The Journal of Nutrition
Nutrient Requirements and Optimal Nutrition

Dietary Intake of Breastfeeding Mothers in Developed Countries: A Systematic Review and Results of the MEDIDIET Study

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ABSTRACT

Background: Lactation is a demanding period for women, and a 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 $\pm$ 1 wk postpartum. Usual diet was concomitantly evaluated through a validated and reproducible FFQ. 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 $\pm$ 445 kcal/d), carbohydrates (270 $\pm$ 20.1 g/d), proteins (87.8 $\pm$ 20.1 g/d), and fats (65.6 $\pm$ 18.9 g/d) were similar to those observed in the SR. Moreover, observed intakes seemed to reflect the typical Mediterranean diet, with low intakes of carbohydrates, SFAs, and PUFAs and high intakes of MUFAs 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. *J Nutr* 2021;151:3459–3482.

Keywords: maternal nutrient intakes, lactation, Mediterranean diet, nutritional epidemiology, MEDIDIET study

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 ∼700 kcal, and the milk secreted during

Manuscript received May 21, 2021. Initial review completed July 8, 2021. Revision accepted July 12, 2021.
First published online August 12, 2021; doi: https://doi.org/10.1093/jn/nxab258.

4 mo 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 B-12 concentrations at birth, and this persists during lactation from B-12–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 compared with mothers living in industrialized areas (1). Dietary recommendations throughout the world provide different nutritional guidelines for lactating mothers. However, a European survey conducted by WHO 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 correct 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 compare nutrient intakes with dietary reference values (DRVs) proposed by the European Food Safety Authority (EFSA).

This study was sponsored by Danone Nutricia Research, Utrecht, Netherlands. FB was supported by grant PSR2015-1719FBRAV from the Department of Clinical Sciences and Community Health of the University of Milan. MDM was supported by an academic fellowship focusing on maternal nutrition.

Author disclosures: 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 (MDM, FB, and MF) without involvement of the sponsor. SRBME, EV, and BS are employees of Danone Nutricia Research, Utrecht, Netherlands. See the MEDIDIET Working Group members in the Acknowledgments.

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Abbreviations used: AI, adequate intake; ALA, α-linolenic acid; AR, average requirement; ARA, arachidonic acid; DFE, dietary folate equivalent; DRV, dietary reference value; EFSA, European Food Safety Authority; LA, linoleic acid; NE, niacin equivalent; PRI, population reference intake; RAE, retinol activity equivalent; RI, reference intake range; α-TE, α-tocopherol; % En, percentage of total energy; % Fats, percentage of total fats.

Methods

SR: search strategy

We performed a literature search up to February 2020 in the MEDLINE/PubMed and Embase databases using the following 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", and "mother milk" (**Appendix A**).

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement for SRs and reporting results for conducting the current study (16, 17). Three authors (MDM, SRBME, and MF) separately reviewed studies, and discrepancies were discussed and resolved. Studies were eligible for inclusion in the SR if they met the following criteria: *1*) the study had an observational design including healthy breastfeeding (any type) mothers with healthy infants born at term (i.e., ≥37 gestational weeks); *2*) the study enrolled breastfeeding mothers who followed a usual diet without any restrictions (e.g., specific diet, dietary interventions, and use of dietary supplements); *3*) the study reported maternal diet either at a single point in time or repetitively between delivery and 12 mo postpartum; *4*) the study reported at least energy and all 3 macronutrient intakes (i.e., carbohydrates, proteins, and fats) of breastfeeding mothers; and *5*) 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: *1*) the study focused on a population with severe nutritional deficiencies (e.g., sub-Saharan African countries or rural areas of developing countries); *2*) the study enrolled breastfeeding mothers with major chronic diseases (e.g., diabetes, hypertension, or HIV/AIDS); *3*) 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); or *4*) the study had an experimental design evaluating the effects of dietary interventions (e.g., dietician counseling) and/or use of dietary supplements (e.g., iron or vitamin D supplements) even if participants belonging to the control arm followed a usual diet without any restrictions. We excluded experimental studies because the intervention setting may have somewhat modified usual maternal dietary behaviors, thus resulting in 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 kilocalories per day for studies (18–22) that reported it in different units (i.e., megajoules per day or kilojoules per 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 and 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., 1, 3, and 6 mo 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, the MEDIDIET study enrolled 300 healthy mothers with healthy term infants between October 2012 and June 2014 in 5 Italian maternity hospitals. All mothers were Caucasian aged 25–41 years, free of disease (i.e., diabetes, autoimmune diseases, cardiovascular diseases, hypertension, and renal diseases), seronegative for HBV/HCV/HIV, nonsmokers, nonabusers of drugs or alcohol, and not severely obese [i.e., prepregnancy BMI (kg/m^2) <35]. Infants were born at term (i.e., ≥37 gestational weeks) with a birth weight of 2500–4500 g and a body length of 46–56 cm, and they were exclusively breastfed (i.e., no other drink or food were given to infants) (36) from birth to the day of milk collection (i.e., age 6 ± 1 wk). 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 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" units (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, and 150 g of beef). Other specific items investigated the fats (e.g., olive oil, seeds oil, and 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., <1/wk but >1/mo) were coded as 0.5 per week. Last, 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 report the minimum, the median, and the maximum for each nutrient intake. We also report 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 ≥1 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 y postpartum (8 articles), enrolling infants born preterm or mothers from areas with severe nutritional deficiencies (3 articles), or 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., the United States), 3 studies (25, 33, 42) enrolled mothers from Central and South America (i.e., Mexico, Chile, and Brazil), 1 study (18) enrolled mothers from Oceania (i.e., Maori and Pacific Island ethnicity living in New Zealand), 9 studies (18, 19, 21, 23, 27, 43–45) enrolled mothers from Asia (i.e., China, Japan, Philippine, South Korea, Thailand, and Asian ethnicity living in New Zealand), 3 studies (46–48) enrolled mothers from the Middle East (i.e., Iran and Turkey), 6 studies (18, 22, 23, 28, 35, 49) enrolled mothers 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) enrolled mothers 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 (kilocalories per day), carbohydrates (grams per day and percentage of total energy), proteins (grams per day and percentage of total energy), fats (grams per day and percentage of total energy), cholesterol (milligrams per day), and fibers (grams per day).

