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Effects of Adherence to Mediterranean Diet During Pregnancy on Neonatal Outcomes: A Systematic Review

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ABSTRACT

Background: Many environmental factors during pregnancy affect neonatal health. Maternal nutrition and dietary patterns are major determinants of neonatal health. Pregnant women face many problems pre- and post-delivery. Some complications include hypertension, obesity, cardiovascular disorders, hyperlipidemia, and gestational diabetes.

Objective: To determine the effects of adherence to the Mediterranean diet during pregnancy on neonatal outcomes

Methods: The systematic review involves different research available in the Cochrane Library and PubMed. It included ten studies for qualitative synthesis and gathered results from different study designs. The key terms and search words included Mediterranean diet, intrauterine growth, Birth outcome, pregnancy outcome, obstetric outcome, neonatal, fetal. The study question was structured according to the PECO criteria. The databases were searched from their inception until December 31, 2024. Studies were included if they were published in English and assessed the association between maternal adherence to the Mediterranean dietary pattern during pregnancy and the health status of the newborn or offspring. Studies were reviewed based on the population studied, the food exposure, and the outcomes of interest. Articles were excluded if they were duplicates or were not available in English. The selection process of studies is shown in the PRISMA flow diagram. Using a structured data collection form, the data were collected. The extracted information encompassed characteristics of the study, study population, study design, assessment of exposure to the Mediterranean diet, neonatal/offspring outcomes, and the key findings presented by each study.

Results: Single dietary pattern, the Mediterranean dietary pattern has positive effects during and after pregnancy on the neonate. Mediterranean diet is linked with reduced risk of neural tube defects (spina bifida), congenital anomalies (atrioventricular septal defects), very low birth weight, prematurity, small for gestational age, and allergic disorders (eczema, atopy, and asthma), and hence reduces the adverse neonatal outcomes.

Conclusion: Adherence to a Mediterranean dietary pattern throughout pregnancy is remarkably related to reducing the risk of adverse neonatal outcomes. There are no consistent associations and less evidence regarding asthma and allergic disease in the progeny. Most of the studies indicate a beneficial association between adherence to the Mediterranean diet during pregnancy and neonatal outcomes.

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INTRODUCTION

Maternal nutrition and dietary patterns are major determinants of neonatal health.[1] For this purpose, many articles were targeted to obtain overall results; hence, pregnant women face many problems pre- and post-delivery. Some complications are hypertension, obesity, cardiovascular disorders, hyperlipidemia, and gestational diabetes.[2,3] On the other hand, neonates also face many complications due to low birth weight and prematurity, so maternal diet plays an important role for both.[4]

Mediterranean Diet (MD) involves a small portion of whole grains, a lot of fruits and vegetables, dairy in small portions, meat portions involving lean meat and fish, and fats that include good fats like monounsaturated and polyunsaturated fats (olive oil, corn oil, sunflower oil, safflower oil, etc.), with high fiber and antioxidants.[5] This diet will reduce complications for both mother and neonate, such as GDM, small-for-gestational age (SGA), and growth restriction.[6] A healthy diet plays a crucial role from the initial stage of placental development to the end. The Mediterranean diet positively influences mothers. MD has an essentially positive effect on maternal and posterity well-being.[1]

This systematic review summarizes the relationship between pregnant women's dietary patterns and neonates, and the Mediterranean dietary pattern proved beneficial in reducing the risk of various diseases. Further, as a result of this review, we evaluated the effects of extra virgin oil and nuts on maternal health and individually checked the results on neonates. In the review, we evaluated many studies showing that olive oil has a positive impact on both maternal health and neonates, and it reduces metabolic risks.

The MD involves a high intake of fruits and vegetables (3 to 5 portions), lean meat like chicken and fish, low amounts of skim milk and yogurt, and good fats with MUFA and PUFA. It can likewise control the risk of birth complications. It has a positive effect on maternal and neonatal well-being. The MD has a generally positive effect on maternal and neonatal well-being, reinforcing the evidence base that following this dietary pattern may protect against complications and support future neonatal health.

