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Psychosocial deprivation in women with gestational diabetes mellitus is associated with poor fetomaternal prognoses: an observational study

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What is already known on this topic

Psychosocial deprivation is associated with more gestational diabetes mellitus.

What this study adds

Among women with gestational diabetes mellitus, psychosocial deprivation is associated with large for gestational age infants, independently of obesity, gestational weight gain and other confounders.

Abstract

Objective To evaluate the prognoses associated with psychosocial deprivation in women with gestational diabetes mellitus (GDM).

Design Observational study considering the 1498 multiethnic women with GDM who gave birth between January 2009 and February 2012.

Setting Four largest maternity units in the northeastern suburban area of Paris.

Participants The 994 women who completed the Evaluation of Precarity and Inequalities in Health Examination Centers [EPICES] questionnaire.

Main outcome measure Main complications of GDM (large infant for gestational age (LGA), shoulder dystocia, cesarean section, preeclampsia).

Results Psychosocial deprivation (EPICES score ≥30.17) affected 577 women (56%) and was positively associated with overweight/obesity, parity, and non-European origin and negatively associated with family history of diabetes, fruit and vegetable consumption, and working status. The psychosocially deprived women were diagnosed with GDM earlier, received insulin treatment during pregnancy more often and were more likely to have LGA infants (15.1 vs. 10.6%, odds ratio 1.5[95% confidence interval 1.02-2.2], p<0.05) and shoulder dystocia (3.1 vs. 1.2%, OR 2.7[0.97-7.2], p<0.05). In addition to psychosocial deprivation, LGA was associated with greater parity, obesity, history of GDM, ethnicity, excessive gestational weight gain and insulin therapy. A multivariate analysis using these covariates revealed that EPICES score was independently associated with LGA infants (per 10 units, OR 1.12[1.03-1.20], p<0.01).

Conclusions In our area, psychosocial deprivation is common in women with GDM and is associated with earlier GDM diagnoses and greater insulin treatment, an increased likelihood of

shoulder dystocia and, independently of obesity, gestational weight gain and other confounders with LGA infants.

Strengths and limitations:

- It is known that psychosocial deprivation is associated with more gestational diabetes and we report for the first time that, among women with gestational diabetes mellitus, psychosocial deprivation is associated with a poor prognosis.
- Our large, multicenter and diverse cohort and the adjustments for the relevant confounding factors, such as body mass index and gestational weight gain, ensure the robustness of our findings.
- We defined psychosocial vulnerability using the Evaluation of Precarity and Inequalities in Health Examination Centers [EPICES] questionnaire, which has been validated during pregnancy or not. This tool evaluates at an individual level several domains, including material goods, money, friendship and family networks, healthcare and leisure.
- However, the EPICES questionnaire was retrospectively fulfilled (6 to 24 months after pregnancy).

Key words: gestational diabetes mellitus, psychosocial deprivation, prognoses, large infant for gestational age

Introduction

Socioeconomic status reflects access to resources to prosper, and psychosocial deprivation is associated, across countries and over time,[1 2] with higher mortality and morbidity, including type 2 diabetes.[3] The main drivers in more incident type 2 diabetes appear to be higher body mass index (BMI) and impaired health behaviors.[4] The American Diabetes Association recommends the inclusion of assessments of patients' psychological and social situations as an ongoing part of the medical management of diabetes.[5] Indeed, psychosocial deprivation in patients with diabetes has been reported to be associated with increased obesity,[6] worse glycemic control,[7] poorer adherence,[8 9] more diabetic complications,[6 7 10 11] and perhaps greater mortality.[12-14] During pregnancy, psychosocial deprivation is also associated with poor outcomes that include increased rates of maternal[15] and neonatal[15 16] hospitalization, stillbirth,[17] postnatal death,[18] preterm delivery[17 19] and changes in fetal growth.[17-20]

Gestational diabetes mellitus (GDM) is defined as any degree of glucose intolerance with onset or first recognition during pregnancy and is now very common, with a prevalence ranging from 9.3 in Israel to 25.5% in California, US.[21] Although GDM is also more frequent in cases of psychosocial deprivation,[18 19 22 23] its prognosis in case of poor psychological and social conditions is currently unknown. We hypothesized that psychosocial deprivation might be associated with poor prognoses in women with GDM when confounding factors, such as obesity,[19] gestational weight gain (GWG)[16] and smoking habits,[20] are considered.

The four largest maternity units in the Northeastern suburban area of Paris, France participated in the IMPACT initiative, which aimed to improve postpartum screening for dysglycemia after GDM.[24 25] The women who attended these maternity units responded to the Evaluation of Precarity and Inequalities in Health Examination Centers [EPICES] questionnaire,

a questionnaire which evaluates psychosocial deprivation.[6 7 19 24 26] Therefore, for the first time, we had the opportunity to investigate the fetomaternal prognoses of these women with GDM according to their individual psychosocial statuses.

Methods

Patients

This study is a secondary analysis of the IMPACT study.[24 25] Briefly, the IMPACT initiative began in March 2011 and was a mobilization campaign for women with GDM and their community caregivers that sought to increase postpartum screening for dysglycemia. We aimed to evaluate the effect of this initiative by comparing the postpartum screening rates between the women who delivered before (between January 2009 and December 2010) and after this initiative (between April 2011 to February 2012). We systematically included women who were at least 18 years of age, free of known pregestational diabetes, had GDM and were followed during pregnancy in one of the four largest maternity units of the Seine-Saint Denis area of France during these periods of time. GDM was detected by oral glucose tolerance test and was defined by fasting blood glucose values ≥ 5.3 mmol/l and/or a 2-hour blood glucose value ≥ 7.8 mmol/l between January 2009 and December 2010,[24 25] and thereafter according to the International Association of Diabetes and Pregnancy Study Groups criteria, adopted in France in 2010.[27] In the primary analyses, we included the women who could be contacted by telephone and provided self-reports that indicated whether they had undergone postpartum screening tests during the six months following their deliveries.[24 25] For the current analysis, we included all of the women who delivered between January 2009 and February 2012 and who retrospectively

completed the [EPICES] questionnaire by phone regardless of their report concerning the postpartum screening.

Data collection and assessment of outcomes

One single investigator extracted the following data from hospital records: age at conception, origin/ethnicity, family history of diabetes, history of previous GDM, gestational age at the time of GDM diagnosis (three classes: <24 weeks of gestation, between 24 and 28 weeks of gestation and ≥ 28 weeks of gestation), insulin treatment during pregnancy, and GWG. Excessive GWG was defined according to the recommendations of the Institute of Medicine; *i.e.,* GWG ≥ 16 kg in women with pregravid BMIs < 25 kg/m², ≥ 11.5 kg in overweight women (BMIs between 25 and 29.9 kg/m²) and ≥ 9 kg in obese women (BMI ≥ 30 kg/m²). We also collected information about events during pregnancy, including offspring birth weight in comparison to the standard French population (large for gestational age (LGA) was defined by a birth weight exceeding the 90th percentile)[28], preeclampsia (blood pressure ≥ 140/90 mmHg on two recordings 4 h apart and proteinuria of at least 300 mg/24 h or 3+ or higher upon dipstick testing of a random urine sample), shoulder dystocia (defined as the use of obstetrical maneuvers *i.e.*, McRoberts episiotomy after delivery of the fetal head, suprapubic pressure, posterior arm rotation to an oblique angle, rotation of the infant by 180 degrees, delivery of the posterior arm) and caesarian section.

The investigator conducted semi-structured interviews by phone between January and November 2011 for the women who delivered before the IMPACT campaign (maximum delay of time since delivery 24 months) and at least six months after delivery for the women who delivered after the IMPACT initiative. The investigator requested information about the subjects' current weights, heights, waist circumferences, professional statuses, smoking statuses, number

of children, antihypertensive and lipid-lowering treatments, family histories of diabetes and daily consumptions of fruits and vegetables. All these data were therefore declarative. Waist circumference was deducted from current waist size of trousers (waist circumference <80 cm: 6-14 (UK) or 34-42 (France), 80-88 cm: 16-20 (UK) or 44-48 (France); >88 cm: 22 (UK) or 48 (France) or more).

The investigator also conducted interviews to assess psychosocial deprivation using the EPICES score, which is a French deprivation score that is calculated based on responses to 11 questions that consider both socioeconomic conditions and family environment (supplementary material).[7 26 29] It evaluates at an individual level several domains, including material goods, money, friendship and family networks, healthcare and leisure. As previously reported, the EPICES score is a continuous variable, and increasing quintiles are associated with increased risks for poor health conditions such as obesity, diabetes in women, higher rates of smoking, poorer access to dental and gynecological care, and poorer perceived health statuses.[24 26] However, psychosocial deprivation can be defined by a score ≥ 30.17,[29] which was the threshold used here.

