

# Effect of a Mediterranean Diet during Pregnancy on Fetal Growth and Preterm Delivery: Results From a French Caribbean Mother–Child Cohort Study (TIMOUN)

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## Abstract

**Background:** Recent studies suggest that a Mediterranean dietary pattern during pregnancy may influence pregnancy outcomes. The aim of this study was to evaluate the effect of adherence to a Mediterranean diet (MD) during pregnancy on fetal growth restriction (FGR) and preterm delivery (PTD) in a French Caribbean island where the population is largely of African descent and presents dietary patterns similar to MD.

**Methods:** Using data from the TIMOUN Mother–Child Cohort Study conducted in Guadeloupe (French West Indies) between 2004 and 2007, we analysed data for 728 pregnant women who delivered liveborn singletons without any major congenital malformations. Degree of adherence to MD during pregnancy was evaluated with a semi-quantitative food frequency questionnaire based on nine dietary criteria. Multiple logistic regression models were used to analyse birth outcomes while taking potential confounders into account.

**Results:** Overall there was no association between MD adherence during pregnancy and the risk of PTD or FGR. However, pre-pregnancy body mass index was a strong effect modifier, and MD adherence was associated with a decreased risk of PTD specifically in overweight and obese women (adjusted odds ratio 0.7, 95% confidence interval 0.6, 0.9) (P heterogeneity <0.01).

**Conclusions:** These results suggest that Caribbean diet during pregnancy may carry some benefits of MD and may contribute to reduce the risk of PTD in overweight and obese pregnant women.

**Keywords:** *Mediterranean diet, preterm birth, fetal development, French West Indies.*

Dietary patterns during pregnancy may have a considerable influence on fetal growth and the future health of children. Since the early 1990s, several studies have shown the beneficial role of some specific food groups (such as fish, fruits, vegetables and dairy products) and nutrients (such as omega-3 fatty acids, vitamins and minerals) on pregnancy and infant health-related outcomes.<sup>1–4</sup> Some other food categories such as processed meat and sweet drinks<sup>5</sup> were shown to have a detrimental role. Such studies usually did not consider the maternal diet as a whole and ignored the existing food and nutrient interactions that define the

global diet of the women.<sup>6</sup> This limitation has been addressed using factor analysis to identify dietary patterns empirically derived from the observed consumptions within the population under study or based on a priori hypotheses (referring to dietary recommendations or adherence to presumably beneficial dietary patterns).

Recently, several mother–child cohorts have examined the potential benefits of adherence to a traditional Mediterranean dietary pattern (characterised by a high monounsaturated/saturated fat ratio, moderate consumption of milk and dairy products and of ethanol, high consumption of vegetables, fruits, legumes and grains, and low consumption of meat and meat products)<sup>7,8</sup> during pregnancy on pregnancy outcomes and child development. Adherence to a Mediterranean diet (MD) during pregnancy was

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associated with reduced risk of preterm delivery (PTD) in Denmark<sup>9</sup> but not in Norway,<sup>10</sup> and of spina bifida malformations.<sup>11</sup> Low adherence to an MD in early pregnancy was associated with decreased intrauterine size with a lower placental and birthweight,<sup>12</sup> while high adherence might modify the detrimental effect of smoking on birth size.<sup>13</sup> A reduction in the risk of asthma and atopy in childhood has been observed in association with high level of adherence to MD during pregnancy in Spain but not in a cross-sectional study in Mexico.<sup>14</sup>

Until now, most investigations of the impact of the MD in pregnant women have studied Northern European (such as Danish and Norwegian) and Mediterranean populations (Spanish and Greek). Our study focuses on the population of the French West Indies, where most of the population is of African descent, and where rates of PTD and low birthweight are high compared with the French mainland.<sup>15</sup> Dietary patterns observed in this population have several characteristics of an MD, including high intakes of fruits, vegetables, fish and crustaceans, and low intakes of cheese and sweets.

The objective of this study was to evaluate the impact of MD adherence during pregnancy on fetal growth restriction (FGR) and PTD in a large population-based mother-child cohort study (TIMOUN) set up in Guadeloupe in 2004.