METHODS

Guidelines for systematic review and meta-analysis (PRISMA) were followed for literature research, study selection, data extraction, and methodological quality assessment (Figure 1). The study question was structured according to the PECO criteria mentioned in Table 1. Literature searches in PubMed and the Cochrane Library were conducted. The key terms and search words included Mediterranean diet, intrauterine growth, Birth outcome, pregnancy outcome, Obstetric outcome, neonatal, fetal. These search words examined the relationship of the Mediterranean diet throughout pregnancy with neonatal outcomes. The following keywords were used to search the literature (Table 2).

These terms were searched in two databases (PUBMED and COCHRANE LIBRARY). Appropriate studies and their reviews were also evaluated for additional studies. We searched the databases from inception through December 31, 2024. Studies were included if they were published in English and assessed the association between maternal adherence to the Mediterranean dietary pattern during pregnancy and the health status of the newborn or offspring. Studies were reviewed based on the population studied, the food exposure, and the outcomes of interest. Articles were excluded if they were duplicates, did not meet the eligibility criteria, or were not available in English.

The initial screening of all the identified records was performed on the basis of title and abstract. Full-text articles that appeared to be potentially relevant were then evaluated for eligibility. The studies were included in the end after applying the predefined inclusion criteria. The process of selection of studies is shown in the PRISMA flow diagram (Figure 2). Using a structured data collection form, the data were collected. The extracted information encompassed characteristics of the study, study population, and

Table 1: PECO criteria

PECO Components	Description
Population (P)	Pregnant women and their offspring or neonates
Exposure (E)	Adherence to a Mediterranean dietary pattern during pregnancy
Comparison (C)	Lower adherence or non-adherence to the Mediterranean diet, or other dietary patterns, where applicable.
Outcomes (O)	Neonatal and fetal outcomes, including birth weight, fetal growth, small-for-gestational-age birth, preterm birth, congenital anomalies, neural tube defects, and allergic or respiratory outcomes in the offspring

Figure 1: Conceptual Framework illustrating the relationship between adherence to the Mediterranean diet during pregnancy and neonatal