Statistical analyses

Sample size calculations were based on the main criterion of the IMPACT study, *i.e.* a postpartum screening test performed six months following delivery.[24 25] Results reported in this manuscript were prespecified, exploratory endpoints. Continuous variables are expressed as means ± SD, and normality was assessed with Kolmogorov-Smirnov tests. There were no missing data concerning psychosocial deprivation and main outcomes. Comparisons of two independent groups were performed using the Student t-test if the variable was normally

distributed; otherwise, the Wilcoxon Mann-Whitney test was used. The significance of differences in proportions (*i.e.*, qualitative variables) were tested with the χ^2 test, and the odds ratios (ORs) and 95% confidence intervals (CIs) were calculated in cases of statistical significance ($p<0.05$). We defined EPICES score tertiles in our cohort: first tertile: EPICES score <23.71 (mean 11.7±6.2; n=296); second tertile: score between 23.71 and 51.5 (mean 35.0±8.5; n=355); and third tertile: score ≥ 51.5 (mean 69.9±12.6; n=343). The factors associated with having a LGA infant were assessed with a univariate logistic regression method. For multivariate analyses, we included all factors that were associated with LGA infants with p values ≤0.05 in the univariate analyses. SAS Statistics version (9.2) (Cary, USA) was used to conduct all statistical analyses.

Results

Characteristics of the women

A total of 1498 women gave birth following GDM between January 2009 and February 2012 in our maternity units. Of these women, 994 retrospectively responded by phone to the EPICES questionnaire. Table 1 illustrates the characteristics of these women. The characteristics of the 994 women who responded to the EPICES questionnaire were similar to those of the 504 who did not respond with the exception of greater daily consumptions of fruits and vegetable (66.1 vs. 59.0%, respectively, $p<0.01$) and a trend toward being older (33.3±5.2 vs. 32.7±5.5 years, respectively, $p=0.06$). The EPICES questionnaire could not be completed by the women who could not be reached by phone and those with French language proficiencies that were insufficient for answering the questions.

Psychosocial deprivation affected 577 women (56%) and was positively associated with parity, overweight and obesity, greater waist circumference, and non-European origin. Psychosocial deprivation was negatively associated with daily fruit and vegetable consumption, reduced family history of diabetes and working status (Table 1).

Pregnancy outcomes

Table 2 shows that the psychosocially deprived women were more likely to have been diagnosed with GDM prior to 24 weeks of gestation and more likely to have been treated with insulin during pregnancy than the non-psychosocially deprived women. The psychosocially deprived women were more likely to have LGA infants and infants with shoulder dystocia, but no differences in cesarean section or preeclampsia were found. Figure 1 (panels A to D) shows that the prevalences of insulin treatment during pregnancy (Figure 1A), LGA infants (Fig 1C) and shoulder dystocia (Figure 1D) increased with increasing EPICES score tertile.

Table 3 shows that, in addition to psychosocial deprivation (OR 1.5 [95%CI 1.02-2.22]), LGA was associated with higher parity, greater BMI and obesity of the mother (OR 2.1 [1.4–3.1]), increased incidence of GDM history (OR 2.0 [1.4–3.1]), ethnicity/origin, greater EPICES score (per 10 units: OR 1.50 [1.22-2.22]), greater GWG and excessive GWG during pregnancy (OR 2.8 [1.9-4.1]) and insulin treatment during pregnancy (OR 1.6 [1.1–2.4]). A multivariate analysis that considered parity, obesity, personal history of GDM, ethnicity, EPICES score, excessive GWG and insulin therapy during pregnancy revealed that the EPICES score remained independently associated with LGA infants (Table 3). In a model that was identical to the aforementioned model with the exception that psychosocial deprivation (*i.e.,* EPICES score

≥ 30.17) was used in the place of the EPICES score, a trend toward an association between psychosocial deprivation and LGA infants remained (OR 1.53 [0.98-2.39], p=0.06).

Discussion

In this study, psychosocial deprivation in women with GDM was associated with earlier GDM diagnoses and more extensive insulin treatment. Moreover, we show for the first time that, independent of confounding factors, psychosocial deprivation was associated with increases in adverse outcomes, particularly LGA infants. We report that psychosocial deprivation (*i.e.*, an EPICES score above 30.17) affected 56% of the women with GDM in our study; another study reported a prevalence of 48% (11/23 women with GDM) in another area of France using the same definition of deprivation.[19] This high prevalence is due to the prevalence of precarity[30] and multiethnicity[31] in the Northeastern suburban area of Paris and to the roles played by these conditions in the rate of GDM. Indeed, the prevalence of GDM has been reported to be 1.7- to 2.9-fold higher among patients with high EPICES scores,[19] low educational statuses[22 23] or low family incomes[18 23] compared to their counterparts without these conditions. Notably, 23% of pregnant women in France have been reported to have high EPICES scores regardless of GDM status,[19] and 17.5% have been coded as psychosocially deprived by social workers[15] in two other areas in France. Together, our results advocate for screening for deprivation among pregnant women with GDM.

As previously reported for women with and without GDM,[19 32] we found that psychosocially deprived women with GDM were more likely to be obese. These women were also more likely to be unemployed and less likely to be daily consumers of fruits or vegetables; the latter

association is likely due to the cost of these foods. An association between socioeconomic status and healthy eating status, including fruits and vegetable consumption, has previously been reported.[33 34] We also observed a link between ethnicity/origin and deprivation; similar links have previously been described as complex relationships.[35-38] The women with and without psychosocial deprivation reported similar prevalences of prepregnancy antihypertensive and lipid-lowering treatments although metabolic disorders are often associated with elevated EPICES scores[39 40] and stress.[41] The lack of association observed in our study might be specific to women of reproductive age or might be attributable to reduced numbers of medical visits prior to pregnancy due to precarity.[16] The latter supposition would also result in undiagnosed metabolic syndrome prior to pregnancy, which would be in accordance with the greater prevalence of GDM diagnoses prior to 24 weeks of gestation among psychosocially deprived women. These findings suggest the possibility that these women might actually have had undiagnosed pregravid type 2 diabetes. Indeed, precarity is a risk factor for undiagnosed type 2 diabetes even in women of reproductive age.[42] However, we do not have access to the results of postpartum glycemic assessments that would be needed to confirm this hypothesis.

We also studied the association between psychosocial deprivation and adverse pregnancy outcomes in women with GDM for the first time. Compared to those without precarity, the women with precarity were more likely to have LGA infants and infants with shoulder dystocia. The association between EPICES scores and LGA infants was independent of obesity, which suggests that this relationship was only partially driven by the increased prevalence of overweight/obesity among the deprived women.[43 44] GWG and the prevalence of excessive GWG, which are other confounding factors regarding LGA infants,[43 44] were comparable between the women with and without precarity. We have recently shown that, compared to

women from Sub-Saharan Africa, European women experience more GDM-related events.[31] Furthermore, racial/ethnic differences in the clinical outcomes of GDM, including macrosomia, are commonly reported (for review).[45] Here, the association of LGA with precarity remained significant after adjusting for origin/ethnicity while we did not find any association between precarity and offspring with birth weights greater than 4000 g or 4250 g. The association between psychosocial deprivation and shoulder dystocia, which was not adjusted for confounding factors because the rate of dystocia events was low, was most likely driven by the prevalence of LGA infants. In a population-based study, the risk for shoulder dystocia significantly increased with BMI category in an unadjusted analysis, but this significance disappeared after adjusting for GDM.[35] As previously reported for pregnant women regardless of GDM status,[15] we found that the women in our cohort with GDM underwent cesarean section at similar rates regardless of the presence of psychosocial deprivation. The vulnerable women were diagnosed with GDM earlier, which suggests that unknown pregravid dysglycemia might partially explain the increased rate of LGA infants.[46] In a recent German study, the groups that were found to at high risk for GDM were women of low socio-economic status, migrants and obese women. An elevated risk of fetal malformations was found among the women who had been diagnosed with GDM, which suggests that many of these women might have had high glucose levels by the first trimester.[47]

The present study has limits and strengths. Our large, multicenter and diverse cohort and the adjustments for the relevant confounding factors ensure the robustness of our findings. However, we did not have access to data about glycemic control, diet, physical activity or the numbers of visits during pregnancy. Thus, the adverse outcomes observed for the women with precarity might have been due to these factors based on the following arguments: *(i)* poor glycemic control

has been reported in vulnerable patients with diabetes[7] and was likely present in our population with GDM and psychosocial insecurity because insulin treatment was more often necessary during GDM among this population; *(ii)* fruit and vegetable consumption was lower among the vulnerable women following pregnancy, which might be indicative of poorer nutritional habits during pregnancy;[33 34 48] *(iii)* exercise during late pregnancy has been reported to vary with the education level of the mother;[33 34 49] and *(vi)* access to health care might depend on socioeconomic status,[19] but it is unlikely that access to health care influenced our results because health care is free of charge within the French healthcare system. We used the EPICES score, which is an individual index that has been validated during pregnancy[19] and appears to be more strongly linked to the risk of adverse materno-fetal outcomes than neighborhood-level socioeconomic status.[17] However, the EPICES questionnaire was retrospectively fulfilled (6 to 24 months after pregnancy).

