Factors associated with screening for glucose abnormalities after gestational diabetes mellitus: Baseline cohort of the interventional IMPACT study

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Received 1st September 2013; received in revised form 29 November 2013; accepted 2 December 2013

Abstract

Introduction. – Although it is important to screen women who have had gestational diabetes mellitus (GDM) for abnormal post-partum glucose levels, such testing is rarely performed. The aim of this study was to use data from the first observational phase of the IMPACT study to determine rates of screening within 6 months of delivery in a multiethnic cohort, focusing in particular on the effects of social deprivation and the risk of future diabetes.

Patients and methods. – To investigate the frequency of post-partum screening, charts were analyzed, and all women attending four centres located in a deprived area who had had GDM between January 2009 and December 2010 were contacted by phone. The Evaluation of Precarity and Inequalities in Health Examination Centres (EPICES) deprivation index and Finnish Diabetes Risk Score (FINDRISK) questionnaire were also evaluated.

Results. – Data were evaluable for 589 of the 719 women contacted (mean age: 33.4 ± 5.2 years; mean body mass index: 27.6 ± 5.4 kg/m²), and 196 (33.3%) reported having been screened. On multivariate analysis, factors associated with a lack of screening were smoking [odds ratio (OR): 0.42 (0.20–0.90), P < 0.05], low consumption of fruit and vegetables [OR: 0.58 (0.39–0.82), P < 0.01] and heavier offspring birth weight (P < 0.05), although there were no differences in FINDRISK and EPICES scores between screened and unscreened women.

Conclusion. – One-third of women who had had GDM reported having been screened for dysglycaemia at 6 months post-partum. However, it is expected that the interventional phase of the IMPACT study will increase screening rates, especially in women with the risk factors associated with lower screening rates during this observational phase.

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Keywords: Gestational diabetes mellitus; Screening test; Glucose abnormalities; Social deprivation

1. Introduction

Women with a history of gestational diabetes mellitus (GDM) have an increased risk of developing type 2 diabetes. During follow-up, diabetes persisted in 5–14% of these women, and 7–29% had glucose intolerance. In addition, 30–84% of these women are expected to have GDM during their next pregnancy [1–3]. Furthermore, of the 788 women evaluated by a 75 g oral glucose tolerance test (OGTT) 3–6 months after a GDM pregnancy, 5.8% had impaired fasting glucose, 10.4% had impaired glucose tolerance, 3.7% had both conditions and 5.4% had outright diabetes [4]. Indeed, as a GDM pregnancy results in a five-fold higher risk of diabetes at 5 years and a nine-fold higher risk at 10 years [1], detecting post-partum abnormalities in glucose homoeostasis is essential for the prevention of diabetes. The
OGTT is now recommended for the detection of these abnormalities, as the technique is two to three times more sensitive than measuring fasting plasma glucose (FPG) alone [5].

Yet, although data are scanty, post-partum screening for abnormalities of glucose homeostasis appears to be rarely performed. The rate of screening varies from 19% to 68%, with average screening frequencies of 45–50% [4–7]. Most of these studies were done in the US except for a recent French study reporting screening rates of 65% [7]. In a focus group study consisting of 22 semi-structured interviews of women with GDM, barriers to post-partum screening included feelings of emotional stress related to the baby and fear of receiving a diabetes diagnosis, whereas screening facilitators included child-care availability and a desire for a check-up [8].

The main objectives of the present study were to evaluate the rate of post-partum screening for diabetes and to identify the factors associated with screening after GDM in women attending four hospital maternity departments in Seine-Saint-Denis, a suburban area northeast of Paris. As an information campaign is intended to follow, this study aimed to provide baseline data for evaluation of the information campaign. It was hypothesized that the factors associated with low screening rates would include:

- low socioeconomic status, as screening is dependent on concern for the future, and women affected by poverty may be distracted by more immediate concerns [9];
- a priori low risk for diabetes, as a doctor’s likelihood of advising screening would be greater for women with a priori high risk. These hypotheses had never been previously explored.

2. Patients and methods

2.1. The IMPACT campaign and patients

The IMPACT study was designed to assess the effectiveness of a campaign aiming to increase the frequency of glucose abnormality screening during the post-partum period following GDM. The study protocol was approved by the National Ethics Committee (CCTIRS: Comité consultatif sur le traitement de l’information en matière de recherche; Advisory Committee on Research Information Processing). The campaign to mobilize women and their caregivers, including general practitioners (GPs), paediatricians, pharmacists, gynaecologists and nurses, started in May 2011. Multidisciplinary meetings were organized at each centre to provide information on the usefulness of post-partum screening and printed materials, such as easy-to-understand illustrations containing post-partum health tips for women with GDM (Supplementary data, Fig. S1). To improve collaboration between maternity caregivers and GPs, the automatic prescription of post-partum OGTTs was arranged and letters were posted to community caregivers focused on the diagnosis of GDM, with instructions for interpreting OGTT results after delivery as well as follow-up advice. These materials were handed out to the participating women and inserted into a health leaflet concerning babies.