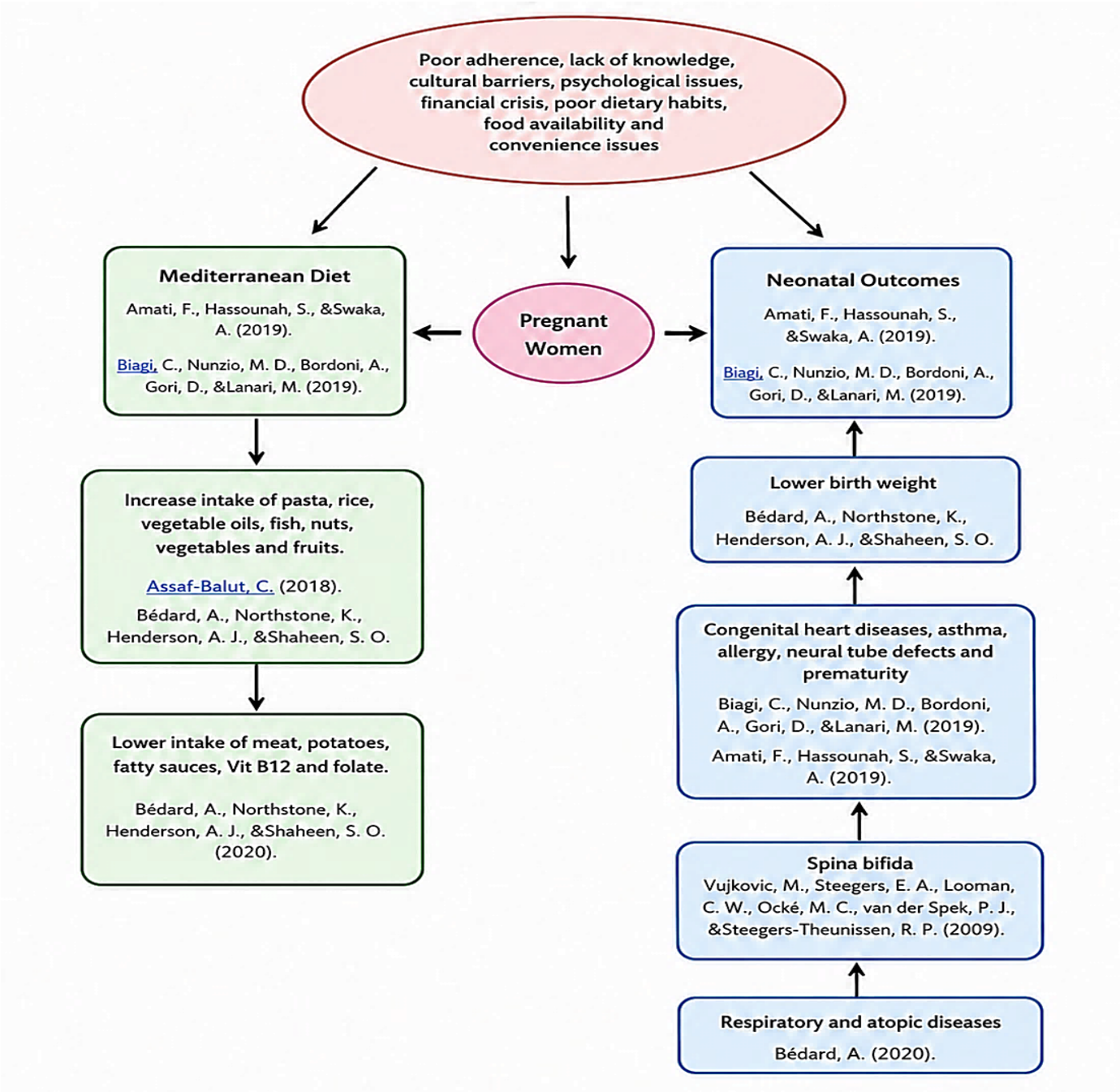


Table 2: Keywords used for search

Keywords
Mediterranean diet* AND Intrauterine growth*
Mediterranean diet* AND Birth outcome*
Mediterranean diet* AND Pregnan* outcome
Mediterranean diet* AND Obstetric outcome*
Mediterranean diet* AND Neonat*
Mediterranean diet* AND fetal*

study design, assessment of exposure to the MD, neonatal/offspring outcomes, and the key findings presented by each study.

RESULTS

The examination of the determination measure is shown in Figure 2 below. We included 234 studies and excluded 127 for duplication. 107 were screened based on titles and abstracts; 96 were excluded. Eight full-text articles were included for additional assessment. After point-by-point assessment, 10 articles were included in this study. The table below presents the characteristics of the included observational investigations. They were distributed from 2007 to 2020, and the majority were systematic reviews (n = 4), with the studies including clinical controlled trials (2), cross-sectional (1), randomized controlled (1), and mixed cohort design (2). Four studies were based in Madrid, Spain. Two were in London, and two in the Netherlands, one in Norway, and one in Italy.

from Italy. Maternal diets were typically assessed by FFQs, 24-h recalls, and food diaries. The main outcome of the study was how the Mediterranean diet affects neonatal outcomes. Results extracted from the 10 selected articles are reported in Table 3.