Conclusions

To conclude, our results from a large multiethnic multicenter European cohort from an area in which precarity is common demonstrate that psychosocial deprivation affected more than half of the women with GDM. Psychosocial deprivation was associated with higher BMIs and earlier GDM diagnoses among the vulnerable women, which suggests that GDM likely corresponded to unknown type 2 diabetes mellitus in these women and that prenatal diagnosis of type 2 diabetes should be reinforced in them, with weight control intervention and adherence to healthy lifestyle before pregnancy.[50] The vulnerable women were also more likely to be treated with insulin, but they gained as much weight during pregnancy as did the non-vulnerable women. Independent of the gestational age at GDM diagnosis, insulin use, overweight/obesity, GWG and other confounders, these women were also more likely to have LGA infants. This finding suggests that

the routine screening of women with GDM for psychosocial vulnerability may be an important tool for improving the prognoses of these women and their children. For example, specific follow-up and psychosocial support might be beneficial in these women.

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Transparency declaration: The lead author, EC, affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Clinical trial registration: observational study.

Data sharing: No additional data available.

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Table1: Characteristics of the total cohort of women by psychosocial status

	Total	No psychosocial deprivation	Psychosocial deprivation	OR [95% CI]	p
	n = 994	**n = 417**	**n = 577**		
EPICES score, unit	40.1 ± 25.5	15.6 ± 8.2	57.7 ± 18.1		< 0.001
Age, years	33.3 ± 5.2	33.5 ± 5.0	33.2 ± 5.4		NS
Parity, n	2.4 ± 1.3	2.3 ± 1.2	2.6 ± 1.3		< 0.001
Nulliparity (%)	266 (26.8)	123 (29.6)	143 (24.8)		0.093
Body mass index, kg/m²	27.8 ± 5.4	27.2 ± 5.3	28.2 ± 5.4		< 0.001
Weight status					<0.01
Normal weight (%)	307 (31.7)	153 (37.4)	154 (27.5)	REF	
Overweight (%)	374 (38.6)	150 (36.7)	224 (40.1)	1.5 [1.1-2.0]	<0.05
Obesity (%)	287 (29.6)	106 (25.9)	181 (32.4)	1.7 [1.2-2.4]	<0.005
Waist circumference					<0.01
<80 cm (%)	505 (51.8)	240 (58.3)	265 (47.2)	REF	
80-88 cm (%)	414 (42.5)	154 (37.4)	260 (46.3)	1.5 [1.2 – 2.0]	<0.01
>88 cm (%)	55 (5.6)	18 (4.4)	37 (6.6)	1.8 [1.03 – 3.36]	<0.05
Family history of diabetes (%)	545 (55.3)	247 (59.8)	298 (52.0)	0.7 [0.6 – 0.9]	<0.05
Non daily fruits and vegetable consumption (%)	336 (33.9)	108 (25.9)	228 (39.7)	1.9 [1.4 – 2.5]	< 0.001
Anti-hypertensive treatment (%)	62 (6.3)	20 (4.8)	42 (7.3)		NS
Lipid lowering treatment (%)	8 (0.8)	2 (0.5)	6 (1.1)		NS
Smoking (%)	76 (7.7)	36 (8.7)	40 (6.9)		NS
History of GDM (%)	184 (20.6)	71 (18.9)	113 (21.8)		NS
Ethnicity / origin					<0.001
Europe (%)	229 (23.7)	140 (34.2)	89 (16.0)	REF	
Antilla (%)	19 (2.0)	8 (2.0)	11 (2.0)		NS
North Africa (%)	382 (39.5)	183 (44.7)	199 (35.7)	1.7 [1.2 – 2.4]	<0.01
Sub Saharan Africa (%)	145 (15.0)	22 (5.4)	122 (22.1)	8.8 [5.2 – 14.9]	< 0.001
Middle East (%)	25 (2.6)	8 (2.0)	17 (3.1)	3.3 [1.4 – 8.1]	<0.01
India Pakistan (%)	74 (7.7)	26 (6.4)	48 (8.6)	2.9 [1.7 – 5.0]	< 0.001
Asia (%)	92 (9.5)	22 (5.4)	70 (12.6)	5.0 [2.9 -8.7]	< 0.001
Working status (%)	376 (38.1)	212 (53.4)	154 (26.9)	0.3 [0.2 – 0.4]	< 0.001

The data are expressed as n (%) or as the means ± the SDs.

GDM: gestational diabetes mellitus; EPICES: Evaluation of Precarity and Inequalities in Health Examination Centers; OR: odds ratio; REF: reference; 95% CI: 95% confidence interval.

Table 2: Events during pregnancy by psychosocial status

	Total	No psychosocial deprivation	Psychosocial deprivation	OR [95% CI]	p
	n = 994	**n = 417**	**n = 577**		
GDM diagnosis					0.024
<24 weeks gestation (%)	122 (15.1)	41 (12.1)	81 (17.3)	REF	
24-28 weeks gestation (%)	350 (43.3)	141 (41.5)	209 (44.7)	0.8 [0.5 – 1.2]	NS
≥28 weeks gestation (%)	336 (41.6)	158 (46.5)	178 (38.0)	0.6 [0.4 -0.9]	0.011
Insulin therapy during pregnancy (%)	260 (29.4)	80 (21.8)	180 (34.8)	1.9 [1.4 – 2.6]	< 0.001
GWG, kg	9.9 ± 6.1	9.9 ± 5.7	9.9 ± 6.4		NS
Excessive GWG (%)	265 (27.4)	109 (26.6)	156 (27.9)		NS
Birth weight, kg	3.4 ± 0.6	3.4 ± 0.5	3.4 ± 0.5		NS
Large for gestational age infants (%)	131 (13.2)	44 (10.6)	87 (15.1)	1.5 [1.02 – 2.2]	0.037
Birth weight ≥ 4000 g (%)	107 (11.7)	39 (10.1)	68 (12.9)		NS
Birth weight ≥ 4250 g (%)	42 (4.6)	17 (4.4)	25 (4.7)		NS
Shoulder dystocia (%)	23 (2.3)	5 (1.2)	18 (3.1)	2.7 [0.97 – 7.2]	0.047
Cesarean section (%)	256 (25.8)	104 (24.9)	152 (26.3)		NS
Preeclampsia (%)	18 (1.8)	11 (2.6)	7 (1.2)	0.5 [0.2 – 1.2]	0.096

The data are expressed as n (%) or as the means ± the SDs.

GDM: gestational diabetes mellitus; GWG: gestational weight gain; OR: odds ratio; REF: reference; 95%

CI: 95% confidence interval.

Table 3: Factors associated with large-for-gestational-age infants

	No LGA infant	LGA infant	Univariate analysis	Multivariate analysis	
	n=863	n=131	p	OR [95% CI]*	p*
Age, years	33.3 ± 5.2	33.5 ± 5.2	NS		-
Parity, n	2.4 ± 1.3	2.7 ± 1.2	< 0.01	1.10 [0.93-1.31]	NS
Body mass index, kg/m²	27.5 ± 5.4	29.8 ± 5.0	< 0.001		-
Obesity (%)	231 (27.4)	56 (44.4)	< 0.001	1.53 [0.998-2.45]	0.06
Family history of diabetes (%)	470 (55.0)	75 (57.3)	NS		-
Non daily fruits and vegetable consumption (%)	284 (33.0)	52 (39.7)	NS		-
Smoking (%)	66 (7.7)	10 (7.6)	NS		-
History of GDM (%)	143 (18.7)	41 (31.8)	<0.001	1.73 [1.09-2.75]	<0.05
Ethnicity / origin			<0.05		
Europe (%)	207 (24.8)	22 (16.8)		REF	
Antilla (%)	17 (2.0)	2 (1.0)		0.90 [0.18-4.38]	NS
North Africa (%)	314 (37.6)	68 (51.9)		1.63 [0.93-2.87]	0.09
Sub Saharan Africa (%)	122 (14.6)	23 (17.6)		1.11 [0.54-2.32]	NS
Middle East (%)	24 (2.9)	1 (0.8)		0.32 [0.04-2.55]	NS
India Pakistan (%)	66 (7.9)	8 (6.1)		1.02 [0.40-2.59]	NS
Asia (%)	85 (10.2)	7 (5.3)		0.59 [0.22-1.61]	NS
Working (%)	499 (39.0)	41 (31.3)	0.09		-
EPICES score, unit	39.1 ± 25.4	46.5 ± 25.3	0.002	1.12 [1.03-1.20]**	<0.01
Psychosocial deprivation (%)	490 (56.8)	87 (66.4)	0.037		-
GDM diagnosis			NS		-
<24 gestational weeks (%)	101 (14.9)	21 (16.4)			-
24-28 gestational weeks (%)	290 (42.6)	60 (46.9)			-
>28 gestational weeks (%)	289 (42.5)	47 (36.7)			-
GWG, kg	9.7 ± 6.1	10.9 ± 5.8	<0.05		-
Excessive GWG (%)	205 (24.3)	60 (47.6)	<0.001	2.34 [1.54-3.55]	<0.0001
Insulin therapy during pregnancy (%)	210 (27.8)	50 (38.8)	<0.05	1.32 [0.86-2.04]	NS

The data are expressed as n (%) or as the means ± the SDs

EPICES: Evaluation of Precarity and Inequalities in Health Examination Centers; GDM: gestational diabetes mellitus; GWG: gestational weight gain; LGA: large for gestational age; OR: odds ratio; REF: reference; 95% CI: 95% confidence interval.