Among the 32 studies included in the SR, the range for energy intake was 1411–2781 kcal/d, with a median of 2111 kcal/d according to the energy intake distribution across studies. The 25th and 75th percentiles were 1949 and 2325 kcal/d, respectively. The average requirement (AR) for energy is nearly 2300 kcal/d, which includes 500 additional kcal/d for lactation period beyond what is recommended for nonpregnant and/or nonlactating women (i.e., ∼1800 kcal/d 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, 3 studies (27, 35, 44) reported an intake lower than the recommendation for nonpregnant and/or nonlactating women (i.e., <1800 kcal/d), whereas 3 studies (23, 28, 49) reported an intake >2500 kcal/d, indicating an exceedance of the AR by ≥200 kcal/d.

With regard to carbohydrates, 29 of 32 studies (18–26, 28–30, 33–35, 41–43, 45–51) reported the intake in grams per day and 18 studies (18, 20–22, 24, 27, 29, 30, 32, 34, 35, 42, 44, 48, 50) in percentage of total energy. Carbohydrate intake, expressed as grams per day, ranged from 207 to 366 g/d, with a median of 274 g/d. Intakes corresponding to 25th and 75th percentiles were 250 and 316 g/d, respectively. When expressed as percentage of total energy, carbohydrates ranged from 41.1 to 65.5% En, with a median of 49.5% En, whereas the 25th and 75th percentiles were 44.9 and 52.0% En, respectively. Two studies (29, 30) showed an intake lower (41.1 and 41.7% En) and 1 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 grams per day and 18 studies (18, 20–22, 24, 27, 29, 30, 32, 34, 35, 42, 44, 48, 50) in percentage of total energy. The range of protein intake was 58.6–111

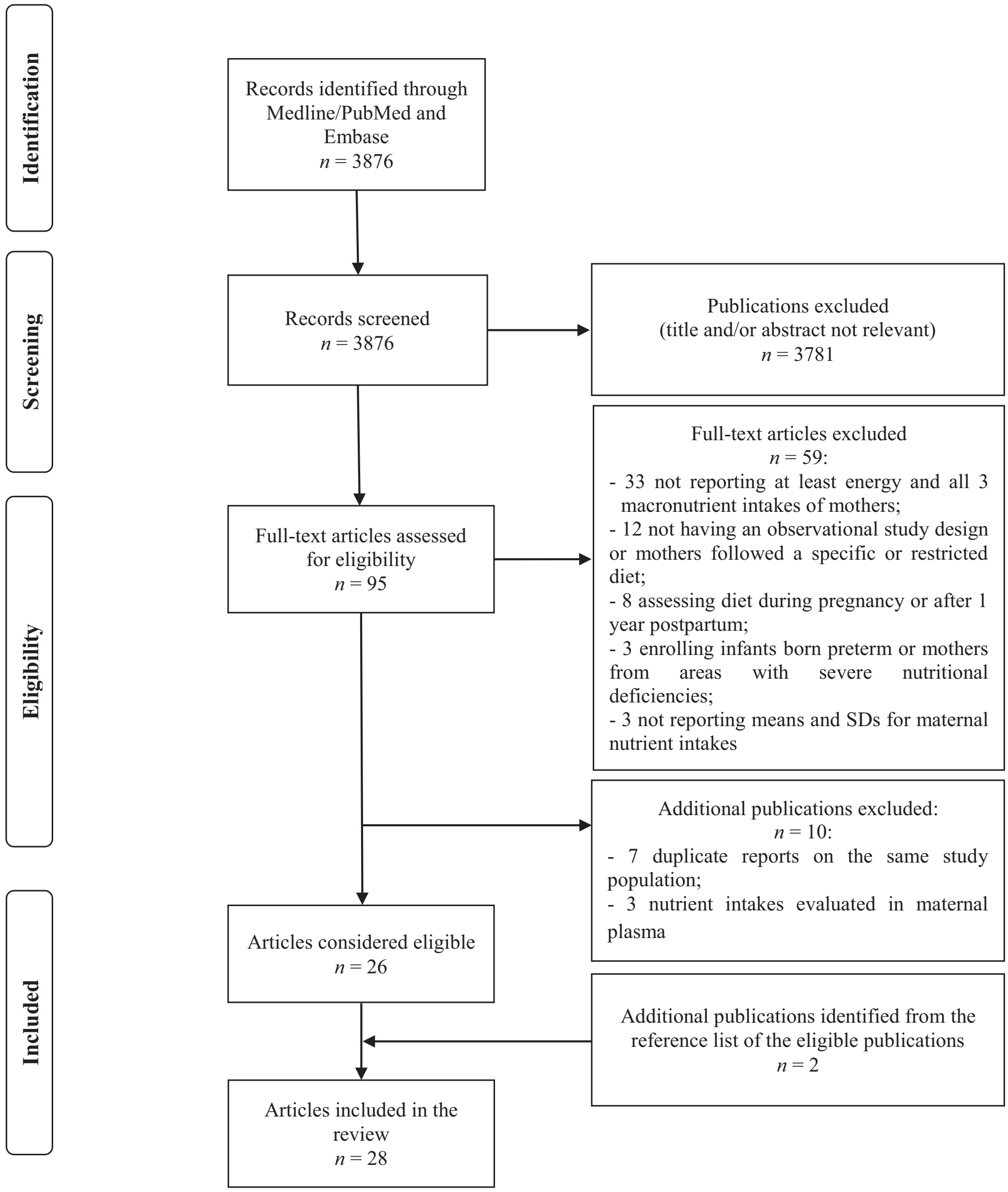

FIGURE 1 Flowchart of study selection on dietary intake of breastfeeding mothers.