Evidence from 3 studies on neural tube defect was taken: one is a systematic review, and two are cross-sectional studies. In one study, 50 cases were studied; the correlation of low- to high-MD diet pattern with spina bifida during pregnancy was examined, along with 81 control mothers. A high MD pattern will result in high RBC folate levels, vitamin B12, and reduced or low homocysteine levels; therefore, low spina bifida risk. A case-control study that included 81 mothers with spina bifida and 81 control mothers, in which RRR and PCA were used, and 50 mothers of children with spina bifida to identify a comparable dietary pattern; according to MD, low adherence to MD results in increased risk for spina bifida in comparison to high adherence to MD.[8]

A case-control study by Haugen et al. included 2475 participants with orofacial clefts, 936 cases with NTDs, and 6147 controls. Hence, the Dietary Quality Index (DQI), incorporating pregnancy-specific nutritional guidelines, along with the Mediterranean Diet (MD) score, was calculated, which shows that a high DQI and MD score are associated with reduced risk. congenital defects.[9] From 3 studies, evidence for congenital defects was taken, including a systematic review and two cross-sectional studies. Chatzi studied 997 mother-child pairs and found that during pregnancy, higher adherence to the MD will result in lower diastolic and systolic blood pressure and protect infants against cardiometabolic risk.[10] A previous study has identified that diet quality has a pivotal role in lowering the occurrence of atrial septal heart defects.[11] Carlotta Biaagi, a case–control