*Multivariate analysis considering parity, obesity, personal history of GDM, ethnic origin, EPICES score, excessive GWG during pregnancy and insulin therapy during pregnancy; **per 10 units.

Figure 1: Prevalence of events according to Evaluation of Precarity and Inequalities in Health Examination Centers (EPICES) score tertiles

* $p<0.05$ versus the first tertile.

GDM: gestational diabetes mellitus; tertile 1: EPICES score <23.71 (mean 11.7±6.2); tertile 2: EPICES score between 23.71 and 51.5 (mean 35.0±8.5) and tertile 3: EPICES score ≥ 51.5 (mean 69.9±12.6).

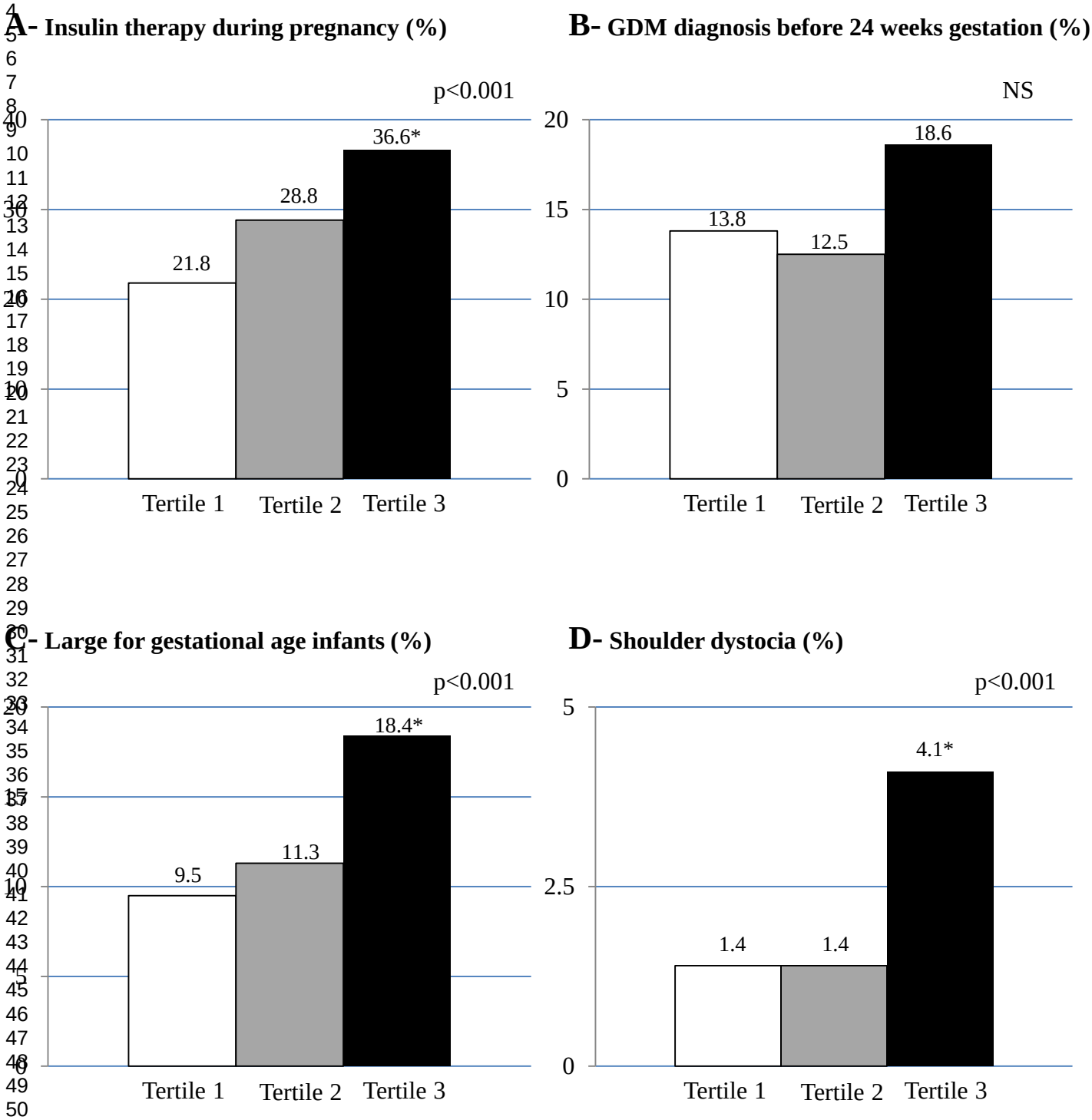

FIGURE 1

Appendix 1 Self-monitoring questionnaire to evaluate deprivation status.

Questions	Coefficient
1. Do you sometimes meet a social worker (welfare worker, educator)?	10.06
2. Do you have a complementary health insurance* (mutual insurance)?	-11.83
3. Do you live as a couple?	-8.28
4. Are you a homeowner or will you be one in the near future?	-8.28
5. Are there periods in the month when you have real financial difficulties to face your needs (food, rent, electricity)?	14.80
6. Have you done any sport activities in the last 12 months?	-6.51
7. Have you gone to any shows (cinema, theatre) over the last 12 months?	-7.10
8. Have you gone on holiday over the last 12 months?	-7.10
9. Have you seen any family member over the last six months (other than your parents or children)?	-9.47
10. If you have difficulties (financial, family or health), is there anyone around you who could take you in for a few days?	-9.47
11. If you have difficulties (financial, family or health), is there anyone around you who could help you financially (material aid such as money lending)?	-7.10
Intercept	75.14

EPICES*: Evaluation de la Précarité et des Inégalités de santé dans les Centres d'Examen de Santé.*

Score calculation: each question coefficient is added to intercept whenever the answer is "yes". A score equal to zero corresponds to non-deprivation, a score equal to 100 corresponds to maximum deprivation.

Questions were translated from French to English.

* In France, about 95% of the population is under the general French social security scheme. It gives right to the basic health insurance coverage that reimburses only part of medical expenses. The remainder of the medical cost not reimbursed by the French social security scheme remind on charge of people. Subscription to a complementary private insurance permits to cover partly or completely the percentage of medical costs not paid by the general social security scheme.

STROBE

Psychosocial deprivation in women with gestational diabetes mellitus is associated with poor fetomaternal prognoses: an observational study

	Item No	Recommendation
Title and abstract		
Page 1 **Page 5**	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale **Page 7**	2	Explain the scientific background and rationale for the investigation being reported
Objectives **Page 7-8**	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design **Page 8**	4	Present key elements of study design early in the paper
Setting **Page 8-10**	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants **Page 8**	6	(*a*) *Cohort study*?Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up*Case-control study*?Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls*Cross sectional study*?Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*?For matched studies, give matching criteria and number of exposed and unexposed*Case-control study*?For matched studies, give matching criteria and the number of controls per case
Variables **Page 8-10**	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement **Page 8-10**	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias **Page 10-11**	9	Describe any efforts to address potential sources of bias
Study size **Page 11**	10	Explain how the study size was arrived at
Quantitative variables **Page 11**	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why

	Item No	Recommendation
Statistical methods **Page 10-11**	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*?If applicable, explain how loss to follow-up was addressed*Case-control study*?If applicable, explain how matching of cases and controls was addressed*Cross sectional study*?If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants **Page 11**	13*	(*a*) Report numbers of individuals at each stage of study?eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(*b*) Give reasons for non-participation at each stage
		(*c*) Consider use of a flow diagram
Descriptive data **Page 11 and Table 1**	14*	(*a*)Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(*b*) Indicate number of participants with missing data for each variable of interest
		(*c*) *Cohort study*?Summarise follow-up time (eg average and total amount)
Outcome data **Page 11 and Table 2**	15*	*Cohort study*?Report numbers of outcome events or summary measures over time
		*Case-control study?*Report numbers in each exposure category, or summary measures of exposure
		*Cross sectional study?*Report numbers of outcome events or summary measures
Main results **Page 11 and Table 1-3 and figure 1**	16	(*a*) Report the numbers of individuals at each stage of the study?eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(*b*) Give reasons for non-participation at each stage
		(*c*) Consider use of a flow diagram
Other analyses Non applicable	17	Report other analyses done?eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results **Page 13-15**	18	Summarise key results with reference to study objectives
Limitations **Page 15**	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results

	Item No	Recommendation
Page 13-16		considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability **Page 15**	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding **Page 17**	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross sectional studies.

T

BMJ Open

Psychosocial deprivation in women with gestational diabetes mellitus is associated with poor fetomaternal prognoses: an observational study

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Psychosocial deprivation in women with gestational diabetes mellitus is associated with poor fetomaternal prognoses: an observational study

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3 tables and 1 figure

1 supplemental file

50 references

What is already known on this topic

Psychosocial deprivation is associated with more gestational diabetes mellitus.

What this study adds

Among women with gestational diabetes mellitus, psychosocial deprivation is associated with large for gestational age infants, independently of obesity, gestational weight gain and other confounders.