## Methods

### Population and study design

The study population consisted of pregnant women enrolled in the Guadeloupean prospective mother-child cohort study TIMOUN, from November 2004 to December 2007. Women who had been living in Guadeloupe for at least 3 years were invited to participate in the study during the third-trimester prenatal visit at a Guadeloupe public hospital (university and local hospital) or a local antenatal care clinic. Doctors presented the objectives of the study, and each participant provided written informed consent. At inclusion, women responded to a detailed questionnaire about their sociodemographic characteristics, medical and obstetric history, occupation and life style during in-person interviews, and specially trained midwives collected medical data. Data collected at delivery included the newborn's health status and details of delivery. A food frequency questionnaire (FFQ),

asking about usual dietary intake during this pregnancy, was also administered shortly after delivery.

From 2004 to 2007, the study included 1068 women, 820 (77%) of whom completed the FFQ. Twenty-three women were further excluded from the analysis because the FFQ or outcome information was incomplete, and 25 were excluded for implausible values for total energy intake (outside the range of 3347–25 104 kJ/d). Finally, the analysis was restricted to women with a liveborn singleton pregnancy without major congenital malformations. The final analysis was based on 728 pregnant women. All procedures were approved by the Guadeloupean Advisory Committee on the Protection of Persons in Biomedical Research.

### Dietary assessment

Women were interviewed about their diet during the current pregnancy with a validated semi-quantitative FFQ including 214 food items administered by trained interviewers in the days following delivery. For each food item, women declared their usual frequency and portion size of intake from which we estimated a daily intake (g/day) by multiplying the intake frequency by the portion size (details of the construction of the questionnaire are given in Supporting Information File S1).

The validity and reproducibility of the FFQ were evaluated by several methods (Supporting Information File S1). The FFQ-based method showed a good reproducibility and validity when compared with a diary-based method in a validation sample (73.0% of total energy intakes classified in the same or adjacent quintile by both methods). Correlations between fatty acid intake estimates from FFQ and maternal blood concentrations of fatty acids were on the order of those previously reported in the literature.

To evaluate the degree of adherence to the traditional MD during pregnancy, we used a scale constructed by Trichopoulou *et al.*<sup>16</sup> revised to include fish intake.<sup>17</sup> Each of the 214 items was classified among the nine categories of the Mediterranean scale (vegetables, legumes, fruits and nuts, cereals, fish, meat and poultry, dairy products, alcohol and fat). As done previously in studies among pregnant women,<sup>13</sup> the classification of food groups as beneficial or detrimental differed from the traditional MD in the general population: we presumed dairy products to be 'protective' components<sup>4</sup> and alcohol consumption to be

'detrimental'.<sup>18</sup> For beneficial components (vegetables, legumes, fruits and nuts, cereals, fish and dairy products), women with daily intake (g/day) below the (cohort-specific) median were assigned a value of 0, and women with consumption at or above the median were assigned a value of 1. For components presumably detrimental (meat, poultry and alcohol), women with daily intake below the median were assigned a value of 1, and women with intake at or above the median were assigned a value of 0. The fat components were expressed as the ratio of monounsaturated lipids [monounsaturated fatty acids (MUFA)] to saturated lipids [saturated fatty acids (SFA)]. The MD score (MDS) was calculated by the sum of the values assigned to the nine components of the MDS and ranged from 0 (minimal adherence to the traditional MD) to 9 (maximal adherence).

### Assessment of fetal growth and PTD

Birthweight was extracted from the pediatricians' records at birth. Gestational age was established by obstetricians on the basis of the last menstrual period and corrected by ultrasound measurement recorded in the first trimester of pregnancy. PTD was defined as any birth occurring before 37 weeks of gestation. FGR was defined according to the statistical method described by Ego *et al.*<sup>19</sup> and was determined by comparing actual birthweight with the expected birthweight, predicted by a multiple linear regression including known determinants of growth such as age, weight and height of the mother, parity, gestational age and sex. This definition therefore takes into account the constitutional characteristics of the mother of the child. Newborns with a weight below the tenth percentile of the predicted distribution were considered growth-restricted.