Figure 2*:* PRISMA Flow diagram of inclusion criteria for eligible studies

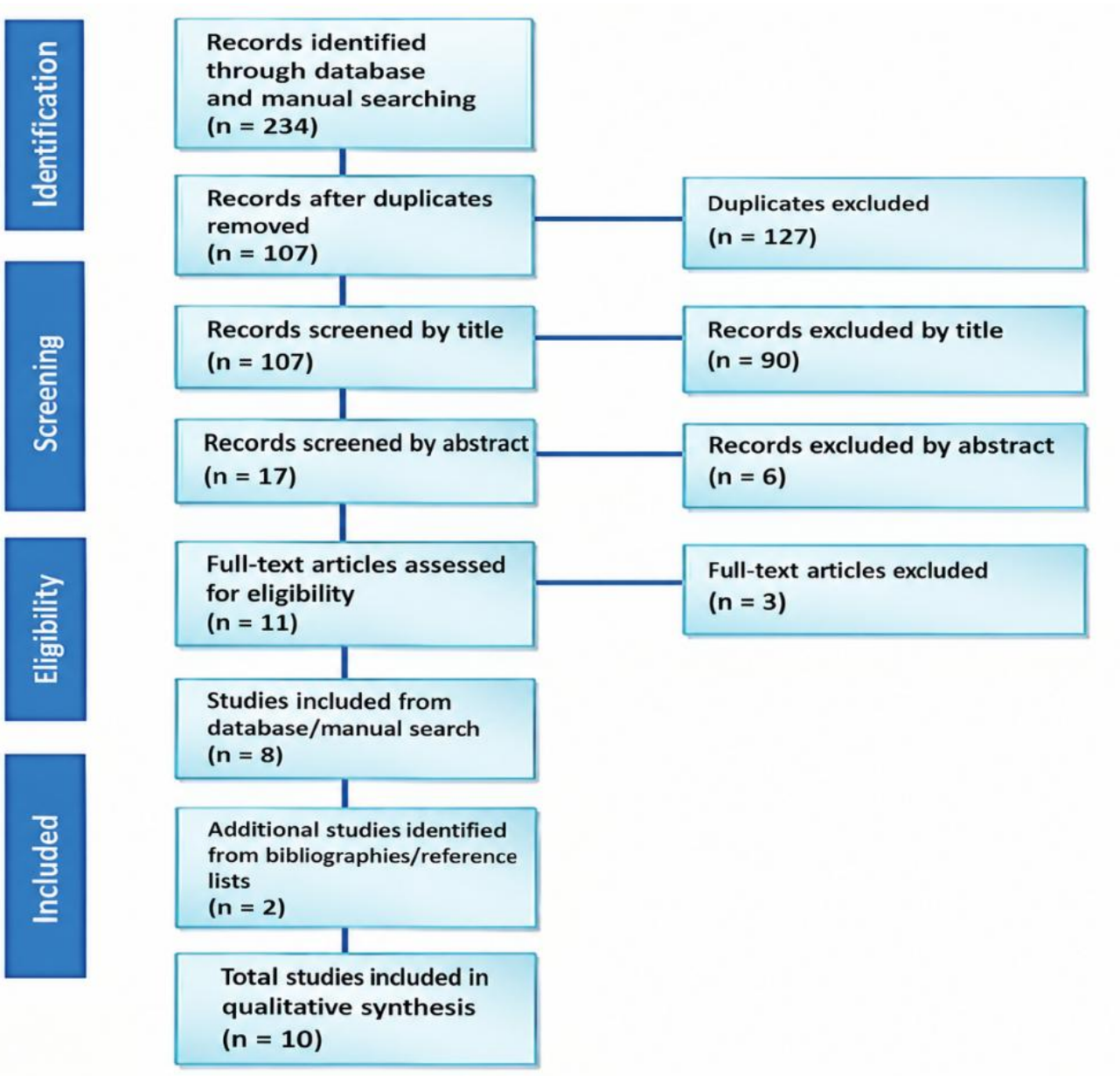


Table 3: Characteristics of studies included

Author (Year)	Country	Study design	Participants	Exposure	Outcome	Main findings	Conclusion
Assaf-Balut et al. (2018)	Spain	Randomized controlled trial	874 pregnant women enrolled at 8–12 weeks of gestation	Adherence to six Mediterranean diet targets, including vegetables, fruits, nuts, and extra virgin olive oil	Gestational diabetes mellitus (GDM), maternal-fetal complications, prematurity, urinary tract infection, and small-for-gestational-age (SGA) infants	Women with greater adherence to the Mediterranean diet had significantly lower odds of GDM, maternal-fetal complications, prematurity, urinary tract infection, and SGA births	Strong adherence to Mediterranean dietary recommendations during early pregnancy was associated with improved maternal and neonatal outcomes
Bédard et al. (2020)	United Kingdom	Prospective cohort study	Participants from the Avon Longitudinal Study of Parents and Children	Maternal Mediterranean diet during pregnancy	Childhood respiratory and allergic outcomes	Higher maternal Mediterranean diet scores were associated with better small airway function during childhood. No significant association was observed with asthma or allergic diseases	Maternal adherence to a Mediterranean diet may contribute to improved childhood lung function, although evidence for protection against asthma remains limited
Assaf-Balut et al. (2019)	Spain	Prospective cohort study	1,066 normo-glycemic pregnant women	Mediterranean diet enriched with extra virgin olive oil and nuts	GDM and pregnancy outcomes	Early nutritional counselling promoting Mediterranean dietary habits reduced the prevalence of GDM and was associated with fewer adverse maternal-fetal outcomes	Early adoption of a Mediterranean diet may serve as an effective strategy for reducing the risk of gestational diabetes
Assaf-Balut et al. (2015)	Spain	Cross-sectional study	874 pregnant women	Mediterranean diet-based nutritional therapy	Glycemic control and pregnancy outcomes among women with GDM	Most women achieved satisfactory glycemic control following Mediterranean diet-based nutritional therapy, with pregnancy outcomes	Mediterranean diet-based nutritional management appears to be an effective approach for women diagnosed with gestational diabetes
Biagi et al. (2019)	Italy	Systematic review	Studies evaluating maternal Mediterranean diet during pregnancy	Maternal adherence to the Mediterranean diet	Neonatal and childhood health outcomes	Most studies reported a lower risk of preterm birth and other adverse neonatal outcomes among women with high Mediterranean diet adherence	Current evidence supports a beneficial role of the Mediterranean diet in promoting favourable pregnancy and neonatal outcomes