Abstract

Objective To evaluate the prognoses associated with psychosocial deprivation in women with gestational diabetes mellitus (GDM).

Design Observational study considering the 1498 multiethnic women with GDM who gave birth between January 2009 and February 2012.

Setting Four largest maternity units in the northeastern suburban area of Paris.

Participants The 994 women who completed the Evaluation of Precarity and Inequalities in Health Examination Centers [EPICES] questionnaire.

Main outcome measure Main complications of GDM (large infant for gestational age (LGA), shoulder dystocia, cesarean section, preeclampsia).

Results Psychosocial deprivation (EPICES score ≥30.17) affected 577 women (56%) and was positively associated with overweight/obesity, parity, and non-European origin and negatively associated with family history of diabetes, fruit and vegetable consumption, and working status. The psychosocially deprived women were diagnosed with GDM earlier, received insulin treatment during pregnancy more often and were more likely to have LGA infants (15.1 vs. 10.6%, odds ratio 1.5[95% confidence interval 1.02-2.2], $p<0.05$) and shoulder dystocia (3.1 vs. 1.2%, OR 2.7[0.97-7.2], $p<0.05$). In addition to psychosocial deprivation, LGA was associated with greater parity, obesity, history of GDM, ethnicity, excessive gestational weight gain and insulin therapy. A multivariate analysis using these covariates revealed that EPICES score was independently associated with LGA infants (per 10 units, OR 1.12[1.03-1.20], $p<0.01$).

Conclusions In our area, psychosocial deprivation is common in women with GDM and is associated with earlier GDM diagnoses and greater insulin treatment, an increased likelihood of

shoulder dystocia and, independently of obesity, gestational weight gain and other confounders with LGA infants.

Strengths and limitations:

- It is known that psychosocial deprivation is associated with more gestational diabetes and we report for the first time that, among women with gestational diabetes mellitus, psychosocial deprivation is associated with a poor prognosis.
- Our large, multicenter and diverse cohort and the adjustments for the relevant confounding factors, such as body mass index and gestational weight gain, ensure the robustness of our findings.
- We defined psychosocial vulnerability using the Evaluation of Precarity and Inequalities in Health Examination Centers [EPICES] questionnaire, which has been validated during pregnancy or not. This tool evaluates at an individual level several domains, including material goods, money, friendship and family networks, healthcare and leisure.
- However, the EPICES questionnaire was retrospectively fulfilled (6 to 24 months after pregnancy).

Key words: gestational diabetes mellitus, psychosocial deprivation, prognoses, large infant for gestational age

Introduction

Socioeconomic status reflects access to resources to prosper, and psychosocial deprivation is associated, across countries and over time,[1 2] with higher mortality and morbidity, including type 2 diabetes.[3] The main drivers in more incident type 2 diabetes appear to be higher body mass index (BMI) and impaired health behaviors.[4] The American Diabetes Association recommends the inclusion of assessments of patients' psychological and social situations as an ongoing part of the medical management of diabetes.[5] Indeed, psychosocial deprivation in patients with diabetes has been reported to be associated with increased obesity,[6] worse glycemic control,[7] poorer adherence,[8 9] more diabetic complications,[6 7 10 11] and perhaps greater mortality.[12-14] During pregnancy, psychosocial deprivation is also associated with poor outcomes that include increased rates of maternal[15] and neonatal[15 16] hospitalization, stillbirth,[17] postnatal death,[18] preterm delivery[17 19] and small for gestational age infants.[17-20]

Gestational diabetes mellitus (GDM) is defined as any degree of glucose intolerance with onset or first recognition during pregnancy and is now very common, with a prevalence ranging from 9.3 in Israel to 25.5% in California, US.[21] Although GDM is also more frequent in cases of psychosocial deprivation,[18 19 22 23] its prognosis in case of poor psychological and social conditions is currently unknown. We hypothesized that psychosocial deprivation might be associated with poor prognoses in women with GDM when confounding factors, such as obesity,[19] gestational weight gain (GWG)[16] and smoking habits,[20] are considered.

The four largest maternity units in the Northeastern suburban area of Paris, France participated in the IMPACT initiative, which aimed to improve postpartum screening for dysglycemia after GDM.[24 25] During this study, the women who attended these maternity units responded to the Evaluation of Precarity and Inequalities in Health Examination Centers

[EPICES] questionnaire, a questionnaire which evaluates psychosocial deprivation.[6 7 19 24 26] Therefore, for the first time, we had the opportunity to investigate the fetomaternal prognoses of these women with GDM according to their individual psychosocial statuses.

Methods

Patients

This study is a secondary analysis of the IMPACT study.[24 25] Briefly, the IMPACT initiative began in March 2011 and was a mobilization campaign for women with GDM and their community caregivers that sought to increase postpartum screening for dysglycemia. We aimed to evaluate the effect of this initiative by comparing the postpartum screening rates between the women who delivered before (between January 2009 and December 2010) and after this initiative (between April 2011 to February 2012). We systematically included women who were at least 18 years of age, free of known pregestational diabetes, had GDM and were followed during pregnancy in one of the four largest maternity units of the Seine-Saint Denis area of France during these periods of time. GDM was detected by oral glucose tolerance test and was defined by fasting blood glucose values ≥ 5.3 mmol/l and/or a 2-hour blood glucose value ≥ 7.8 mmol/l between January 2009 and December 2010,[24 25] and thereafter according to the International Association of Diabetes and Pregnancy Study Groups criteria, adopted in France in 2010.[27] GDM screening was universal in the four centers. In the primary analyses, we included the women who could be contacted by telephone and provided self-reports that indicated whether they had undergone postpartum screening tests during the six months following their deliveries.[24 25] For the current analysis, we included all of the women who delivered between January 2009

and February 2012 and who retrospectively completed the [EPICES] questionnaire by phone regardless of their report concerning the postpartum screening.

Data collection and assessment of outcomes

One single investigator extracted the following data from hospital records: age at conception, origin/ethnicity, family history of diabetes, history of previous GDM, gestational age at the time of GDM diagnosis (three classes: <24 weeks of gestation, between 24 and 28 weeks of gestation and ≥ 28 weeks of gestation), insulin treatment during pregnancy, and GWG. Excessive GWG was defined according to the recommendations of the Institute of Medicine; *i.e.,* GWG ≥ 16 kg in women with pregravid BMIs < 25 kg/m², ≥ 11.5 kg in overweight women (BMIs between 25 and 29.9 kg/m²) and ≥ 9 kg in obese women (BMI ≥ 30 kg/m²). We also collected obstetrical and neonatal outcomes , including offspring birth weight in comparison to the standard French population (large for gestational age (LGA) was defined by a birth weight exceeding the 90th percentile)[28], preeclampsia (blood pressure ≥ 140/90 mmHg on two recordings 4 h apart and proteinuria of at least 300 mg/24 h or 3+ or higher upon dipstick testing of a random urine sample), shoulder dystocia (defined as the use of obstetrical maneuvers *i.e.*, McRoberts, episiotomy after delivery of the fetal head, suprapubic pressure, posterior arm rotation to an oblique angle, rotation of the infant by 180 degrees, delivery of the posterior arm and acute or elective cesarian section.

The investigator conducted semi-structured interviews by phone between January and November 2011 for the women who delivered before the IMPACT campaign (maximum delay of time since delivery 24 months) and at least six months after delivery for the women who delivered after the IMPACT initiative. The investigator requested information about the subjects' current weights, heights, waist circumferences, professional statuses, smoking statuses, number

of children, antihypertensive and lipid-lowering treatments, family histories of diabetes and daily consumptions of fruits and vegetables. All these data were therefore declarative. Waist circumference was deducted from current waist size of trousers (waist circumference <80 cm: 6-14 (UK) or 34-42 (France), 80-88 cm: 16-20 (UK) or 44-48 (France); >88 cm: 22 (UK) or 48 (France) or more).

The investigator also conducted interviews to assess psychosocial deprivation using the EPICES score, which is a French deprivation score that is calculated based on responses to 11 questions that consider both socioeconomic conditions and family environment (appendix 1).[7 26 29] It evaluates at an individual level several domains, including material goods, money, friendship and family networks, healthcare and leisure. As previously reported, the EPICES score is a continuous variable, and increasing quintiles are associated with increased risks for poor health conditions such as obesity, diabetes in women, higher rates of smoking, poorer access to dental and gynecological care, and poorer perceived health statuses.[24 26] However, psychosocial deprivation can be defined by a score ≥ 30.17,[29] which was the threshold used here.

Statistical analyses

Sample size calculations were based on the main criterion of the IMPACT study, *i.e.* a postpartum screening test performed six months following delivery.[24 25] Results reported in this manuscript were prespecified, exploratory endpoints. Continuous variables are expressed as means ± SD, and normality was assessed with Kolmogorov-Smirnov tests. There were no missing data concerning psychosocial deprivation and main outcomes. Comparisons of two independent groups were performed using the Student t-test if the variable was normally distributed; otherwise, the Wilcoxon Mann-Whitney test was used. The significance of

differences in proportions (*i.e.*, qualitative variables) were tested with the χ^2 test, and the odds ratios (ORs) and 95% confidence intervals (CIs) were calculated in cases of statistical significance ($p<0.05$). We defined EPICES score tertiles in our cohort: first tertile: EPICES score <23.71 (mean 11.7±6.2; n=296); second tertile: score between 23.71 and 51.5 (mean 35.0±8.5; n=355); and third tertile: score ≥ 51.5 (mean 69.9±12.6; n=343). The factors associated with having a LGA infant were assessed with a univariate logistic regression method. For multivariate analyses, we included all factors that were associated with LGA infants with p values ≤0.05 in the univariate analyses. SAS Statistics version (9.2) (Cary, USA) was used to conduct all statistical analyses.