### Statistical analysis

The outcome variables of interest were PTD and FGR as categorical variables. The primary exposure of interest was MD adherence during pregnancy measured by the MDS. The score was categorised into three levels of adherence, as previously done by Trichopoulos *et al.*<sup>20</sup> and Chatzi *et al.*<sup>13</sup>: low adherence (MDS  $\leq 3$ ), medium adherence (MDS = 4 or 5), high adherence (MDS  $\geq 6$ ). Multiple logistic regressions were used to analyse dichotomous birth outcomes. Regression models included covariates that have an

established or potential association with outcome variables and MD adherence: maternal region of birth (Guadeloupe/Martinique, other Caribbean islands, Europe), marital status (married or in couple, single or single living with own family), pre-pregnancy body mass index (BMI; in kg/m<sup>2</sup>) (underweight or normal:  $<25$ , overweight or obese:  $\geq 25$ ), maternal education (low:  $<5$ , medium: 5–12, high:  $>12$  years of education), enrolment site (university hospital, local antenatal care clinic, local hospital), average weekly weight gain during pregnancy (in g/week) ( $<340$ ,  $\geq 340$ ) and smoking during pregnancy (yes, no). Gestational weight gain (GWG) was computed as average weekly weight gain to take into account varying gestational week at measurement. Adherence to IOM recommendations<sup>21</sup> was assessed in three categories (low, normal or high weight gain during pregnancy) according to pre-pregnancy BMI. All analyses were further adjusted for total energy intake during pregnancy, categorised into tertiles (in kJ/day) ( $<9243$ , 9234–12 410,  $>12 410$ ). Effect modifications according to pre-pregnancy BMI and infant sex were tested and considered significant when Wald test *P* value  $< 0.20$ . Medically indicated and spontaneous PTD were also studied separately. Analyses were performed with Statistical Analysis Systems statistical software package version 9.3 (SAS Institute, Cary, NC, USA).

### Results

The identified diet was characterised by high intakes of fruits and nuts (median 501 g/d), dairy products (median 331 g/d), vegetables (median 283 g/d), cereals (median 272 g/d) and fish (median 88 g/d) (Table 1). The mean MDS was 4.9 ( $\pm 1.6$ ) (median: 5, interquartile range: 4–6). Twenty per cent of the women had low adherence to MD (MDS  $\leq 3$ ), 42% medium adherence ( $4 \leq \text{MDS} \leq 5$ ) and 37% high adherence (MDS  $\geq 6$ ). Women with high MDS differed from those with low MDS by higher intakes of fish ( $\times 4$ ), vegetables ( $\times 3$ ) and legumes ( $\times 3$ ), fruits and nuts ( $\times 2$ ). Overweight and obese women did not differ from underweight/normal regarding any food group intake.

Women included in the analysis had a mean age ( $\pm$  standard deviation) of 31 ( $\pm 7$ ) years (Table 2). Most of them were born in Guadeloupe or Martinique (78.4%) and were enrolled at the University Hospital (73.8%). Of the 728 women, only 399 (56.2%) were living in couple. Sixty-eight per cent had a medium

**Table 1.** Median daily intakes (grams/day) of food categories, according to maternal Mediterranean diet adherence and pre-pregnancy BMI

Food category (grams/day)	Mediterranean diet adherence				Pre-pregnancy BMI	
	All				Underweight/normal	Overweight/obesity
	MDS ≤ 3 <i>n</i> = 148	4 ≤ MDS ≤ 5 <i>n</i> = 308	MDS ≥ 6 <i>n</i> = 272		<i>n</i> = 429	<i>n</i> = 299
	Median [Q1–Q3]	Median [Q1–Q3]	Median [Q1–Q3]	Median [Q1–Q3]	Median [Q1–Q3]	Median [Q1–Q3]
Fruits and nuts	501 [287–784]	282 [153–394]	461 [279–734]	685 [510–959]	501 [283–763]	499 [300–793]
Dairy products	331 [192–432]	231 [103–320]	314 [201–406]	382 [289–548]	338 [192–414]	325 [193–458]
Vegetables	283 [174–441]	145 [100–227]	252 [168–383]	419 [315–580]	277 [166–434]	297 [180–446]
Cereals	272 [172–408]	202 [143–276]	272 [176–454]	316 [194–439]	269 [170–402]	275 [172–421]
Fish	88 [45–169]	42 [23–69]	77 [43–131]	168 [96–255]	87 [46–168]	89 [45–171]
Meat and poultry	82 [50–133]	83 [40–123]	86 [52–132]	77 [51–145]	84 [51–128]	79 [46–140]
Legumes	39 [21–72]	21 [13–29]	32 [20–57]	59 [42–100]	36 [21–72]	42 [20–72]
MUFA	29 [20–38]	29 [17–43]	36 [27–49]	34 [26–44]	28 [21–37]	30 [20–40]
SFA	37 [26–51]	21 [13–31]	29 [20–36]	44 [32–57]	37 [27–50]	38 [26–55]
Ratio MUFA/SFA	0.8 [0.7–0.9]	0.8 [0.7–0.9]	0.8 [0.7–0.9]	0.8 [0.7–0.9]	0.8 [0.7–0.9]	0.8 [0.7–0.9]
Alcohol <sup>a</sup>	1.4	3.4	0.7	1.1	1.4	1.3
Total energy intake <sup>b</sup>	10 804 [8 459–13 591]	10 349 [7 427–14 019]	10 740 [8 447–13 443]	11 058 [8 680–13 769]	10 986 [8 591–13 880]	10 589 [8 203–13 135]