Author (Year)	Country	Study design	Participants	Exposure	Outcome	Main findings	Conclusion
Amati et al. (2019)	United Kingdom	Systematic review	Pregnant women of all gestational ages	Mediterranean dietary pattern assessed using validated dietary assessment methods.	Maternal and neonatal health outcomes	Greater adherence to the Mediterranean diet was associated with a lower risk of gestational diabetes in mothers and congenital anomalies in offspring	Encouraging Mediterranean dietary habits before and during pregnancy may provide important health benefits for both mother and child
Steegers-Theunissen et al. (2012)	Netherlands	Population-based cohort study	3,207 pregnant women	Maternal adherence to the Mediterranean diet	Birth weight and fetal growth	Lower adherence to the Mediterranean diet during early pregnancy was associated with reduced birth weight and smaller fetal size	Maternal dietary quality during early pregnancy may influence fetal growth and birth weight
Steegers-Theunissen et al. (2009)	Netherlands	Case-control study	50 mothers of infants with spina bifida and 81 control mothers	Maternal dietary pattern	Risk of spina bifida	Women with greater adherence to a Mediterranean dietary pattern had a lower risk of delivering infants affected by spina bifida	A Mediterranean dietary pattern may contribute to the prevention of neural tube defects
Llopis-González et al. (2018)	Spain	Systematic review	492 pregnant women	Mediterranean dietary adherence	Birth weight and neonatal anthropometry	Higher adherence to the Mediterranean diet was associated with increased birth weight and a lower likelihood of SGA births, particularly among women with higher seafood intake	Adequate adherence to the Mediterranean diet supports optimal fetal growth and neonatal development
Haugen et al. (2007)	Norway	Prospective cohort study	Approximately 75,000 pregnancies	Mediterranean diet score based on dietary intake	Preterm birth	Adherence to Mediterranean diet criteria was not associated with a significant reduction in preterm birth	Mediterranean diet did not demonstrate a protective effect against preterm birth in this cohort

study registered 9468 mothers of unaffected infants and 9885 mothers of infants with major CHD. In this study, DQI and MD scores were assessed to reflect the best and worst diet quality. MDS, estimated risk reduction, and DQI-P were associated with only 14% for perimembranous ventricular septal defects. For DQI-P, 37% estimated risk reduction for tetralogy of Fallot, 23% for atrial septal defects, 24% for all conotruncal defects, and 14% for all septal defects.[12]

Evidence for prematurity was taken from 3 studies, comprising a systematic review, a cohort study, and a randomized controlled trial.[13] A total of 874 women were categorized into three groups based on their compliance with specific dietary guidelines during the late first trimester. These recommendations targeted the consumption of six foods: more than twelve servings per week of fruits and vegetables, less than two servings per week of juice, at least 40 mL per day, more than

three servings per week of nuts, and consumption of extra virgin olive oil (EVOO) on more than 6 days per week. It was concluded that increased adherence to MD-fix targeted foods lowers the risk of prematurity. He concluded that higher intake of fruits, nuts, vegetables, and legumes is linked with a reduced risk of prematurity.[13]

About 5738 American women serving as controls in a nationwide multicenter, population-based, case-control study were involved in the Birth Defects Prevention Study in the United States. Those women participants delivered non-malformed infants; it was concluded that adherence to a good-quality maternal diet and consuming MD is linked with a lower occurrence of negative outcomes in neonates.[9] Data from 40,817 pregnant women were analyzed using version 2 of the quality-assured data files made available for research purposes; it was concluded that women meeting the criteria for an MD did not reduce the risk of preterm birth.[14,15]

From four studies, evidence for low birth weight was taken, comprising a population-based cohort study, a cohort study, and two systematic reviews. A prospective observational study of 3207 pregnant women living in Rotterdam evaluated the relationship between dietary habits in the early phase of pregnancy (GA <18 weeks) and fetal size or weight at the time of birth and concluded that, in early pregnancy, lower adherence to the MD is linked with low birth weight and small intrauterine size, compared to high adherence.[12] Federica Amati examined six studies investigating the influence of diet on gestational diabetes, premature birth, low birth weight, and childhood obesity; it was concluded that mothers of neonates with less compliance with the MD had increased intrauterine growth and lower birth weight.[1]