Results

Characteristics of the women

A total of 1498 women gave birth following GDM between January 2009 and February 2012 in our maternity units. Of these women, 994 retrospectively responded by phone to the EPICES questionnaire. Table 1 illustrates the characteristics of these women. The characteristics of the 994 women who responded to the EPICES questionnaire were similar to those of the 504 who did not respond with the exception of greater daily consumptions of fruits and vegetable (66.1 vs. 59.0%, respectively, $p<0.01$) and a trend toward being older (33.3±5.2 vs. 32.7±5.5 years, respectively, $p=0.06$). The EPICES questionnaire could not be completed by the women who could not be reached by phone and those with French language proficiencies that were insufficient for answering the questions.

Psychosocial deprivation affected 577 women (56%) and was positively associated with parity, overweight and obesity, greater waist circumference, and non-European origin.

Psychosocial deprivation was negatively associated with daily fruit and vegetable consumption, reduced family history of diabetes and working status (Table 1).

Pregnancy outcomes

Table 2 shows that the psychosocially deprived women were more likely to have been diagnosed with GDM prior to 24 weeks of gestation and more likely to have been treated with insulin during pregnancy than the non-psychosocially deprived women. The psychosocially deprived women were more likely to have LGA infants and infants with shoulder dystocia, but no differences in cesarean section or preeclampsia were found. Figure 1 (panels A to D) shows that the prevalences of insulin treatment during pregnancy (Figure 1A), LGA infants (Fig 1C) and shoulder dystocia (Figure 1D) increased with increasing EPICES score tertile.

Table 3 shows that, in addition to psychosocial deprivation (OR 1.5 [95%CI 1.02-2.22]), LGA was associated with higher parity, greater BMI and obesity of the mother (OR 2.1 [1.4–3.1]), increased incidence of GDM history (OR 2.0 [1.4–3.1]), ethnicity/origin, greater EPICES score (per 10 units: OR 1.50 [1.22-2.22]), greater GWG and excessive GWG (OR 2.8 [1.9-4.1]) and insulin treatment during pregnancy (OR 1.6 [1.1–2.4]). A multivariate analysis that considered parity, obesity, personal history of GDM, ethnicity, EPICES score, excessive GWG and insulin therapy during pregnancy revealed that the EPICES score remained independently associated with LGA infants (Table 3). In a model that was identical to the aforementioned model with the exception that weight and height were used in the place of the obesity, an association between psychosocial deprivation and LGA infants remained (per 10 units: OR 1.11 [1.02-1.20, $p<0.05$). In another model that was identical to the aforementioned model with the exception that psychosocial deprivation (*i.e.,* EPICES score ≥ 30.17) was used in the place of the

EPICES score, a trend toward an association between psychosocial deprivation and LGA infants remained (OR 1.53 [0.98-2.39], p=0.06). The prevalence of shoulder dystocia was too low to allow multivariate analyses.

Discussion

In this study, psychosocial deprivation in women with GDM was associated with earlier GDM diagnoses and more extensive insulin treatment. Moreover, we show for the first time that, independent of confounding factors, psychosocial deprivation was associated with increases in adverse outcomes, particularly LGA infants. We report that psychosocial deprivation (*i.e.*, an EPICES score above 30.17) affected 56% of the women with GDM in our study; another study reported a prevalence of 48% (11/23 women with GDM) in another area of France using the same definition of deprivation.[19] This high prevalence is due to the prevalence of precarity[30] and multiethnicity[31] in the Northeastern suburban area of Paris and to the roles played by these conditions in the rate of GDM. Indeed, the prevalence of GDM has been reported to be 1.7- to 2.9-fold higher among patients with high EPICES scores,[19] low educational statuses[22 23] or low family incomes[18 23] compared to their counterparts without these conditions. Notably, 23% of pregnant women in France have been reported to have high EPICES scores regardless of GDM status,[19] and 17.5% have been coded as psychosocially deprived by social workers[15] in two other areas in France. Together, our results advocate for screening for deprivation among pregnant women with GDM.

As previously reported for women with and without GDM,[19 32] we found that psychosocially deprived women with GDM were more likely to be obese. These women were also more likely to be unemployed and less likely to be daily consumers of fruits or vegetables; the latter

association is likely due to the cost of these foods. An association between socioeconomic status and healthy eating status, including fruits and vegetable consumption, has previously been reported.[33 34] We also observed a link between ethnicity/origin and deprivation; similar links have previously been described as complex relationships.[35-38] The women with and without psychosocial deprivation reported similar prevalences of prepregnancy antihypertensive and lipid-lowering treatments although metabolic disorders are often associated with elevated EPICES scores[39 40] and stress.[41] The lack of association observed in our study might be specific to women of reproductive age or might be attributable to reduced numbers of medical visits prior to pregnancy due to precarity.[16] The latter supposition would also result in undiagnosed metabolic syndrome prior to pregnancy, which would be in accordance with the greater prevalence of GDM diagnoses prior to 24 weeks of gestation among psychosocially deprived women. These findings suggest the possibility that these women might actually have had undiagnosed pregravid type 2 diabetes. Indeed, precarity is a risk factor for undiagnosed type 2 diabetes even in women of reproductive age.[42] However, we do not have access to the results of postpartum glycemic assessments that would be needed to confirm this hypothesis.

We also studied the association between psychosocial deprivation and adverse pregnancy outcomes in women with GDM for the first time. Compared to those without precarity, the women with precarity were more likely to have LGA infants and infants with shoulder dystocia. The association between EPICES scores and LGA infants was independent of obesity, which suggests that this relationship was only partially driven by the increased prevalence of overweight/obesity among the deprived women.[43 44] GWG and the prevalence of excessive GWG, which are other confounding factors regarding LGA infants,[43 44] were comparable between the women with and without precarity. We have recently shown that, compared to

women from Sub-Saharan Africa, European women experience more GDM-related events.[31] Furthermore, racial/ethnic differences in the clinical outcomes of GDM, including macrosomia, are commonly reported (for review).[45] Here, the association of LGA with precarity remained significant after adjusting for origin/ethnicity while we did not find any association between precarity and offspring with birth weights greater than 4000 g or 4250 g. The association between psychosocial deprivation and shoulder dystocia, which was not adjusted for confounding factors because the rate of dystocia events was low, was most likely driven by the prevalence of LGA infants. In a population-based study, the risk for shoulder dystocia significantly increased with BMI category in an unadjusted analysis, but this significance disappeared after adjusting for GDM.[35] As previously reported for pregnant women regardless of GDM status,[15] we found that the women in our cohort with GDM underwent cesarean section at similar rates regardless of the presence of psychosocial deprivation. The vulnerable women were diagnosed with GDM earlier, which suggests that unknown pregravid dysglycemia might partially explain the increased rate of LGA infants.[46] In a recent German study, the groups that were found to at high risk for GDM were women of low socio-economic status, migrants and obese women. An elevated risk of fetal malformations was found among the women who had been diagnosed with GDM, which suggests that many of these women might have had high glucose levels by the first trimester.[47]

The present study has limits and strengths. The public hospital recruitment and the area we cover probably included a higher proportion of women living with vulnerable conditions, precluding a generalization of our results. On the other hand, we could only include women who could fulfill the EPICES instrument and this may have underestimated the prevalence of psychosocial deprivation. Our large, multicenter and diverse cohort and the adjustments for the

relevant confounding factors ensure the robustness of our findings. However, we did not have access to data about glycemic control, diet, physical activity or the numbers of visits during pregnancy. Thus, the adverse outcomes observed for the women with precarity might have been due to these factors based on the following arguments: *(i)* poor glycemic control has been reported in vulnerable patients with diabetes[7] and was likely present in our population with GDM and psychosocial insecurity because insulin treatment was more often necessary during GDM among this population; *(ii)* fruit and vegetable consumption was lower among the vulnerable women following pregnancy, which might be indicative of poorer nutritional habits during pregnancy;[33 34 48] *(iii)* exercise during late pregnancy has been reported to vary with the education level of the mother;[33 34 49] and *(vi)* access to health care might depend on socioeconomic status,[19] but it is unlikely that access to health care influenced our results because health care is free of charge within the French healthcare system. Compliance may also differ according to psychosocial vulnerability status. Some data were self-reported, such as current weight, height, waist circumference class, professional status, smoking status, number of children, antihypertensive and lipid-lowering treatments, family history of diabetes and daily consumptions of fruits and vegetables. We used the EPICES score, which is an individual index that has been validated during pregnancy[19] and appears to be more strongly linked to the risk of adverse materno-fetal outcomes than neighborhood-level socioeconomic status.[17] However, the EPICES questionnaire was retrospectively fulfilled (6 to 24 months after pregnancy).