<sup>a</sup>% of consumers.<sup>b</sup>Expressed in kJ/day.

MDS, Mediterranean diet score; BMI, Body mass index; MUFA, monounsaturated fatty acids; SFA, saturated fatty acids; [Q1–Q3], interquartile range.

**Table 2.** Mediterranean Diet Score according to maternal sociodemographic and lifestyle characteristics, preterm delivery and fetal growth restriction ( $n = 728$ )

	<i>n</i>	%	MDS		<i>P</i>
			Mean	SD	
Maternal place of birth					0.03
Guadeloupe/Martinique	571	78.4	5.0	1.6	
Other Caribbean islands	72	9.9	4.5	1.5	
Europe	85	11.7	4.9	1.6	
Marital status					0.64
Single	176	24.8	5.0	1.5	
Married or in couple	399	56.2	5.0	1.6	
Living with own family	135	19.0	4.8	1.6	
Maternal Education (years)					0.30
Low (<5)	36	5.0	4.6	1.8	
Medium (5–12)	492	67.6	4.9	1.5	
High (>12)	200	27.5	5.0	1.6	
Enrolment site					<0.01
University hospital	537	73.8	5.1	1.5	
Local antenatal care clinic	126	17.3	4.7	1.7	
Local hospital	65	8.9	4.5	1.6	
Pre-pregnancy BMI (kg/m <sup>2</sup> )					0.56
Underweight	50	6.9	5.3	1.8	
Normal	379	52.0	4.9	1.6	
Overweight	163	22.4	5.1	1.5	
Obese	136	18.7	4.9	1.5	
Weight gain during pregnancy (g/week)					0.18
<340	372	51.1	5.0	1.5	
≥340	356	48.9	4.9	1.6	
Energy intake during pregnancy (kJ/d)					0.73
<9234	241	33.1	4.9	1.7	
9234–12 410	239	32.8	5.0	1.5	
>12 410	248	34.1	5.0	1.5	
Smoking during pregnancy					0.60
No	689	94.6	4.9	1.6	
Yes	39	5.4	5.1	1.3	
Alcohol during pregnancy					0.13
No	706	97.0	5.0	1.5	
Yes	22	3.0	4.4	1.6	
Sex of the newborn					0.78
Male	370	50.8	5.0	1.6	
Female	358	49.2	4.9	1.6	
Preterm delivery					0.27
No	621	85.3	5.0	1.6	
Yes	107	14.7	4.8	1.5	
Fetal growth restriction					0.85
No	635	87.2	4.9	1.6	
Yes	93	12.8	5.0	1.5	

MDS, Mediterranean diet score; SD, standard deviation; BMI, body mass index.

education level and 27.5% had a high education level. Fifty-two per cent had a normal pre-pregnancy BMI, 6.9% were underweight, 22.4% were overweight and 18.7% were obese. Women born in other Caribbean Islands had significantly lower adherence to MD, and those enrolled at the University hospital had significantly higher MDS.

The mean birthweight was 3095 ( $\pm 508$ ) g. Preterm deliveries accounted for 14.7% of all births (interquartile range: 37–40 weeks), and 52.8% of them were spontaneous. FGR was diagnosed in 93 newborns (12.8%). Preterm (14%, 17%, 13%) and FGR (11%, 12%, 14%) prevalence was similar amongst the three categories of MDS.

Table 3 reports the associations between MD adherence during pregnancy and PTD, stratified for pre-pregnancy BMI and infant sex. A non-significant decrease in the risk of PTD in association with MDS was observed in the entire sample of women (adjusted odds ratio (aOR) 0.9, 95% confidence interval (CI) 0.8, 1.0). Adherence to the MD during pregnancy was associated with a statistically significant decrease in the risk of PTD in overweight and obese women (aOR 0.7, 95% CI 0.6, 0.9) ( $P$  heterogeneity < 0.01) especially among those with low or normal weight gain during pregnancy (Supporting Information File S2). There was no correlation between MDS score and GWG in overweight and obese women. We also observed an almost significant reduced risk of PTD among baby girls (aOR 0.8, 95% CI 0.7, 1.0), but the effect heterogeneity was not significant ( $P$  heterogeneity = 0.21).