g/d, whereas the 25th, 50th, and 75th percentiles were 78.9, 85.4, and 91.5 g/d, respectively. All studies reported an intake of proteins substantially higher than the corresponding AR of 53.5 g/d (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/d (calculated using the same method as for the AR), except for a few studies (23, 35, 42, 45, 48) that showed an intake slightly higher or close to this reference value. In terms of percentage of total energy, protein intake ranged from 13.8 to 19.3% En. 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 grams per day and 18 studies (18, 20–22, 24, 27, 29, 30, 32, 34, 35, 42, 44, 48, 50) as percentage of total energy. Fat intake ranged from 47.5 to 110 g/d (median, 82.4 g/d). The 25th–75th percentile range was 62.7–97.0 g/d. When expressed as percentage of total energy, fat intakes were 15.5% En (minimum), 30.3% En (25th percentile), 34.5% En (median), 36.7% En (75th percentile), and 42.4% En (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/d and a median of 276 mg/d. The minimum cholesterol intake was reported in the South Korean study of Kim et al. (19), and the highest intake was reported 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/d, with a median of 23.4 g/d, which was close to the adequate intake (AI) of 25 g/d. In 2 studies (21, 26), intake levels were far lower (i.e., <11.1 g/d)

TABLE 1 Characteristics of observational studies included in the systematic review on nutrient intakes of breastfeeding mothers[1]

Author, year	Country	Study design	Participants, *n*; age,[2] y	Tool used for diet assessment	Nutrient intake (unit/d)
North America					
Bopp et al., 2005 (24)	United States	Cross-sectional	23 mothers with low physical activity Age: 31.5 ± 4.8 30 mothers with consistent physical activity Age: 31.5 ± 3.3	3-d diary at 12 wk 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)	United States	Longitudinal	45 mothers at 1, 2, 3, and 4 mo postpartum Age: 28.0 ± 3.1	Three consecutive dietary record (2 weekdays and 1 weekend day) at 1, 2, 3, and 4 mo 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)	United States	Longitudinal	60 mothers Age: 29.0	A 24-h dietary recall at the enrolment (in the first 2 mo postpartum) and 2-d diet record monthly (up to 18 mo 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)	United States	Cross-sectional	61 mothers at 1–6 mo postpartum Age: 28.0 (50 mothers taking supplements; 11 mothers taking no supplements)	3-d 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)	United States	Cross-sectional	40 mothers at 3–6 wk postpartum Age: not reported	7-d dietary record and an FFQ at 3–6 mo 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 wk of gestation Age: 20–33; 29.4 ± 6.2	FFQ administered by trained dietitians at 1 and 6 mo 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 d postpartum Age: 15–35; 19.8± 4.4	Two 24-h recalls administered by interviewers at 15–30 d 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 d postpartum Age: 18–39; 23.6 ± 4.5	24-h dietary recall at 15 ± 1 d postpartum	Energy (kcal), carbohydrates (g and % En), proteins (g and % En), and fats (g and % En)

(*Continued*)

TABLE 1 (*Continued*)

Author, year	Country	Study design	Participants, *n*; age,[2] y	Tool used for diet assessment	Nutrient intake (unit/d)
Oceania					
Butts et al., 2018 (18)	New Zealand	Cross-sectional	17 Maori and Pacific Island mothers at 6–8 wk postpartum Age: 19–42; 31.2 ± 1.5	3-d food diaries (2 weekdays and 1 weekend day) at 6–8 wk 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 wk postpartum Age: 19–42; 30.4 ± 1.2	3-d food diaries (2 weekdays and 1 weekend day) at 6–8 wk 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 d postpartum Age: 31.8 ± 3.9	3-d 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 B-6 (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 Beijing, and 142 mothers from Lanzhou Age: 28.3 ± 3.6	Three self-administered 24-h dietary recall at 1, 14, and 42 d postpartum	Energy (kcal), carbohydrate (% En), proteins (% En), and fats (% En)
Kim et al., 2017 (19)	South Korea	Cross-sectional	238 mothers Age: 21–45; 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 wk 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)

(*Continued*)

TABLE 1 (*Continued*)

Author, year	Country	Study design	Participants, *n*; age,[2] y	Tool used for diet assessment	Nutrient intake (unit/d)
Leelahakul et al., 2009 (21)	Japan and Thailand	Cross-sectional	14 Japanese mothers in postpartum period Age: 30.5 ± 4.9	24-h dietary records at 2–4 d 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: 26.0 ± 5.4	24-h dietary records at 2–4 d 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 <18 mo Age: 23–24; 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 mo postpartum Age: 16–40; 28.4 ± 6.0	3-d dietary record at 2–4 mo postpartum (2 weekdays and 1 weekend day) and an FFQ at 2–4 mo 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 mo postpartum Age: 27.4 ± 0.8	3-d dietary record at 3 mo 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 d 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 h after delivery Age: 28.4 ± 5.6	1-d food record questionnaire at 8–72 h 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 wk postpartum Age: 17–39; 26.2 ± 5.5	3-d dietary record at 12–16 wk 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)

