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Review

Olive oil consumption confers protective effects on maternal-fetal outcomes: A systematic review of the evidence

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ABSTRACT

Because of the maternal diet's importance, numerous studies have examined the effects of olive oil on pregnancy outcomes. This study provides a systematic review that evaluates the evidence between olive oil consumption and maternal-fetal outcomes. We hypothesized that olive oil reduced the risk of adverse pregnancy complications. We searched Web of Science, Scopus, PubMed, and Biblioteca Virtual em Saúde electronic databases (October and November 2021). The keywords used were pregnancy, olive oil, and pregnancy outcomes. This review included all the available studies in English and Portuguese. The exclusion criteria were (1) unrelated to olive oil consumption, (2) other outcomes, and (3) animal studies. The review included 9 articles (6 experimental and 3 observational). In the maternal outcome studies (n = 6), a higher olive oil consumption was associated with a lower prevalence of gestational diabetes mellitus, preeclampsia, and cardiovascular risk. In the fetal outcome studies (n = 8), olive oil consumption was associated with a lower risk for small- or large-for-gestational-age infants. Olive oil consumption confers protective effects on pregnancy outcomes; however, further studies are needed that are specifically designed for the impact of olive oil consumption on maternal-fetal outcomes.

Abbreviations: EVOO, extra virgin olive oil; FFQ, food frequency questionnaire; GDM, gestational diabetes mellitus; LGA, large-for-gestational-age; MD, Mediterranean diet; SGA, small-for-gestational-age; VOO, virgin olive oil.

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1. Introduction

Pregnancy is a crucial period of restructuring in women's lives. During this stage, many physiological, emotional, behavioral, and dietary changes occur [1]. Nutrition, because it plays a significant role in this process and is a modifiable factor, has been the focus of several interventions [2]. A healthy diet, such as the Mediterranean Diet (MD), reduces the risk of related disorders for both the mother and the fetus. The MD has been associated with a reduced risk of gestational diabetes, preeclampsia, hypertension, and preterm birth [3–6].

The MD is a sustainable dietary pattern rich in fiber and antioxidants due to owing to the high consumption of fruits, vegetables, legumes, whole grains, and olive oil [7,8]. Olive oil is an essential dietary component, having a high content of monounsaturated oleic acid and bioactive compounds such as terpenes, carotenoids, and polyphenols [9]. It is important to recognize that various grades of olive oil exist and each has its unique combination of production methods, nutritional content, and sensory appeal. Virgin olive oil (VOO) may have sensory defects at a low level, and its acidity should not exceed 2%. Extra virgin olive oil (EVOO) is the highest quality, with an acidity not exceeding 0.8% and no sensorial defects present [10]. Using EVOO as a part of an MD intervention has been shown to prevent cardiovascular events compared with low-fat intervention using other vegetable oils such as sunflower oil or regular olive oil [11]. This cardioprotective potential has been partially attributed to polyphenol compounds from EVOO acting on the protection of blood lipids from oxidative stress [12] and their antiteratogenic and anti-inflammatory activity [13–16].

Considered the benefits of olive oil consumption, studies have examined the effect of olive oil on pregnancy outcomes in both mother and fetus. This review aimed to assess the evidence between olive oil consumption and maternal-fetal outcomes through a systematic review of the literature. We hypothesized that olive oil reduces the risk of adverse pregnancy outcomes. A search of the relevant literature showed that this is the first systematic review to assess this topic.

2. Materials and methods

This study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines [17]. No review protocol has been registered. This systematic review did not require ethical approval.

2.1. Research question

The Population, Intervention, Comparison, and Outcome [18] strategy was used to plan the research question: "How does olive oil consumption or supplementation affect pregnancy outcomes?" Table 1 describes the strategy in detail.

The authors included prospective human observational cohort and case-control studies that measured olive oil intake and assessed maternal-fetal outcomes. Complete experimental studies were selected when they met the following criterion: evaluated maternal and fetal health in pregnant women supplemented or not with olive oil.

Table 1 – The Population, Intervention, Comparison, and Outcome strategy.