MD adherence was not significantly associated with the risk of delivering an infant with FGR, but we observed a significant interaction term ( $P$  heterogeneity = 0.03) and a non-significantly decreased risk of FGR associated with MDS among underweight and normal-weight women only (aOR 0.8, 95% CI 0.6, 1.0) (Table 4). The same pattern was observed when analysis was restricted to FGR among term births.

Sensitivity analyses confirm these findings, showing a statistically significant decrease in the risk of PTD in relation with MD adherence among overweight and obese women when taking into account infants without FGR exclusively, and identical estimates among indicated preterm deliveries. However, the association between MD adherence and the risk of PTD was not found significant among spontaneous preterm deliveries (probably due to a lower proportion of overweight and obese women in this group) (Supporting Information File S2).

**Table 3.** Odds ratios of preterm delivery per unit of Mediterranean Diet Score, stratified for pre-pregnancy BMI and infant sex ( $n = 728$ )

	N	PTD cases	Unadjusted OR	95% CI	Adjusted OR	95% CI	<i>P-value</i> <sup>a</sup>
Non stratified model <sup>b</sup>	728	107	0.9	0.8, 1.1	0.9	0.8, 1.0	<0.01
Model stratified for BMI <sup>c</sup>							
Underweight/normal	429	56	1.1	0.9, 1.3	1.1	0.9, 1.3	
Overweight/obesity	299	51	0.7	0.6, 0.9	0.7	0.6, 0.9	0.20
Model stratified for infant sex <sup>b</sup>							
Male	370	58	1.0	0.8, 1.2	1.0	0.8, 1.2	
Female	358	49	0.9	0.7, 1.0	0.8	0.7, 1.0	

<sup>a</sup>*P* values for the effect heterogeneity test.

<sup>b</sup>Adjusted for maternal place of birth, marital status, pre-pregnancy BMI, maternal education, enrolment site, weight gain during pregnancy, energy intake and maternal smoking during pregnancy ( $N = 710$  with complete data).

<sup>c</sup>Adjusted for maternal place of birth, marital status, maternal education, enrolment site, weight gain during pregnancy, energy intake and maternal smoking during pregnancy ( $N = 710$  with complete data).

PTD, preterm delivery; OR, odds ratio; CI, confidence interval; BMI, pre-pregnancy body mass index.

## Comments

This study shows a significant reduction in the risk of PTD among pregnant overweight and obese women who ate a Mediterranean-type diet during their pregnancy.

Its potential beneficial effects on health, especially its potential to reduce the risks of cancer and cardiovascular and chronic diseases, have made the MD a topic of major interest today.<sup>22–24</sup> Despite the common characteristics of this dietary pattern (high consumption of fruit, vegetables, legumes and grains, moderate

**Table 4.** Odds ratios of fetal growth restriction per unit of Mediterranean Diet Score, stratified for pre-pregnancy BMI and infant sex

	N	FGR cases	Unadjusted OR	95% CI	Adjusted OR	95% CI	<i>P-value</i> <sup>a</sup>
All births							
Non stratified model <sup>b</sup>	728	93	1.0	0.9, 1.2	1.0	0.8, 1.1	0.03
Model stratified for BMI <sup>c</sup>							
Underweight/normal	429	42	0.9	0.7, 1.1	0.8	0.7, 1.0	
Overweight/obesity	299	51	1.1	0.9, 1.4	1.2	0.9, 1.5	0.69
Model stratified for infant sex <sup>b</sup>							
Male	370	39	1.0	0.8, 1.2	0.9	0.7, 1.1	
Female	358	54	1.0	0.9, 1.2	1.0	0.8, 1.2	
Among term births							
Non-stratified model <sup>b</sup>	621	68	1.0	0.9, 1.2	1.0	0.8, 1.2	0.05
Model stratified for BMI <sup>c</sup>							
Underweight/normal	373	31	0.9	0.7, 1.2	0.8	0.7, 1.1	
Overweight/obesity	248	37	1.2	0.9, 1.5	1.3	0.9, 1.7	0.92
Model stratified for infant sex <sup>b</sup>							
Male	312	26	1.1	0.8, 1.4	0.9	0.7, 1.3	
Female	309	42	1.0	0.8, 1.3	1.0	0.8, 1.2	

<sup>a</sup>*P* values for the effect heterogeneity test.