(*Continued*)

TABLE 1 (*Continued*)

Author, year	Country	Study design	Participants, n; age,[2] y	Tool used for diet assessment	Nutrient intake (unit/d)
North and Central Europe					
Butts et al., 2018 (18)	New Zealand	Cross-sectional	53 New Zealand European mothers at 6–8 wk postpartum Age: 19–42; 30.7 ± 0.7	3-d food diaries (2 weekdays and 1 weekend day) at 6–8 wk 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 mo postpartum Age: 31.1 ± 4.4	3-d self-administered dietary record checked by a qualified dietitian at 1 ($n = 40$), 3 ($n = 22$), and 6 ($n = 15$) mo 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 B-6 (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 mo postpartum Age: 25–37; 28.7 ± 3.0	24-h dietary recall administered by expert interviews for 3 consecutive days at 1–12 mo 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: 26.2 ± 3.9 35 mothers enrolled at delivery in autumn season Age: 26.2 ± 4.3	7-d dietary record at 9–10 wk 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 mo postpartum Age: 31.0 ± 4.0 (18 mothers consuming cod liver oil; 59 mothers not consuming cod liver oil)	24-h dietary recall at 2–4 mo 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)

(*Continued*)

TABLE 1 (*Continued*)

Author, year	Country	Study design	Participants, *n*; age,[2] y	Tool used for diet assessment	Nutrient intake (unit/d)
Xiang et al., 2005 (23)	China and Sweden	Cross-sectional	17 Swedish mothers at 3 mo postpartum Age: 29.5 ± 1.0	3-d dietary record at 3 mo 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 mo postpartum, 39 mothers at 3 mo postpartum, and 23 mothers at 6 mo postpartum Age: 25–39; 32.5 ± 3.1	3-d dietary record (2 consecutive weekdays and 1 weekend day) at 1, 3, and 6 mo 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; 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 mo postpartum Age: 19–40	Two consecutive 24-h dietary recall at 1, 3, and 6 mo 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 B-6 (mg), folate (μg DFE), and vitamin D (μg)
Sanchez et al., 2008 (29)	Spain	Cross-sectional	39 mothers at 1 mo postpartum Age: 18–40; 34.3 ± 5.2	24-h dietary recall at 1 mo 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 d postpartum and 4, 7, 14, 21, and 28 d after colostrum appearance	Energy (kcal), carbohydrates (g), proteins (g), fats (g), SFA (g), MUFA (g), PUFA (g), LA (g), and ALA (g)

[1] ALA, α-linolenic acid; ARA, arachidonic acid; DFE, dietary folate equivalent; LA, linoleic acid; NE, niacin equivalent; RAE, retinol activity equivalent; α-TE, α-tocopherol; % En, percentage of total energy; % Fats, percentage of total fats.
[2] Values are ranges, means, or means ± SDs.

TABLE 2 Energy, macronutrient, cholesterol, and fiber intakes of breastfeeding mothers in studies included in the systematic review and in the MEDIDIET study[1]

Author, year	Participants, n	Energy	Carbohydrates		Proteins		Fats		Cholesterol	Fiber
		kcal/d[2]	g/d[2]	% En[2]	g/d[2]	% En[2]	g/d[2]	% En[2]	mg/d[2]	g/d[2]
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 and Pacific Islanders	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); New Zealand 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	—	—	—

(*Continued*)

TABLE 2 (*Continued*)

Author, year	Participants, *n*	Energy kcal/d[2]	Carbohydrates g/d[2]	Carbohydrates % En[2]	Proteins g/d[2]	Proteins % En[2]	Fats g/d[2]	Fats % En[2]	Cholesterol mg/d[2]	Fiber g/d[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., 2019 (15)	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[3]
EFSA's DRVs, 2017 (40)		AR = 2300	—	RI = 45–60	AR = 53.5; PRI = 68	—	—	AR = 20–35	—	AI = 25

[1]AI, adequate intake; AR, average requirement; DRVs, dietary reference values; EFSA, European Food Safety Authority; PRI, population reference intake; RI, reference intake range; % En, percentage of total energy.
[2]Values are means ± SDs.
[3]Calculated according to the Englyst method.

than the AI; similarly, 2 studies (18, 43) showed an intake of fiber higher (i.e., >31.6 g/d) than the AI.

SR: fatty acids

Table 3 provides means and SDs of maternal daily intakes for SFA (grams per day, percentage of total fats, and percentage of total energy), MUFA (grams per day, percentage of total fats, and percentage of total energy), and PUFA (grams per day, percentage of total fats, and percentage of total energy). **Table 4** provides the same data for PUFA components. In particular, we presented total ω-6 fatty acids (grams per day and percentage of total energy) with parental compound linoleic acid (LA; grams per day) and its major byproduct arachidonic acid (ARA; grams per day); and total ω-3 fatty acids (grams per day and percentage of total energy) with the parental compound α-linolenic acid (ALA; grams per day) and its major byproducts EPA (grams per day) and DHA (grams per day). For fatty acids, EFSA provided DRVs for SFA, LA, ALA, and EPA + DHA. However, the recommendation for SFA was as low as possible, and those for LA and ALA were given in terms of percentage of total energy, whereas studies included in the SR reported the intake in absolute values (grams per 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 grams per day, 5 studies (18, 32, 48) reported it as percentage of total fats, and 7 studies (18, 20, 22, 28, 50) reported it as percentage of total energy. The intake of SFA expressed as grams per day ranged from 13.4 g/d for Chinese mothers participating in the study of Xiang et al. (23) to 45.0 g/d for Icelander mothers in the study of Olafsdottir et al. (22). The median intake of SFA distribution across studies was 33.7 g/d. In terms of percentage of total fats and percentage of total energy, intakes of SFA ranged from 13.1 to 46.7% Fats and from 11.1 to 17.1% En, respectively.