Conclusions

To conclude, our results from a large multiethnic multicenter European cohort from an area in which precarity is common demonstrate that psychosocial deprivation affected more than half of the women with GDM. Psychosocial deprivation was associated with higher BMIs and earlier

GDM diagnoses among the vulnerable women, which suggests that GDM likely corresponded to unknown type 2 diabetes mellitus in these women and that prenatal diagnosis of type 2 diabetes should be reinforced in them, with weight control intervention and adherence to healthy lifestyle before pregnancy.[50] The vulnerable women were also more likely to be treated with insulin, but they gained as much weight during pregnancy as did the non-vulnerable women. Independent of the gestational age at GDM diagnosis, insulin use, overweight/obesity, GWG and other confounders, these women were also more likely to have LGA infants. This finding suggests that the routine screening of women with GDM for psychosocial vulnerability may be an important tool for improving the prognoses of these women and their children. For example, specific follow-up and psychosocial support might be beneficial in these women.

Contributors: EC researched data, directed research and wrote the manuscript; HB researched data and wrote the manuscript; GR directed research and reviewed/edited the manuscript; LV researched data and contributed to discussion; LC researched data and reviewed/edited the manuscript; PV directed research and reviewed/edited the manuscript. All authors contributed to the interpretation of the results and the revision of the manuscript for intellectual content and approved the final version of the manuscript. Delphine Dubois, Umanis, Paris, is the guarantor of this work and, as such, had fully access to all the data in the study and takes the responsibility for the integrity of the data and the accuracy of the data analyses.

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Transparency declaration: The lead author, EC, affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Clinical trial registration: observational study.

Data sharing: No additional data available.

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Table1: Characteristics of the total cohort of women by psychosocial status

	Total	No psychosocial deprivation	Psychosocial deprivation	OR [95% CI]	p
	n = 994	**n = 417**	**n = 577**		
EPICES score, unit	40.1 ± 25.5	15.6 ± 8.2	57.7 ± 18.1		< 0.001
Age, years	33.3 ± 5.2	33.5 ± 5.0	33.2 ± 5.4		NS
Parity, n	2.4 ± 1.3	2.3 ± 1.2	2.6 ± 1.3		< 0.001
Nulliparity (%)	266 (26.8)	123 (29.6)	143 (24.8)		0.093
Weight (kg)	74.3±15.1	72.2±14.5	75.7±155		<0.001
Height (cm)	163±6	163±6	164±7		**0.073**
Body mass index, kg/m²	27.8 ± 5.4	27.2 ± 5.3	28.2 ± 5.4		< 0.001
Weight status					<0.01
Normal weight (%)	307 (31.7)	153 (37.4)	154 (27.5)	REF	
Overweight (%)	374 (38.6)	150 (36.7)	224 (40.1)	1.5 [1.1-2.0]	<0.05
Obesity (%)	287 (29.6)	106 (25.9)	181 (32.4)	1.7 [1.2-2.4]	<0.005
Waist circumference					<0.01
<80 cm (%)	505 (51.8)	240 (58.3)	265 (47.2)	REF	
80-88 cm (%)	414 (42.5)	154 (37.4)	260 (46.3)	1.5 [1.2 – 2.0]	<0.01
>88 cm (%)	55 (5.6)	18 (4.4)	37 (6.6)	1.8 [1.03 – 3.36]	<0.05
Family history of diabetes (%)	545 (55.3)	247 (59.8)	298 (52.0)	0.7 [0.6 – 0.9]	<0.05
Non daily fruits and vegetable consumption (%)	336 (33.9)	108 (25.9)	228 (39.7)	1.9 [1.4 – 2.5]	< 0.001
Anti-hypertensive treatment (%)	62 (6.3)	20 (4.8)	42 (7.3)		NS
Lipid lowering treatment (%)	8 (0.8)	2 (0.5)	6 (1.1)		NS
Smoking (%)	76 (7.7)	36 (8.7)	40 (6.9)		NS
History of GDM (%)	184 (20.6)	71 (18.9)	113 (21.8)		NS
Ethnicity / origin					<0.001
Europe (%)	229 (23.7)	140 (34.2)	89 (16.0)	REF	
Antilla (%)	19 (2.0)	8 (2.0)	11 (2.0)		NS
North Africa (%)	382 (39.5)	183 (44.7)	199 (35.7)	1.7 [1.2 – 2.4]	<0.01
Sub Saharan Africa (%)	145 (15.0)	22 (5.4)	122 (22.1)	8.8 [5.2 – 14.9]	< 0.001
Middle East (%)	25 (2.6)	8 (2.0)	17 (3.1)	3.3 [1.4 – 8.1]	<0.01
India Pakistan (%)	74 (7.7)	26 (6.4)	48 (8.6)	2.9 [1.7 – 5.0]	< 0.001
Asia (%)	92 (9.5)	22 (5.4)	70 (12.6)	5.0 [2.9 -8.7]	< 0.001
Working status (%)	376 (38.1)	212 (53.4)	154 (26.9)	0.3 [0.2 – 0.4]	< 0.001

The data are expressed as n (%) or as the means ± the SDs.

GDM: gestational diabetes mellitus; EPICES: Evaluation of Precarity and Inequalities in Health Examination Centers; OR: odds ratio; REF: reference; 95% CI: 95% confidence interval.

Table 2: Events during pregnancy by psychosocial status

	Total	No psychosocial deprivation	Psychosocial deprivation	OR [95% CI]	p
	n = 994	**n = 417**	**n = 577**		
GDM diagnosis					0.024
<24 weeks gestation (%)	122 (15.1)	41 (12.1)	81 (17.3)	REF	
24-28 weeks gestation (%)	350 (43.3)	141 (41.5)	209 (44.7)	0.8 [0.5 – 1.2]	NS
≥28 weeks gestation (%)	336 (41.6)	158 (46.5)	178 (38.0)	0.6 [0.4 -0.9]	0.011
Insulin therapy during pregnancy (%)	260 (29.4)	80 (21.8)	180 (34.8)	1.9 [1.4 – 2.6]	< 0.001
GWG, kg	9.9 ± 6.1	9.9 ± 5.7	9.9 ± 6.4		NS
Excessive GWG (%)	265 (27.4)	109 (26.6)	156 (27.9)		NS
Birth weight, kg	3.4 ± 0.6	3.4 ± 0.5	3.4 ± 0.5		NS
Large for gestational age infants (%)	131 (13.2)	44 (10.6)	87 (15.1)	1.5 [1.02 – 2.2]	0.037
Birth weight ≥ 4000 g (%)	107 (11.7)	39 (10.1)	68 (12.9)		NS
Birth weight ≥ 4250 g (%)	42 (4.6)	17 (4.4)	25 (4.7)		NS
Shoulder dystocia (%)	23 (2.3)	5 (1.2)	18 (3.1)	2.7 [0.97 – 7.2]	0.047
Cesarean section (%)	256 (25.8)	104 (24.9)	152 (26.3)		NS
Preeclampsia (%)	18 (1.8)	11 (2.6)	7 (1.2)	0.5 [0.2 – 1.2]	0.096

The data are expressed as n (%) or as the means ± the SDs.

GDM: gestational diabetes mellitus; GWG: gestational weight gain; OR: odds ratio; REF: reference; 95% CI: 95% confidence interval.

Table 3: Factors associated with large-for-gestational-age infants

	No LGA infant	LGA infant	Univariate analysis	Multivariate analysis	
	n=863	n=131	p	OR [95% CI]*	p*
Age, years	33.3 ± 5.2	33.5 ± 5.2	NS		-
Parity, n	2.4 ± 1.3	2.7 ± 1.2	< 0.01	1.10 [0.93-1.31]	NS
Weight (kg)	73.1±14.8	82.1±15.3	<0.001		
Height (cm)	163±6	167±6	<0.001		
Body mass index, kg/m²	27.5 ± 5.4	29.8 ± 5.0	< 0.001		-
Obesity (%)	231 (27.4)	56 (44.4)	< 0.001	1.53 [0.998-2.45]	0.06
Family history of diabetes (%)	470 (55.0)	75 (57.3)	NS		-
Non daily fruits and vegetable consumption (%)	284 (33.0)	52 (39.7)	NS		-
Smoking (%)	66 (7.7)	10 (7.6)	NS		-
History of GDM (%)	143 (18.7)	41 (31.8)	<0.001	1.73 [1.09-2.75]	<0.05
Ethnicity / origin			<0.05		
Europe (%)	207 (24.8)	22 (16.8)		REF	
Antilla (%)	17 (2.0)	2 (1.0)		0.90 [0.18-4.38]	NS
North Africa (%)	314 (37.6)	68 (51.9)		1.63 [0.93-2.87]	0.09
Sub Saharan Africa (%)	122 (14.6)	23 (17.6)		1.11 [0.54-2.32]	NS
Middle East (%)	24 (2.9)	1 (0.8)		0.32 [0.04-2.55]	NS
India Pakistan (%)	66 (7.9)	8 (6.1)		1.02 [0.40-2.59]	NS
Asia (%)	85 (10.2)	7 (5.3)		0.59 [0.22-1.61]	NS
Working (%)	499 (39.0)	41 (31.3)	0.09		-
EPICES score, unit	39.1 ± 25.4	46.5 ± 25.3	0.002	1.12 [1.03-1.20]**	<0.01
Psychosocial deprivation (%)	490 (56.8)	87 (66.4)	0.037		-
GDM diagnosis			NS		-
<24 gestational weeks (%)	101 (14.9)	21 (16.4)			-
24-28 gestational weeks (%)	290 (42.6)	60 (46.9)			-
>28 gestational weeks (%)	289 (42.5)	47 (36.7)			-
GWG, kg	9.7 ± 6.1	10.9 ± 5.8	<0.05		-
Excessive GWG (%)	205 (24.3)	60 (47.6)	<0.001	2.34 [1.54-3.55]	<0.0001
Insulin therapy during pregnancy (%)	210 (27.8)	50 (38.8)	<0.05	1.32 [0.86-2.04]	NS