Criteria	Definition
Population	Pregnant women
Intervention	Supplementation or assessment of dietary intake of olive oil (extra virgin olive oil/virgin olive oil)
Comparison	With pregnant women who did not consume olive oil or consumed less
Outcome	Pregnancy complication for maternal and fetal health

Maternal-fetal complications included size for gestational age (small-for-gestational-age [SGA] and large-for-gestational-age [LGA]), prematurity, gestational diabetes mellitus [GDM], preeclampsia, and cardiovascular risk). Exclusion criteria were (1) unrelated to olive oil consumption, (2) other outcomes, and (3) animal studies.

2.2. Research strategy

We searched the Web of Science, Scopus, PubMed, and Biblioteca Virtual em Saúde electronic databases (October 2021). The following keywords were used: ("pregnancy" OR "pregnancies" OR "pregnant women") AND ("olive oil" OR "olive" OR "Olea") AND ("maternal health" OR "pregnancy complications" OR "pregnancy outcome"). This review included all the available studies in English and Portuguese, without restrictions on publication date.

2.3. Screening and selection of studies

The search for articles was carried out in October and November 2021 and analyzed by 2 researchers (A.C.R. and J.A.S.). The studies retrieved after the search were imported into software Excel, version 16.65, and duplicates were removed. First, the articles were selected by reading all titles and abstracts. In the second step, they were read in full and selected based on the inclusion criteria. Subsequently, the following information was extracted: author, year, location, study design, results (relationship between olive oil consumption and pregnancy outcomes: risk ratio), and the risk of bias. The article identification and selection processes are shown in Fig. 1.

2.4. Risk of bias

The Joanna Briggs Institute critical appraisal tool [19] was used to assess the quality of the studies. The studies were classified by 2 authors (A.C.R. and J.A.S.) who evaluated them as "yes," "no," or "not applicable." The quality level was determined as fair, moderate, or good (fair when $\leq$40% of items presented were positive; moderate, $\geq$41 and $<$80%; good, $\geq$80% of items presented are positive). No studies were excluded based on their quality. However, the process allows for transparency and understanding of the study's contribution to the review findings.