For the current baseline study (first phase), women who were at least 18 years of age without pregestational diabetes who had had GDM, and who had delivered at any of the four largest maternity centres in Seine-Saint-Denis between January 2009 and December 2010, were systematically included. GDM was detected by OGTT, and defined as fasting plasma glucose (FPG) values ≥ 5.3 mmol/L (according to French recommendations) [7] and/or a 2-h blood glucose value ≥ 7.8 mmol/L [World Health Organization (WHO) criteria] [8]. All of the included participants could be contacted by phone and could self-report if they had received a post-partum screening test within 6 months of their pregnancy. The women exposed to the campaign information (prospective second phase) were those who had had GDM between April 2011 and February 2012.

2.2. Data collection and outcome assessment

One research doctor (F.F) collected the following information from the hospital records of each participant: sociodemographic data; age at conception; professional status (employed, unemployed or at home); origin/ethnicity; family history of diabetes; parity; personal history of previous GDM; hypertension; smoking habits during pregnancy; child with macrosomia (birth weight ≥ 4 kg); gestational age at GDM diagnosis; and insulin treatment. The occurrence of any of the following events during pregnancy were also recorded: [0] pre-eclampsia (blood pressure ≥ 140/90 mmHg for two measurements taken 4 h apart, and proteinuria of at least 300 mg/24 h or 3+ or more on dipstick testing in a random urine sample); a newborn large for gestational age (LGA; birth weight > 90th percentile for the standard French population) [10]; shoulder dystocia, defined as the use of obstetric manoeuvres (McRoberts episiotomy after presentation of fetal head, suprapubic pressure, posterior arm rotation to an oblique angle, rotation of infant by 180º, delivery of posterior arm); and caesarean section.

The research doctor also conducted semi-structured interviews by phone at least 6 months after delivery to assess whether a screening test for glucose abnormalities had been performed within the first 6 months of delivery and, if so, what the test was. Weight and height were self-reported and used to calculate maternal body mass index (BMI). F.F also conducted interviews to allow calculation of the EPICES (Evaluation of Precariness and Inequalities in Health Examination Centres) score [11] and the Finnish Diabetes Risk Score (FINDRISK) [12]. The EPICES score is a French index of deprivation as assessed by 11 questions on both socioeconomic conditions and family environment [11]; a score > 30.17 is associated with an increased risk of obesity, diabetes in women and poor perceived health status [11]. Quintiles have also been described based on 197,389 people in a validation study, and the EPICES score appears to be related to all indicators of lifestyle (smoking), access to dental and gynaecological care, and health status (perception of health and BMI). The risk associated with any of these events (such as smoking, poor health perception, poor access to care) increased in a linear manner from quintile 1 (not deprived) to quintile 5 (more deprived) [11], wherein Q1 = 0 to < 7.1, Q2 = 7.1 to < 16.6, Q3 = 16.6 to < 30.2, Q4 = 30.2 to < 48.5 and Q5 = 48.5 to 100.