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

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

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

TABLE 3 Fatty acid intakes of breastfeeding mothers in studies included in the systematic review and in the MEDIDIET study[1]

Author, year	Participants, *n*	SFA			MUFA			PUFA		
		g/d[2]	% Fats[2]	% En[2]	g/d[2]	% Fats[2]	% En[2]	g/d[2]	% Fats[2]	% En[2]
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 and Pacific Islanders	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), New Zealand 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	—	—

(*Continued*)

TABLE 3 (*Continued*)

Author, year	Participants, *n*	SFA g/d[2]	SFA % Fats[2]	SFA % En[2]	MUFA g/d[2]	MUFA % Fats[2]	MUFA % En[2]	PUFA g/d[2]	PUFA % Fats[2]	PUFA % En[2]
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., 2019 (15)	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] % En, percentage of total energy; % Fats, percentage of total fats.
[2] Values are means ± SDs.

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

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

Last, 6 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/d, with a median of 1.2 g/d. The intake of EPA and DHA ranged from 0.02 to 0.09 g/d and from 0.01 to 0.14 g/d, respectively. Medians were 0.04 g/d (EPA) and 0.09 g/d (DHA).

SR: minerals

Maternal intakes of calcium (milligrams per day), phosphorus (milligrams per day), potassium (milligrams per day), iron (milligrams per day), zinc (milligrams per day), and sodium (milligrams per 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 mg/d, with a median of 1001 mg/d. Three studies (21, 35, 43) reported a considerably lower calcium intake (i.e., <700 mg/d) than the AR of 805 mg/d (calculated as the average of ARs for lactating women according to different age groups). Likewise, 3 studies (25, 26, 41) reported an intake of calcium considerably higher (i.e., >1300 mg/d) 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/d. The median intake was 1465 mg/d. All studies reported an intake of phosphorus higher than the AI (550 mg/d). In particular, except for Thai mothers participating in the study of Leelahakul et al. (21) that showed an intake (680 mg/d) close to the AI, other studies reported an intake considerably higher (i.e., >1200 mg/d).

Potassium intake was reported in 9 studies (18, 21, 25, 26, 35, 43). The minimum intake was 1677 mg/d, the median was 3063 mg/d, and the maximum was 4084 mg/d. Only 1 study (43) reported an intake of potassium close to the corresponding AI (4000 mg/d). 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/d, respectively) than the AI, and for the remaining studies the intake ranged from 3000 to 3650 mg/d.

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/d. In particular, the intake ranged from 12.0 to 23.2 mg/d, with a median of 14.8 mg/d.

Nine studies (18, 20, 21, 25, 35, 43) provided an intake for zinc. The range was 2.9–13.1 mg/d and the median was 10.0 mg/d, which was close to the AR (~10.6 mg/d, which included an intake of 8.2 mg/d, calculated as the average of ARs for nonpregnant and nonlactating women according to different age groups and levels of phytate intake, and an additional intake

TABLE 4 PUFAs component intakes of breastfeeding mothers in studies included in the systematic review and in the MEDIDIET study[1]

		PUFA component								
	Participants,	ω-6 fatty acids		LA	ARA	ω-3 fatty acids		ALA	EPA	DHA
Author, year	*n*	g/day[2]	% En[2]	g/d[2]	g/d[2]	g/d[2]	% En[2]	g/d[2]	g/d[2]	g/d[2]
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 and Pacific Islanders	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); New Zealand 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

(*Continued*)

TABLE 4 *(Continued)*

Author, year	Participants, *n*	ω-6 fatty acids		LA	ARA	PUFA component: ω-3 fatty acids		ALA	EPA	DHA
		g/day[2]	% En[2]	g/d[2]	g/d[2]	g/d[2]	% En[2]	g/d[2]	g/d[2]	g/d[2]
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., 2019 (15)	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[3]	

[1]AI, adequate intake; ALA, α-linolenic acid; ARA, arachidonic acid; DRVs, dietary reference values; EFSA, European Food Safety Authority; LA, linoleic acid; % En, percentage of total energy.
[2]Values are means ± SDs.
[3]Value refers to EPA + DHA.

of 2.4 mg/d 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 and 5.2 mg/d, respectively).

For sodium, 9 studies (18, 21, 25, 26, 35, 43) provided the intake. Intakes of 899, 2579, and 6345 mg/d 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/d; conversely, the maximum was observed for South Korean mothers in the study of Choi et al. (43), which was more than 3-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 [micrograms retinol activity equivalent (RAE) per day], thiamin (milligrams per day), riboflavin (milligrams per day), niacin equivalent (NE; milligrams NE per day), vitamin B-6 (milligrams per day), folate [micrograms dietary folate equivalent (DFE) per day], vitamin C (milligrams per day), vitamin D (micrograms per day), vitamin E [milligrams α-tocopherol (α-TE) per day], and β-carotene equivalent (milligrams per 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/d and the median was 1132 μg RAE/d. Leelahakul et al. (21) reported the minimum intake for Thai mothers (262 μg RAE/d), which was considerably lower than the AR for vitamin A (1020 μg RAE/d); conversely, 4 studies (25, 26, 30, 34) showed an intake considerably higher (i.e., >2000 μg RAE/d) than the AR.