The data are expressed as n (%) or as the means ± the SDs

EPICES: Evaluation of Precarity and Inequalities in Health Examination Centers; GDM: gestational diabetes mellitus; GWG: gestational weight gain; LGA: large for gestational age; OR: odds ratio; REF: reference; 95% CI: 95% confidence interval.

*Multivariate analysis considering parity, obesity, personal history of GDM, ethnic origin, EPICES score, excessive GWG during pregnancy and insulin therapy during pregnancy; **per 10 units.

Current weights, heights, professional statuses, smoking statuses, number of children, family histories of diabetes and daily consumptions of fruits and vegetables were self-reported.

Figure 1: Prevalence of events according to Evaluation of Precarity and Inequalities in Health Examination Centers (EPICES) score tertiles

* $p<0.05$ versus the first tertile.

GDM: gestational diabetes mellitus; tertile 1: EPICES score <23.71 (mean 11.7±6.2); tertile 2: EPICES score between 23.71 and 51.5 (mean 35.0±8.5) and tertile 3: EPICES score ≥ 51.5 (mean 69.9±12.6).

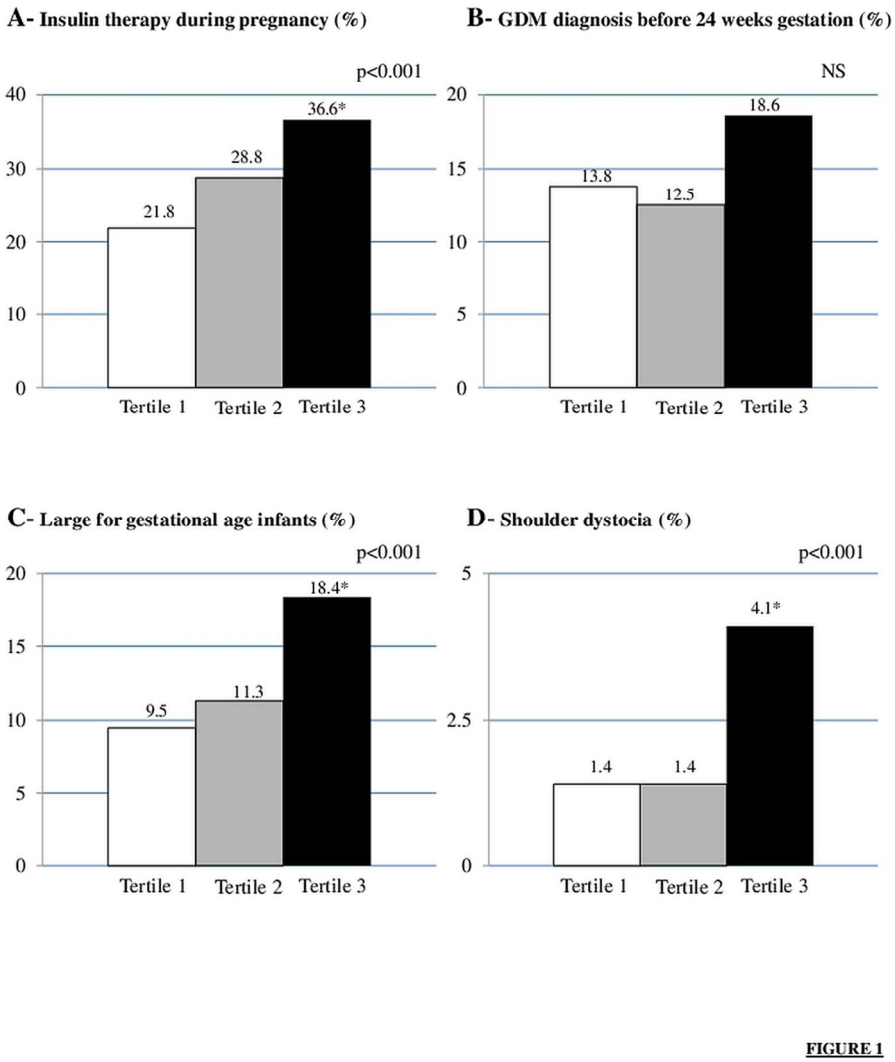

FIGURE 1

90x119mm (300 x 300 DPI)

Appendix 1 Self-monitoring questionnaire to evaluate deprivation status.

Questions	Coefficient
1. Do you sometimes meet a social worker (welfare worker, educator)?	10.06
2. Do you have a complementary health insurance* (mutual insurance)?	-11.83
3. Do you live as a couple?	-8.28
4. Are you a homeowner or will you be one in the near future?	-8.28
5. Are there periods in the month when you have real financial difficulties to face your needs (food, rent, electricity)?	14.80
6. Have you done any sport activities in the last 12 months?	-6.51
7. Have you gone to any shows (cinema, theatre) over the last 12 months?	-7.10
8. Have you gone on holiday over the last 12 months?	-7.10
9. Have you seen any family member over the last six months (other than your parents or children)?	-9.47
10. If you have difficulties (financial, family or health), is there anyone around you who could take you in for a few days?	-9.47
11. If you have difficulties (financial, family or health), is there anyone around you who could help you financially (material aid such as money lending)?	-7.10
Intercept	75.14

EPICES*: Evaluation de la Précarité et des Inégalités de santé dans les Centres d'Examen de Santé.*

Score calculation: each question coefficient is added to intercept whenever the answer is "yes". A score equal to zero corresponds to non-deprivation, a score equal to 100 corresponds to maximum deprivation.

Questions were translated from French to English.

* In France, about 95% of the population is under the general French social security scheme. It gives right to the basic health insurance coverage that reimburses only part of medical expenses. The remainder of the medical cost not reimbursed by the French social security scheme remind on charge of people. Subscription to a complementary private insurance permits to cover partly or completely the percentage of medical costs not paid by the general social security scheme.

STROBE

Psychosocial deprivation in women with gestational diabetes mellitus is associated with poor fetomaternal prognoses: an observational study

	Item No	Recommendation
Title and abstract		
Page 1 **Page 5**	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale **Page 7**	2	Explain the scientific background and rationale for the investigation being reported
Objectives **Page 7-8**	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design **Page 8**	4	Present key elements of study design early in the paper
Setting **Page 8-10**	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants **Page 8**	6	(*a*) *Cohort study*?Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up*Case-control study*?Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls*Cross sectional study*?Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*?For matched studies, give matching criteria and number of exposed and unexposed*Case-control study*?For matched studies, give matching criteria and the number of controls per case
Variables **Page 8-10**	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement **Page 8-10**	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias **Page 10-11**	9	Describe any efforts to address potential sources of bias
Study size **Page 11**	10	Explain how the study size was arrived at
Quantitative variables **Page 11**	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why

	Item No	Recommendation
Statistical methods **Page 10-11**	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*?If applicable, explain how loss to follow-up was addressed*Case-control study*?If applicable, explain how matching of cases and controls was addressed*Cross sectional study*?If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants **Page 11**	13*	(*a*) Report numbers of individuals at each stage of study?eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(*b*) Give reasons for non-participation at each stage
		(*c*) Consider use of a flow diagram
Descriptive data **Page 11 and Table 1**	14*	(*a*)Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(*b*) Indicate number of participants with missing data for each variable of interest
		(*c*) *Cohort study*?Summarise follow-up time (eg average and total amount)
Outcome data **Page 11 and Table 2**	15*	*Cohort study*?Report numbers of outcome events or summary measures over time
		*Case-control study?*Report numbers in each exposure category, or summary measures of exposure
		*Cross sectional study?*Report numbers of outcome events or summary measures
Main results **Page 11 and Table 1-3 and figure 1**	16	(*a*) Report the numbers of individuals at each stage of the study?eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(*b*) Give reasons for non-participation at each stage
		(*c*) Consider use of a flow diagram
Other analyses Non applicable	17	Report other analyses done?eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results **Page 13-15**	18	Summarise key results with reference to study objectives
Limitations **Page 15**	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results

	Item No	Recommendation
Page 13-16		considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability Page 15	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding Page 17	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross sectional studies.

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