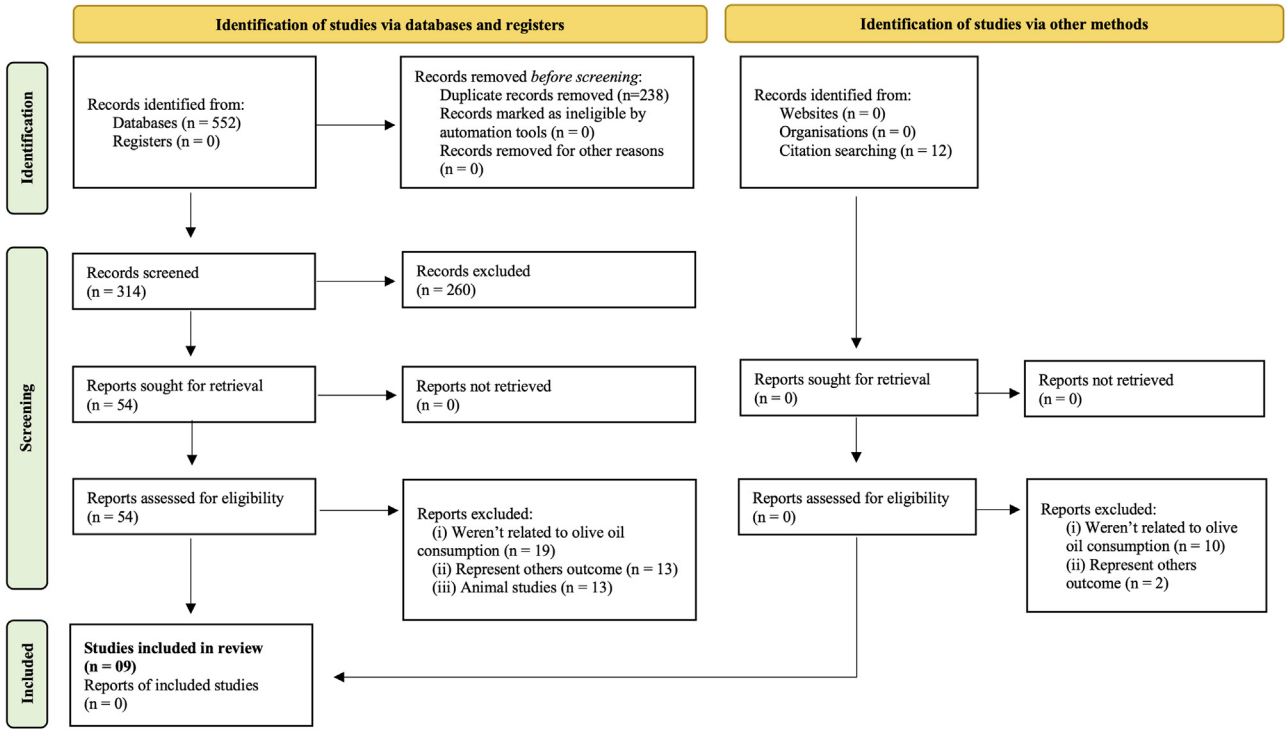

Fig. 1 – Flow diagram of the studies included in the review. The selection process of included studies was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines.

3. Results

3.1. *Search findings*

First, a total of 552 studies were included. After removing duplicates, 312 articles were selected based on their titles and abstracts, leaving 54 articles for complete reading. Of these, 45 were rejected based on the exclusion criteria. In the end, 9 studies were included in the review (Fig. 1).

3.2. *Characteristics of the included studies*

The 9 selected studies provided information on women from Spain, Argentina, Denmark, Italy, and the United Kingdom. The sample size included in each study ranged from 30 to 35,530 women, and the articles were published between 2008 and 2020. Detailed descriptions of the selected experimental and observational studies are presented in Tables 2 and 3.

The risk of SGA newborns was addressed in 7 studies [20–26]. Four articles assessed the risk of LGA infants [20–22,24]. Premature birth and GDM were addressed in 3 articles [20,24,27]. The risk of preeclampsia [21,26] and cardiovascular disease [24,28] was addressed in 2 of the 9 articles analyzed.

Data on eating habits, including olive oil consumption, were collected using a food frequency questionnaire (FFQ). Five studies used the shorter 15-item FFQ, whereas the remaining studies used the full version with 101, 137, and 360 items. The methods of olive oil consumption measures are described in Tables 2 and 3.

3.3. *Quality of reporting*

Of the included studies, 67% (n = 6) were interventional, of which 5 were randomized controlled trials (RCTs) and 1 was quasi-experimental; 33% were observational, 2 were case-control, and one1 was a cohort study. Quality analysis was performed based on the critical appraisal criteria for the Joanna Briggs Institute critical appraisal tool [19]. Of the articles, 78% (n = 7) were classified as moderate quality and 22% (n = 2) were classified as good quality. Tables 2 and 3 present these results.

3.4. *Evidence synthesis*

Considering the wealth of maternal-fetal outcomes, we categorized them into 1 of 6 categories: SGA and LGA newborns and prematurity on the fetal side, and GDM, preeclampsia, and cardiovascular risk on the maternal side.

3.4.1. *SGA newborns*

Evidence for this outcome came from 5 RCTs and 2 case-control studies. Three randomized studies showed that the interventional group (supplementation with 40 g/d of EVOO) had significantly lower SGA levels than the control group (restricted fat diet) [20–22]. In a case-control study [23], the consumption of VOO (at least 54 g/d) also showed a reduced risk of SGA, demonstrating a protective effect on birth weight. However, in another case-control study [25], SGA risk increased with high consumption of VOO. Ribot et al. [24] and Wattar et al. [26] found no differences between the means of the intervention (supplemented with EVOO) and the control groups.

Table 2 – Characteristics of the interventional studies (n = 6).