Eleven studies provided thiamin intake (18, 20, 21, 26, 30, 34, 35, 43). The minimum intake was 1.1 mg/d observed for Croatian mothers in the study of Kresic et al. (20), the median was 1.6 mg/d reported for Asian mothers by Butts et al. (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 to or slightly higher than the corresponding AR of 1.7 mg/d. 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/d and the median was 2.0 mg/d.

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

Only 3 studies reported vitamin B-6 intake. Kresic et al. (20) showed an intake of 1.6 mg/d for Croatian mothers, which was lower that the corresponding AR of 2.2 mg/d. Bzikowska-Jura et al. (35) reported an intake of 2.5 mg/d for Polish mothers, and Choi et al. (43) reported an intake of 2.5 mg/d for South Korean mothers, close to the AR (2.2 mg/d).

Folate intake was reported by 7 studies (18, 20, 25, 35, 43). The minimum intake corresponding to 105 μg DFE/d was reported by Kresic et al. (20), the median (312 μg DFE/d) was reported by Caire-Juvera et al. (25), and the maximum (587 μg DFE/d) was reported 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/d and a median of 122 mg/d. With regard to the AR for vitamin C (145 mg/d), Leelahakul et al. (21) for Thai mothers and Butts et al.

TABLE 5 Mineral intakes of breastfeeding mothers in studies included in the systematic review and in the MEDIDIET study[1]

Author, year	Participants, *n*	Calcium, mg/d[2]	Phosphorus, mg/d[2]	Potassium, mg/d[2]	Iron, mg/d[2]	Zinc, mg/d[2]	Sodium, mg/d[2]
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 and Pacific Islanders	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); New Zealand 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., 2019 (15)	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]AI, adequate intake; AR, average requirement; DRVs, dietary reference values; EFSA, European Food Safety Authority.
[2]Values are means ± SDs.

TABLE 6 Vitamin and β-carotene equivalent intakes of breastfeeding mothers in studies included in the systematic review and in the MEDIDIET study[1]

Author, year	Participants, n	Vitamin A retinol equivalent, μg RAE/d[2]	Thiamin, mg/d[2]	Riboflavin, mg/d[2]	Niacin equivalent, mg NE/d[2]	Vitamin B-6, mg/d[2]	Folate, μg DFE/d[2]	Vitamin C, mg/d[2]	Vitamin D, mg/d[2]	Vitamin E, mg α-TE/d[2]	β-carotene equivalent, mg/d[2]
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 and Pacific Islanders	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); New Zealand 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	—

(*Continued*)

TABLE 6 (*Continued*)

Author, year	Participants, *n*	Vitamin A retinol equivalent, µg RAE/d[2]	Thiamin, mg/d[2]	Riboflavin, mg/d[2]	Niacin equivalent, mg NE/d[2]	Vitamin B-6, mg/d[2]	Folate, µg DFE/d[2]	Vitamin C, mg/d[2]	Vitamin D, mg/d[2]	Vitamin E, mg α-TE/d[2]	β-carotene equivalent, mg/d[2]
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., 2019 (15)	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]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; α-TE, α-tocopherol.
[2]Values are means ± SDs.

(18) for mothers of Maori and Pacific Islands ethnicity reported an intake far lower (i.e., 84.4 and 87.9 mg/d, respectively).

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

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

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

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 y, and the mean prepregnancy BMI was 22.3 ± 3.22 [data shown in Moro et al. (15)].

MEDIDIET study: energy, macronutrients, cholesterol, and fiber

Figure 2 shows box-and-whisker plots for energy (kilocalories per day) and macronutrient (expressed both in grams per day and percentage of total energy) intakes of studies included in the SR, the intake of the MEDIDIET study, and the corresponding DRVs.

In the MEDIDIET study, the energy intake was 1950 kcal/d, 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 that in 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/d; Figure 2A).

Mothers participating in the MEDIDIET study had an intake of carbohydrates of 269.8 g/d, which was close to the median intake (i.e., 270 g/d; Figure 2B) 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/d) and Italian (280 g/d) mothers, respectively. In addition, Spanish breastfeeding women in the study of Sanchez at al. (29) showed a carbohydrate intake slightly lower than that of 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 2C).

The protein intake was higher than the AR of 53.5 g/d but close to the median of the protein intake distribution (MEDIDIET = 87.8 g/d compared with the median = 85.4 g/d; Figure 2D) and similar to those (from 79.2 to 96.7 g/d) 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 2E).

With a fat intake of 65.6 g/d, MEDIDIET was lower than the 25th percentile of fat intake distribution and the lowest intake among Mediterranean studies (20, 29, 50, 51). In terms