<sup>b</sup>Adjusted for maternal place of birth, marital status, pre-pregnancy BMI, maternal education, enrolment site, weight gain during pregnancy, energy intake and maternal smoking during pregnancy ( $N = 710$  with complete data in all births,  $N = 609$  in term births only).

<sup>c</sup>Adjusted for maternal place of birth, marital status, education level, enrolment site, weight gain during pregnancy, energy intake and maternal smoking during pregnancy ( $N = 710$  with complete data in all births,  $N = 609$  in term births only).

FGR, fetal growth restriction; OR, odds ratio; CI, confidence interval; BMI, body mass index.

consumption of fish, dairy products and alcohol, low meat intake), it is subject to some regional variations associated with sociocultural, population and geographic differences,<sup>25,26</sup> as well as with changes and different influences associated with the globalisation process.<sup>27</sup> These factors make it difficult to establish a specific definition. To these difficulties we must add the nutritional specificities of pregnant women, who should avoid alcohol consumption during pregnancy because of its harmful impact on fetal development and should consume more dairy products than usual because of their increased calcium requirements. Chatzi *et al.*<sup>13</sup> showed heterogeneity between Spain and Greece, countries traditionally known for an MD: intake of fish and dairy products was higher in the Atlantic region of Spain and fruit and nut intake higher in Crete. They reported a lower risk of delivering FGR infants for women with high MD adherence in the Mediterranean-INMA study (Spain), but not in the Atlantic-INMA or the RHEA cohort (Greece). If we compare these observations with the dietary pattern of our Guadeloupean population, we observe higher daily consumption of vegetables (283 g/day), fruit and nuts (501 g/day) and fish (88 g/day) in this cohort than among the women questioned in the Atlantic Spain, Mediterranean Spain or Greek cohorts. Although this dietary profile does not truly match any of these three particular patterns, the high fruit and nut intake and moderate dairy product consumption are similar to that of the Greek cohort, while the high fish consumption is closer to the pattern of the Atlantic region of Spain.

Very few studies have examined the effect on length of gestation and fetal growth of eating an MD during pregnancy.<sup>9,10,12,13</sup> To our knowledge, only a few recent prospective studies have shown an association between this type of diet and the risk of PTD. In 2005, a randomised study in a cohort of Norwegian women showed a 90% reduction in the PTD rate among women who ate a low-cholesterol diet and reduced their SFA intake during pregnancy.<sup>28</sup> In that study, the women in the intervention group were supposed to follow a diet including greater intake of fish, vegetable oils (olive oil in particular), fruit and vegetables, nuts, and a reduction in meat, butter, margarine, cream and other fat-rich dairy products, together with a reduction in coffee. Among the 141 women included in the intervention group, 1 woman (0.7%) gave birth to a preterm child, compared with 11 (7.4%) of the 149 women in the control group.

In an observational cohort of 35 530 Danish women published in 2008, Mikkelsen *et al.*<sup>9</sup> showed a 72% reduction in the risk of early preterm delivery (defined as birth before 35 weeks of gestation) associated with following an MD during pregnancy. The women meeting all the following criteria were considered to be following an MD correctly: consumption of fish at least twice a week, consumption of olive oil, high consumption of fruit and vegetables (at least five a day), meat eaten a maximum of twice a week and a maximum of two cups of coffee a day.

Similarly, an MD throughout pregnancy appeared to reduce the risk of PTD in our study. According to Khoury *et al.*,<sup>28</sup> several hypotheses may explain this effect. Some factors included in this diet could contribute to this result, in particular, the n-3 (omega-3) polyunsaturated fatty acids (PUFA). Increased intake of PUFA together with a reduction in SFA could influence the levels of inflammatory cytokines, which are involved in the pathophysiological mechanisms of PTD.<sup>29</sup> Despite some contradictory findings, several studies have shown an association between PUFA and the duration of gestation.<sup>30</sup> Khoury *et al.*<sup>28</sup> also suggest that some micronutrients, such as vitamins C and E, influence this increased duration of gestation; they also suggest that some dietary factors may play a role in reducing intrauterine bleeding, which is a known risk factor for PTD. Finally, according to Ness *et al.*,<sup>31</sup> there is probably an interaction between maternal blood levels of two folate isoforms and the risk of preterm delivery.