Author	Geographic area	Included participants	Olive oil consumption measure	Outcome	Results	Quality
Assaf-Balut et al. (2017) [20]	Spain	IG: n = 500, MD supplemented with EVOO (>40 g/d) CG: n = 500, MD restricted in fat	FFQ (15 items) and MEDAS (14 items) by trained interviewers (at first ultrasound visit, at 24-28 GA, at 36-38 GA, and delivery)	Maternal: GDM	IG: <GDM (0.73 [95% CI, 0.56-0.97], $P = .022$)	77% Moderate
				Fetal: Prematurity SGA LGA	IG: <Prematurity (0.29 [95% CI, 0.11-0.77], $P = .013$) IG: <SGA (0.21 [95% CI, 0.08-0.54], $P = .001$) IG: <LGA (0.19 [95% CI, 0.07-0.57], $P = .003$) (Adjusted for smoker, gestational, and family history)	
Assaf-Balut et al. (2018) [21]	Spain	IG: n = 500, MD supplemented with EVOO (>40 g/d) CG: n = 500, MD restricted in fat	FFQ (15 items) and MEDAS (14 items) by trained interviewers (at first ultrasound visit, at 24-28 GA, 36-38 GA, and delivery)	Maternal: Preeclampsia	IG: <Preeclampsia (0.22 [95% CI, 0.12-0.41], P = .001)	69% Moderate
				Fetal: SGA LGA	IG: <SGA (0.26 [95% CI, 0.08-0.80], $P = .018$); IG: <LGA (0.25 [95% CI, 0.07-0.90], $P = .034$)	
Assaf-Balut et al. (2019) [28]	Spain	IG: n=999, MD supplemented with EVOO (>40 g/d) CG: n=676, MD restricted in fat	FFQ (15 items) and MEDAS (14 items) by trained interviewers (at first ultrasound visit, at 24-28 GA, at 36-38 GA, and delivery)	Maternal: Cardiovascular risk	IG: <Cardiovascular risk (0.74 [95% CI, 0.60-0.90])	69% Moderate
				Fetal: 0		
Ribot et al. (2020) [24]	Argentina	IG: n=15 pregnant women with GDM, diet supplemented with EVOO (36 g/d) CG: n=15 mothers with GDM, diet restricted in EVOO (0-12 g/d)	FFQ by nutrition professionals and diet composition is evaluated (every 1-4 wk)	Maternal: Hypertension	IG: <Triglyceridemic level ($P = .002$)	54% Moderate

(*continued on next page*)

Table 2 (*continued*)

Author	Geographic area	Included participants	Olive oil consumption measure	Outcome	Results	Quality
				Fetal: Prematurity SGA LGA	IG = CG: Prematurity IG = CG: SGA IG = CG: LGA	
Melero et al. (2020) [22]	Spain	IG: n = 143, MD supplemented with EVOO (>40 g/d) CG: n = 142, MD restricted in fat RWG: n=315	FFQ (15 items) and MEDAS (14 items) by trained interviewers (at first ultrasound visit, at 24-28 GA, at 36-38 GA, and delivery)	Maternal: GDM	IG compared with CG: <GDM (25.8% CG vs. 14.8% IG, $P = .021$) RWG compared with IG: <GDM (13.4% RWG, $P = .011$)	62% Moderate
				Fetal: SGA LGA	IG compared with CG: <SGA (5.3% CG vs. 0.8% IG, $P = .036$) IG compared with CG: <LGA (6.1% CG vs. 0.8% IG, $P = .02$) RWG compared with IG: no differences found	
Wattar et al. (2019) [26]	United Kingdom	IG: n = 627, MD supplemented with EVOO (>50 g/d) CG: n = 625 MD restricted in fat	Validated FFQ (101 items) and ESTEEM Q shot questionnaire by trained research during (at 18 GA, 20 GA, and 28 GW)	Maternal: GDM, preeclampsia	IG = CG: GDM (0.76 [95% CI, 0.56-1.03], $P = .08$) IG = CG: preeclampsia (0.76 [95% CI, 0.56-1.03], $P = .08$)	85% Good
				Fetal: SGA	IG = CG: SGA (0.79 [95% CI, 0.58-1.08], $P = .14$) (sdjusted for age, history of previous GDM or stillbirth, and family history)	

Abbreviations: BMI, body mass index; CG, control group; CI, confidence interval; ESTEEM Q, Effect of Simple, Targeted Diet in Pregnant Women with Metabolic Risk Factors on Pregnancy Outcomes questionnaire; EVOO, extra-virgin olive oil; FFQ, food frequency questionnaire; GA, gestational age; GDM, gestational diabetes mellitus; IG, interventional group; LGA, large-for-gestational-age; MD, Mediterranean diet; MEDAS, Mediterranean Diet Adherence Screener; RWG, real-word group (another group that implemented the same IG routine clinical practice); SGA, small-for-gestational-age.

Table 3 – Characteristics of observational studies (n = 3).