Régine P, from early pregnancy, conducted a longitudinal study and concluded that during early pregnancy, less adherence to MD is linked with low birth weight and smaller intrauterine size.[16] Haugen et al. targeted 40,817 pregnant women utilizing version 2 of the quality-assured data files for research purposes. The total number of preterm births (<37 weeks) in the MD group was 26 (4.6%); in the group of women who did not meet the criteria for MD, it was 10 (6.3%). It was concluded that lower risk was associated with consuming fish twice or more per week, and women who met the criteria for MD did not have a high risk of preterm birth.[9]

The evidence for allergic reaction was taken from three studies, constructed from a systematic assessment and a cohort examination. Annabelle Bédard targeted the Avon Longitudinal Study of Parents and Children (ALSPAC), which enrolled 14,541 pregnant white women who had residency in Avon; it was concluded that following a Mediterranean style dietary pattern in pregnancy can improve features of small airways in a child, but no proof was found for a decreased risk of asthma and various allergies.[12] Seven studies describe the relationship between MD and allergic outcomes in neonates; adherence to MD is generally related to a decrease in adverse effects in infants, such as allergic issues.

The evidence for SGA is taken from two studies, comprising a cross-sectional study and a randomized controlled trial. Assaf-Balut et al. (2018 studied 874 women and then stratified them into three groups, with the late 1st trimester providing 6 meals. High consumption of the 6 targeted foods was associated with a decreased risk of SGA. Meanwhile, a food regimen rich in staple cereals, pork, bakery, fats, and fruits was related to a lower risk of SGA.[14] Peraita-Costa et al., in 2018, studied 492 pregnant women; two groups were identified among those 492 women: one with low adherence and the second with optimum adherence. It is concluded that 40.2% of the ladies confirmed low adherence to the MD. This means 40.2% (n=198) showed low adherence and 59.7% (n=294) confirmed optimal adherence. Results recommend that low adherence to the MD is not related to a high risk of SGA, but women with parental BMI >30 have a higher risk of having an SGA child.

Evidence for this outcome came from 4 studies, including a total of 874 ladies who were stratified into three groups in line with late 1st trimester with 6 target meals. Six food objectives are related to decreasing the risk of GDM. A single institution gave interventions to 932 ladies. They had a detailed lifestyle interview on regular intake of EVOO and nuts, which was collected and analyzed. They verified that an MD, along with EVOO and nuts, decreased the GDM rate from 23. Alejandra Durán did a sub-evaluation of 177 women who had been identified with gestational diabetes, and 697 had normal blood glucose levels. All GDM participants received a Med Diet-based medical vitamins remedy with a recommended daily intake of >40 mL of virgin olive oil and an everyday handful of nuts. Results were compared. At 36–38 GWs, values were comparable among them. Homeostatic and insulin resistance assessments (HOMA-IR) were better in females with gestational diabetes during fasting.

A medical nutrition remedy for gestational diabetes mellitus is primarily based on the MD. Not only GDM,

but this diet also facilitates conquering other diseases in neonates in addition to mothers. The MD pattern, which includes a low amount of sugars, ought to bring about better blood glucose control during pregnancy.

DISCUSSION

This study demonstrates the relationship between MD effects on mothers that may affect the fetus, so that we can examine the consequences of adherence to a Mediterranean food plan at some stage in pregnancy on fetal health, together with the consequences on the fetus for not following the Mediterranean eating regimen by pregnant women; as a result, the impact of MD on fetal growth limitation and the position of MD towards neural tube defects, prematurity, and different congenital abnormalities are also assessed.

We have extensively summarized various research studies to affirm the outcome of the Mediterranean diet on neonates throughout pregnancy. By analyzing the literature focusing on Mediterranean diet exposure, we have a clear evaluation of how the MD pattern affects neonatal outcomes. The studied populations and effects measured show that compliance with the MD in pregnancy has a prospective effect on reducing the chances of unfavorable neonatal results such as neural tube defects (spina bifida), congenital anomalies (atrial and ventricular septal defects), small gestational age, prematurity, low birth weight, and allergic problems (eczema, atopy, and allergies); another study found that low adherence to the MD throughout gestational duration will increase the likelihood of unfavorable neonatal consequences.