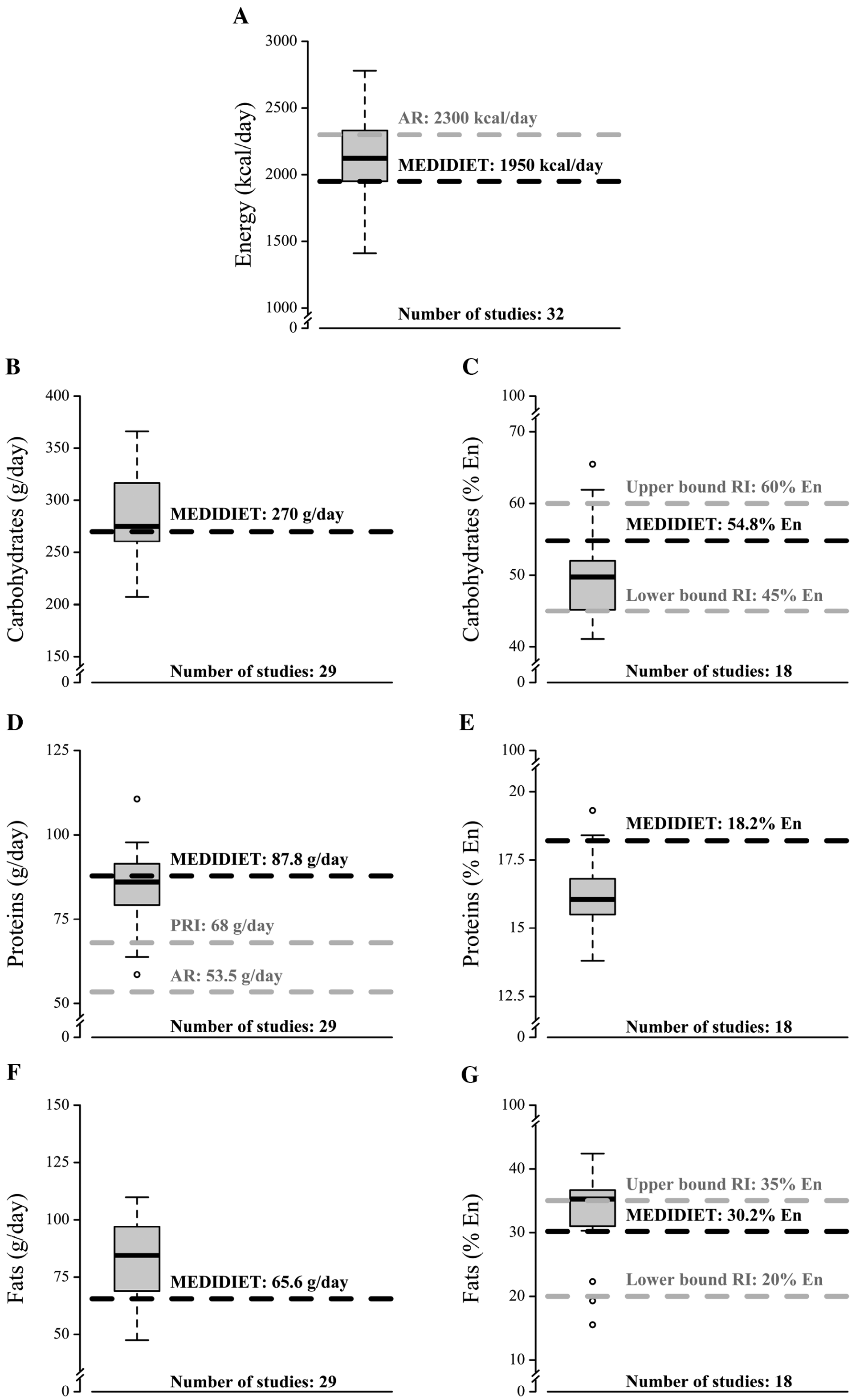

FIGURE 2 Box-and-whisker plots of energy (A), carbohydrates (B, C), proteins (D, E), and fats (F, G) intake distributions of breastfeeding mothers for studies included in the systematic review and in the MEDIDIET study, and the corresponding dietary reference values. The black dotted lines indicate the intake of the MEDIDIET study; the gray dotted lines indicate the EFSA's DRVs (40). AR, average requirement; DRVs, dietary reference values; EFSA, European Food Safety Authority; PRI, population reference intake; RI, reference intake range; % En, percentage of total energy.

of percentage of total energy, the intake of mothers participating in the MEDIDIET was 30.2% En, conforming to the RI (Figure 2F).

The cholesterol intake was 298 mg/d, 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/d) of the cholesterol intake distribution of the SR.

With regard to fiber, the MEDIDIET study showed an intake of 14.8 g/d, which was less than the AI of 25 g/d, the median intake distribution of 23.4 g/d observed in the SR, and the intake of 20 g/d 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/d; Table 3) far below the median of SFA intake distribution (33.7 g/d). In addition, MEDIDIET showed an intake of SFA considerably lower than those of other countries (20, 51) bordering the Mediterranean Sea—that is, 31.7 g/d in the study of Kresic et al. (20) and 41.0 g/d in the study of Scopesi et al. (51). Likewise, MUFA intake of 29.4 g/d was lower than the median of MUFA intake distribution (32.8 g/d) 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/d), which was close to that of the Italian study of Scopesi et al. (51) of 8.6 g/d but far lower than 15.4 g/d 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/d and 3.1% En) and LA (6.4 g/d) compared with studies included in the SR (Table 4). Conversely, with an intake of 0.26 g/d, Italian mothers showed an ARA intake considerably higher than that in other studies but far lower than that (1.10 g/d) reported by Barrera et al. (33) for Chilean mothers. The intake of ω-3 fatty acids of the MEDIDIET study was 1.4 g/d. In terms of percentage of total energy, the intake was 0.7% En, close to the intake of 0.6% En reported by Samur et al. (48). With 1.1 g/d, ALA intake was slightly lower than the intake of 1.5 g/d reported by Scopesi et al. (51) but close to the median of ALA intake distribution (1.2 g/d). The MEDIDIET study showed the highest values for EPA and DHA with intakes of 0.13 g/d (EPA) and 0.17 g/d (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/d).