Author	Geographic area	Study design	Included participants	Olive oil consumption measure	Outcomes	Results	Quality
Mikkelsen et al. (2008) [27]	Danish	Prospective cohort	N = 35,530, with a live-born singleton pregnancy	FFQ (360 items) self-administered by e-mail (25 wk)	**Maternal:** 0		73% Moderate
					Fetal: prematurity	Consumption of VOO does not affect the risk of prematurity (1.02 [CI, 0.86-1.23]) (Adjusted for parity, BMI, maternal height, socioeconomic status, and cohabitant status)	
Ricci et al. (2009) [25]	Italy	Case-control	Case: n = 555 with SGA (olive oil intake high, n = 65; moderate, n = 417; low, n = 72) Control: n = 1966 (olive oil intake high, n = 146; moderate, n = 1611; low, n = 209)	FFQ (15 items) by trained interviewers (the period immediately before becoming pregnant and in the last month of pregnancy)	Maternal: 0		70% Moderate
					Fetal: SGA	High consumers of VOO increase the risk of SGA (1.6 [95% CI, 1.0–2.5], P = .04) (adjusted for age, education, parity, BMI, smoker, alcohol consumption, SGA, and weight gain in pregnancy)	
Martínez-Galiano et al. (2018) [23]	Spain	Case-control	Case: n = 518 with SGA Control: n = 518 with normal weight for GA	FFQ (137 items) by trained interviewers (2 days after delivery)	Maternal: 0		80% Good
					Fetal: SGA	Daily consumption of VOO (>54 g/d) reduces the risk of SGA (0.53 |95% CI, 0.34-0.85) (adjusted for smoker, SGA, previous SGA/preterm, energy intake, and prepregnancy BMI)	

Abbreviations: BMI, body mass index; CI, confidence interval; FFQ, food frequency questionnaire; GA, gestational age; SGA, small-for-gestational-age; VOO, virgin olive oil.

3.4.2. *LGA newborns*

Four of the 9 included articles evaluated olive oil consumption and the possibility of LGA in newborns. All papers are RCTs and evaluated the effect of an EVOO-enhanced MD on the intervention, compared with the MD with a fat-restricted control group. Three studies [20–22] reported a significant decrease in newborn LGA rates in the intervention group and 1 study [24] reported no difference in offspring complications between both groups.

3.4.3. *Prematurity*

From the reviewed studies, 2 [24,27] concluded that there was no associative effect between olive oil and prematurity risk. The prospective cohort study conducted on 35,530 pregnant women showed that maternal consumption of VOO was not associated with reduced risk of preterm birth [27], and the RCT [24] reported no differences between the means of intervention (supplemented with 36 g/d of EVOO) and the control group (restricted fat diet). However, another RCT [20] revealed that the intake of an MD supplemented with 40 g/d of EVOO reduced prematurity rates compared with a control group with restricted fat.

3.4.4. *Gestational diabetes mellitus*

Evidence for this outcome was obtained from 3 RCTs. Assaf-Balut et al. [20] and Melero et al. [22] demonstrated that 40 g/d of EVOO supplementation reduced the incidence of GDM. Wattar et al. [26] found no differences in GDM incidence between the intervention group, which was encouraged to consume at least 50 g of EVOO per day, and the control group.

3.4.5. *Preeclampsia*

Wattar et al. [26] found that EVOO (supplementation of 50 g/d) does not reduce the overall risk of pregnancy complications but can reduce gestational weight, which is a risk factor for preeclampsia. In contrast, Assaf-Balut et al. [21] reported that promoting EVOO consumption (supplementation of 40 g/d) lowered the risk of preeclampsia.

3.4.6. *Cardiovascular risk*

One study [28] observed a reduction in postpartum rates among pregnant women who followed a diet based on an MD enriched with EVOO. Ribot et al. [24] also reported reduced triglyceride levels in mothers who were supplemented with EVOO compared with those who followed a low-fat diet during pregnancy.

4. Discussion

This study assessed the effects of olive oil consumption and maternal-fetal outcomes. The review included 9 articles: 6 interventional and 3 observational. Although in all the interventional studies included, the type of olive oil is clearly identified as EVOO, in the observational articles, the type of olive oil consumed was not specified in the FFQ or not identified in the study. Most studies have indicated that olive oil consumption can reduce adverse maternal and fetal effects, such as SGA and LGA newborns, GDM, preeclampsia, and cardiovascular risk, confirming our hypothesis. To our knowledge, no systematic review has been performed summarizing the evidence on olive oil consumption and maternal-fetal outcomes.