A novel finding in this study is that the beneficial effects of the MD on the risk of PTD were significantly greater among overweight and obese women compared with the normal and underweight women, although MDS score did not differ between these two categories. A pathophysiological perspective may explain this result. Excess weight is known to increase the risk of glucose intolerance and pregnancy-related diabetes.<sup>32</sup> Moreover, it is recognised that glucose intolerance is associated with a shorter duration of gestation, independently of other known risk factors for PTD.<sup>33,34</sup> An appropriate diet, including fewer simple carbohydrates, should result in better blood glucose regulation, which in turn should be associated with an increase in the duration of gestation, especially for obese women, who might be the first to benefit from this change. In our study, there is no indication that a mode of action of MD adherence through a reduction in GWG in overweight/obese women is

acting, since no correlation was observed between MDS score and GWG.

Moreover, we observed a slight decreased risk of FGR associated with MDS among underweight and normal-weight women with a significant interaction term. This result is in accordance with a previous analysis within a large mother–child cohort in Spain that have showed a significantly lower risk of delivering an FGR infant for weight among women with high MD adherence.<sup>13</sup>

This study has numerous strengths. To our knowledge, it is the first prospective cohort study to explore the association between an MD in pregnant women and fetal growth and PTD in a Caribbean population of African descent. The few studies in this domain have been conducted principally in European Nordic or Mediterranean populations. The particularly high rates of PTD and low birthweight in the Caribbean population of African descent makes research into factors that might reduce these risks a public health priority. Data on food consumption come from an FFQ specific to the French West Indies (in particular, in terms of types of foods and methods of preparation and cooking) and validated by various methods described above. To minimise the response biases inherent in this type of questionnaire, a trained investigator administered it during a face-to-face interview. In our study, introducing an interviewer in the dietary assessment was relevant since the women's education level was low or medium for 72.6% of them, and some of them probably did not speak French fluently. FGR was defined according to an internal reference in view of the absence of reference curves adapted to this population. Midwives and paediatricians participating in this cohort study collected the fetal measurements at birth.

This study is nonetheless subject to some limitations. The PTD rate observed in our cohort of pregnant women in Guadeloupe is high (14.7%), exceeding the estimates for the overseas districts and territories obtained from the French Perinatal Survey conducted in 2010 (12%).<sup>15</sup> The high recruitment at the Guadeloupe University Hospital (73.8%) probably explains this difference since it favours inclusion of pregnant women with diseases during pregnancy, indications of induced delivery.

On the other hand, the FFQ was administered at the end of pregnancy and concerned the women's average diet throughout pregnancy. We therefore could not take into account the possible variations in

diet during pregnancy or define a window of exposure during which the dietary pattern might be more important. A longitudinal study intended to identify dietary patterns among women throughout their pregnancy nonetheless shows that these variations are not significant.<sup>35</sup> Finally, the intake estimates were completed retrospectively, after delivery. Accordingly, they could possibly have been influenced by the pregnancy outcome. This is nonetheless improbable because women with major pregnancy-related diseases were not included in the study; 99.1% of the PTD were moderately preterm, and the detailed questionnaire did not refer to any 'at risk' food, except for alcoholic beverages.

In conclusion, among women who were overweight or obese before pregnancy, the risk of PTD was significantly lower for those who followed an MD during pregnancy. This result, if confirmed, suggests a benefit of this type of diet during pregnancy and is especially interesting in the French West Indian population, which has a particularly elevated prevalence of obesity and PTD. Indeed, the multi-causal and complex nature of PTD makes its control particularly difficult. As a potentially modifiable contributor to PTD risk, setting up preventive dietary measures as part of the management of these overweight and obese pregnancies may have a substantial impact on the child's health status at birth and subsequent outcome.

## Acknowledgements

This study was made possible by the support of the French National Health Directorate, French Ministry of Environment, French Agency for Environmental and Occupational Safety, National Agency for Research, French Institute for Public Health Surveillance, Regional Council of Guadeloupe. All authors saw and approved the final manuscript. The authors declare no conflict of interests.

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### Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

**File S1.** Construction and validation of the food frequency questionnaire.

**File S2.** Sensitivity analyses and complementary stratified analyses taking into account weight gain during pregnancy.