This study observed that the MD pattern, which also involves low sugar consumption, results in better glucose control during the duration of pregnancy. Whether in the first trimester, pre-gestational diabetes, or gestational diabetes with ordinary glucose tolerance in all circumstances, GDM decreases after the intake of the Mediterranean diet.

One in every four mothers has previous weight gain, constant hypertension, or raised lipid levels. These can prompt pregnancy complications, along with gestational diabetes (when glucose builds up throughout pregnancy) and hypertensive disorders of pregnancy, including preeclampsia, that could now and again transform into additional severe conditions influencing several organs. These mothers and their offspring are likewise at a prolonged period of risk of diabetes and cardiovascular diseases. A Mediterranean-style weight-loss plan, rich in unsaturated fats, lessens the frequency of cardiovascular diseases in the non-pregnant population. In pregnancy, such a weight-loss plan can improve maternal and fetal outcomes, yet it has never been widely assessed to date.[17] The one-carbon-rich nutritional pattern characterized by excessive consumption of seafood and fish has been associated with a reduced risk of having children with CHDs.

Many studies show that there is a correlation between a Mediterranean diet and neural tube defects. An excessive MD score is associated with higher vitamin B12 and RBC folate levels and lower homocysteine levels; therefore, it is associated with a lower risk of spina bifida. Two cross-sectional studies have been completed to date that show high MD scores and DQI are associated with decreased congenital defects, whereas low adherence to MD results in increased risk for spina bifida compared to high adherence.[12,18]

Promoting a healthful eating regimen is especially essential because we confirmed that females not consuming folic acid and multivitamins were at higher risk of having infants with NTD. Taking a multivitamin regularly is difficult to maintain, and currently, only forty percent of women of reproductive age report conducting this type of behavior. Our research outputs highlight the significance of making changes in dietary choices during preconception counseling to maximize not only reproductive effects but also maternal health. In general, a healthy eating pattern might also prevent NTDs and reduce CHDs, even with the technology of food fortification.[19]

We established halfway proof supporting a protective impact of MD on preterm delivery, with the partner contemplating arriving at the best outcomes for top-notch. MD design, alongside lower measures of sugars, should achieve better blood glucose guidelines throughout pregnancy. Although glucose intolerance is related to a shorter gestational period, it is also a distinct risk factor for preterm birth. An early dietary intervention with MD, enhanced with more noteworthy extra virgin olive oil and pistachios, significantly lessens the risk of preterm birth.[20]

At present, there is less evidence of maternal compliance with the Mediterranean diet and the occurrence of asthma and hypersensitivity ailments in the offspring. Mediterranean diet during pregnancy might be related to improved small airway function in adolescence. The MD during pregnancy supports a protective effect against asthma-like indications and atopic allergy in adolescence. At the same time, adherence to the MD was not related to the risk of wheezing and dermatitis. The relationship between SGA and the MD shows that high consumption of the six food groups is related to a decrease in the risk of SGA. Late first-trimester adherence to the Mediterranean diet is not related to a higher risk of delivering an SGA infant; however, while adjusting for

parental BMI >30, women with low adherence have a higher risk of having an SGA infant.

CONCLUSION

The Mediterranean diet is associated with positive effects on both maternal and neonatal outcomes. High adherence to the Mediterranean diet decreases the risk of low birth weight and smaller placental size. It also has additional positive effects on labor and birth outcomes. This dietary example reduces the risk of congenital birth defects like spina bifida. Adherence to the Mediterranean diet and maternal eating routine quality is firmly connected with a diminished risk of some negative outcomes in children. It likewise lessens the risk factors for rashness.

DECLARATIONS

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Authors' contributions: All authors have read and approved the final manuscript.
KT: Conceptualization, methods, data extraction.
AA: Investigation, review & editing, proofreading & editing, data synthesis.

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