Regarding weight at birth, 7 papers analyzed SGA and LGA. These 2 parameters assess fetal growth; SGA is an indicator of fetal growth restriction, which increases the risk of fetal mortality and mobility, and LGA is an indicator of sizable fetal development, which is related to an increase in birth complications [29] Four articles [20–23] demonstrated that consumption of olive oil reduced the risk of SGA newborns. Three of these articles evaluated EVOO intake and 1 evaluated VOO consumption. Concerning LGA, 3 studies [20–22] demonstrated a reduced risk when the mother maintained a healthy diet supplemented with EVOO. A nutritional intervention that reduced both extremes (SGA and LGA) and increased EVOO consumption was beneficial. In the study by Ricci et al. [25], the risk of SGA was increased when olive oil consumption was "high," but this study had methodological limitations. Fat consumption was subjectively assessed as low, normal, or high, which did not allow the identification of the average amount of consumption. Ribot et al. [24] found no association between olive oil consumption and SGA or LGA; however, they presented only a moderate study quality classification.

Preterm birth was defined as the birth of a baby before 37 weeks' gestation. Prematurity is significantly associated with mortality, morbidity, and long-term adverse fetal health complications [30]. An MD during pregnancy may reduce the risk of early delivery; nevertheless, when the authors separately evaluated the consumption of olive oil, no associations were observed [24,27]. Conversely, Assaf-Balut et al. [20] found a significant reduction in the rates of prematurity.

GDM is a form of glucose intolerance first diagnosed during pregnancy. It has grave consequences for pregnant women and their fetuses [31]. Two articles [20,22] reported a decreased risk of GDM. This positive effect may be mediated by the ingestion of dietary polyphenols in EVOO, which appear to reduce insulin resistance and modulate gliosis release [32]. Another study [26] concluded that olive oil consumption during pregnancy did not reduce the overall risk of GDM but could reduce gestational weight gain, a risk factor.

Preeclampsia is characterized by the onset of hypertension after 20 weeks of gestation [33]. Some studies have shown that maternal diet potentially affects the modulation of the placental microbiome [34]. In a study by Assaf-Balut et al. [21], the decreased risk of preeclampsia was related to the consumption of EVOO, a food rich in antioxidant compounds and a source of phenolic acids, alcohols, and flavonoids [13,35]. Wattar et al. [26] did not observe any reduction in preeclampsia risk. Placental remodeling occurs during the first weeks of pregnancy; consequently, dietary interventions may not have been started sufficiently early to see any benefits.

When evaluating cardiovascular risk, 2 articles [24,28] included in the review assessed and found a relationship between the reduction in triglyceride levels in pregnant women who followed nutritional therapy based on the increased consumption of olive oil, particularly EVOO. Beneficial effects are in part attributed to hydroxytyrosol and phenolic compounds in EVOO through the regulation of microRNAs involved in the development of cardiovascular diseases [36,37].

This systematic review has certain limitations. Notably, the heterogeneity of the studies, divergent sample sizes, different questionnaires used in the assessment of olive oil consumption and identified biases could have compromised the accuracy of the results. The heterogeneity of the type of olive oil consumed (EVOO/VOO or refined olive oil), as well as possible differences in the phenolic compound content of different types of olive oil, may affect the results. Additionally, some of the included studies had the primary objective of assessing other criteria than olive oil intake. Therefore, more studies focusing on the impact of olive oil consumption on decreasing the possibility of adverse maternal-fetal outcomes are still necessary.

5. Conclusion

Our systematic review suggests that olive oil consumption can confer protective effects on pregnancy outcomes, specifically by decreasing the risk of SGA and LGA infants, GDM, preeclampsia, and maternal cardiovascular risk. However, further studies are needed that are specifically designed for the impact of olive oil consumption on maternal-fetal outcomes.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Anna Carolina Cortez-Ribeiro: Conceptualization, Methodology, Formal analysis, Writing – original draft, Visualization. **Manuela Meireles:** Formal analysis, Writing – review & editing, Supervision, Funding acquisition. **Vera Ferro-Lebres:** Conceptualization, Writing – review & editing, Supervision. **Juliana Almeida-de-Souza:** Conceptualization, Methodology, Writing – review & editing, Supervision.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.nutres.2022.12.013.

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