles considered eligible n = 26
Additional publications identified from the reference list of the eligible publications n = 2
Articles included in the review n = 28


A
Energy (kcal/day)
3000
2500
2000
1500
1000
0
AR: 2300 kcal/day
MEDIDIET: 1950 kcal/day
Number of studies: 32
B
Carbohydrates (g/day)
400
350
300
250
200
150
0
MEDIDIET: 270 g/day
Number of studies: 29
C
Carbohydrates (% En)
100
70
60
50
40
0
Upper bound RI: 60% En
MEDIDIET: 54.8% En
Lower bound RI: 45% En
Number of studies: 18
D
Proteins (g/day)
125
100
75
50
0
MEDIDIET: 87.8 g/day
PRI: 68 g/day
AR: 53.5 g/day
Number of studies: 29
E
Proteins (% En)
100
20
17.5
15
12.5
0
MEDIDIET: 18.2% En
Number of studies: 18
F
Fats (g/day)
150
125
100
75
50
0
MEDIDIET: 65.6 g/day
Number of studies: 29
G
Fats (% En)
100
40
30
20
10
0
Upper bound RI: 35% En
MEDIDIET: 30.2% En
Lower bound RI: 20% En
Number of studies: 18