MEDIDIET study: minerals

The intake of calcium (792 mg/d; Table 5) observed in the MEDIDIET study was in accordance to the corresponding AR of 805 mg/d. In addition, the MEDIDIET study showed a calcium intake lower than those reported by the Mediterranean studies of Kresic et al. (20) and Sanchez et al. (29). The intake of phosphorus was 1358 mg/d, 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, the MEDIDIET study showed an intake considerably higher than the AI of 550 mg/d. With regard to potassium, in the MEDIDIET study the intake was 3304 mg/d, which was higher than the median (3063 mg/d) of potassium intake distribution but lower than the AI (4000 mg/d). Mothers participating in the MEDIDIET study had the lowest intake of iron (10.8 mg/d), similar to the intakes observed in the studies of Kresic et al. (20) and Sanchez et al. (29) (12.0 and 15.2 mg/d, respectively). However, the intake observed in the MEDIDIET study was higher than the AR for iron of 7 mg/d. With 11.4 mg/d, the intake of zinc was slightly higher than both the median observed in the SR (10.0 mg/d) and the corresponding recommendation (AR = 10.6 mg/d). The intake of sodium for mothers participating in the MEDIDIET study was 1903 mg/d, in accordance with the AI of 2000 mg/d.

MEDIDIET study: vitamins and β-carotene equivalent

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

Discussion

In this work, we reviewed the literature on energy and nutrient intakes 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 behaviors across geographical area, populations, and over time, findings of the current 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 were in agreement with the recommendations, whereas protein intake was generally higher. In addition, our findings showed higher intakes for phosphorus, iron, and vitamin B-6 than the DRVs. Phosphorus intake was two- or threefold higher than the AI of 550 mg/d. 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/d in adults aged >18 y (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 longer term with dosages of phosphorus up to 3000 mg/d (53). All studies included in the SR showed an intake of iron higher than the AR (7 mg/d). In particular, the study of Choi et al.

(43) showed an intake of iron (23.2 mg/d) considerably higher than the AR and also higher than the corresponding PRI of 16 mg/d. Few studies reported the intake of vitamin B-6, which was slightly higher than the recommendation. Conversely, the intakes of potassium and vitamin D were lower than the DRVs (AIs of 4000 mg/d and 15 μg/d, respectively). Both cohort studies and randomized controlled trials suggested that an intake of potassium <3500 mg/d was associated with adverse health outcomes, particularly cardiovascular diseases (54). Only a few studies included in the SR (18, 26, 43) showed an intake of potassium >3500 mg/d, whereas mothers participating in the MEDIDIET study had an intake slightly lower than this threshold (3304.3 mg/d). Maternal vitamin D deficiency during lactation has been the subject of intensive research assessing the relation between adequate vitamin D concentration in maternal serum and infant growth and development. Low vitamin D serum concentration of breastfeeding women is essentially related to lack of sun exposure and minimal intake of vitamin D from the diet (55). In 2013, an SR of experimental studies showed a strong positive association between maternal vitamin D supplementation during lactation and infant serum 25-hydroxyvitamin D concentration. 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 that is characterized by high consumption of vegetables, fruits 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 previous 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 grams per day was attributable to the low energy intake observed in the MEDIDIET study. In terms of percentage of total fats, however, mothers in the MEDIDIET study showed the highest concentration 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 (grams per 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, concentrations 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 review of studies reporting plasma levels of ω-3 fatty acids, DHA, and EPA in healthy adults found very low blood concentrations 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 concentrations and adherence to the Mediterranean diet (63). With regard to mineral and vitamin intakes, mothers in the MEDIDIET study showed concentrations of these nutrients consistent with a typical Mediterranean diet (64). MEDIDIET showed the highest intake of vitamin C, but a direct comparison with Mediterranean area studies 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 nonpregnant and nonlactating women aged 20–50 y enrolled in the Mediterranean Healthy Eating, Ageing, and Lifestyle 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 AI 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 concerns the assessment of maternal diet in different time periods (e.g., 1, 3, and 6 mo or later postpartum). Indeed, for studies in the SR that 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. Because higher within-subject correlation leads to lower variance, we overestimated the overall SD because we assumed independence (i.e., within-subject correlation equal to 0) (31). In addition, studies included in the current 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 behaviors change over time, introducing a further source of variability in the maternal nutrient intakes. The limited sample size (i.e., <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 an SD for nutrient intake considerably lower or higher than those of the other studies. Different populations with different dietary behaviors could partially explain these different SDs; however, we cannot exclude some bias in collecting and reporting dietary information for these studies. Last, 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." Regarding the MEDIDIET study, the FFQ used to collect dietary information was validated in an Italian sample of a healthy adult population, which could substantially differ from the 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 current 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—that is, 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 has used this tool to investigate Italian dietary behavior in adults for a long time (67, 68), strengthening reliability of dietary information collected. Last, 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. Last, 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 not only may be beneficial to the mother but also may play a positive influential role in the composition and quality of human milk as well and therefore for the growing infant.

Acknowledgments

We thank M. Parpinel for her valuable comments. We also thank Frank Wiens, who was former project leader of the MEDIDIET study for Danone Nutricia Research. The authors' responsibilities were as follows—EV and MF: designed the research; MDM, SRBME, and MF: conducted the research (reviewed the literature); MDM: analyzed the data, performed statistical analysis, wrote the paper, and had primary responsibility for the final content; SRBME, FB, CA, BS, and MF: contributed to the results' interpretation; GEM: directed data acquisition for the MEDIDIET study; PT, PAQ, GS, CP, and IK: managed data acquisition for the MEDIDIET study; and all authors: read and approved the final 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); and Villani Antonio ("Casa Sollievo della Sofferenza" Foundation, San Giovanni Rotondo, Italy).

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Appendix A

("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, 31 January, 2020; species, human; language, English.