The FINDRISK has been validated in France [13] and includes the following eight items: age, BMI, waist
### Characteristics of women who did and did not undergo post-partum glucose screening.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Screened (n = 196)</th>
<th>Not screened (n = 393)</th>
<th>OR [95% CI]</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>33.6 ± 5.2</td>
<td>33.2 ± 5.2</td>
<td>0.333</td>
<td></td>
</tr>
<tr>
<td>Children (n)</td>
<td>2.3 ± 1.2</td>
<td>2.5 ± 1.4</td>
<td>0.457</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>72.8 ± 13.8</td>
<td>74.2 ± 15.8</td>
<td>0.495</td>
<td></td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>27.1 ± 5.0</td>
<td>27.9 ± 5.6</td>
<td>0.228</td>
<td></td>
</tr>
<tr>
<td>Obesity (%)</td>
<td>48 (25.3)</td>
<td>123 (32.5)</td>
<td>0.7 [0.5–1.03]</td>
<td>0.074</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 80</td>
<td>105 (55.6)</td>
<td>187 (49.6)</td>
<td>REF</td>
<td></td>
</tr>
<tr>
<td>80–88</td>
<td>80 (42.5)</td>
<td>170 (45.1)</td>
<td>0.332</td>
<td></td>
</tr>
<tr>
<td>&gt; 88</td>
<td>4 (2.1)</td>
<td>20 (5.3)</td>
<td>0.4 [0.1–1.1]</td>
<td>0.066</td>
</tr>
<tr>
<td>Family history of diabetes (%)</td>
<td>108 (56.5)</td>
<td>225 (58.0)</td>
<td>0.741</td>
<td></td>
</tr>
<tr>
<td>Previous GDM (%)</td>
<td>33 (17.3)</td>
<td>81 (22.3)</td>
<td>0.163</td>
<td></td>
</tr>
<tr>
<td>Sedentarity (%)</td>
<td>62 (31.6)</td>
<td>135 (34.4)</td>
<td>0.497</td>
<td></td>
</tr>
<tr>
<td>Non-daily fruit and vegetable consumption (%)</td>
<td>54 (27.6)</td>
<td>157 (40.1)</td>
<td>0.6 [0.4–0.8]</td>
<td>0.003</td>
</tr>
<tr>
<td>Hypertension</td>
<td>10 (5.1)</td>
<td>22 (5.6)</td>
<td>0.792</td>
<td></td>
</tr>
<tr>
<td>Lipid-lowering treatment (%)</td>
<td>1 (0.5)</td>
<td>1 (0.3)</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Smoking (%)</td>
<td>11 (5.6)</td>
<td>43 (11.0)</td>
<td>0.5 [0.2–0.96]</td>
<td>0.034</td>
</tr>
<tr>
<td>History of macrosomia (%)</td>
<td>4 (2.0)</td>
<td>20 (5.1)</td>
<td>0.323</td>
<td></td>
</tr>
<tr>
<td>FINDRISC, unit</td>
<td>11.4 ± 3.9</td>
<td>12.0 ± 3.9</td>
<td>0.086</td>
<td></td>
</tr>
</tbody>
</table>

**Sociodemographic characteristics**

| Ethnicity/origin [n (%)] | Europe | West Indies | North Africa | Sub-Saharan Africa | Middle East | India, Pakistan, Asia | Working (%) | EPICES score (unit) | Precarity score > 30.17 (%) | Pregnancy-related data | Gestational weight gain (kg) | Newborn birth weight (kg) | Insulin therapy (%) | Pre-eclampsia (%) | Caesarean section (%) | Macrosomia (%) | Shoulder dystocia (%) | Pre-eclampsia, macrosomia or shoulder dystocia (%) |
|--------------------------|--------|-------------|--------------|-------------------|-------------|------------------------|-------------|---------------------|--------------------------|----------------------|------------------------|----------------------|----------------------|----------------|----------------|----------------------|----------------|----------------|-----------------------|
| Europe                   | 53 (27.2) | 108 (28.4) | REF          |                   |             |                        |             |                     |                          |                     |                        |                     |                     |                     |               |               |                      |
| West Indies              | 1 (0.5)   | 10 (2.6)   | 0.1342       |                   |             |                        |             |                     |                          |                     |                        |                     |                     |                     |               |               |                      |
| North Africa             | 73 (37.4) | 149 (39.2) | 0.9940       |                   |             |                        |             |                     |                          |                     |                        |                     |                     |                     |               |               |                      |
| Sub-Saharan Africa       | 30 (15.4) | 44 (11.6)  | 0.2571       |                   |             |                        |             |                     |                          |                     |                        |                     |                     |                     |               |               |                      |
| Middle East              | 7 (3.6)   | 13 (3.4)   | 0.8521       |                   |             |                        |             |                     |                          |                     |                        |                     |                     |                     |               |               |                      |
| India, Pakistan, Asia   | 31 (15.9) | 56 (14.8)  | 0.6667       |                   |             |                        |             |                     |                          |                     |                        |                     |                     |                     |               |               |                      |

**Social indicators**

<table>
<thead>
<tr>
<th>Working (%)</th>
<th>74 (37.8)</th>
<th>146 (37.3)</th>
<th>0.922</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPICES score (unit)</td>
<td>35.4 ± 25.4</td>
<td>37.2 ± 24.6</td>
<td>0.391</td>
</tr>
<tr>
<td>Precarity score &gt; 30.17 (%)</td>
<td>66 (49.6)</td>
<td>141 (52.4)</td>
<td>0.598</td>
</tr>
</tbody>
</table>

**Pregnancy-related data**

<table>
<thead>
<tr>
<th>Gestational weight gain (kg)</th>
<th>9.3 ± 5.7</th>
<th>9.9 ± 5.8</th>
<th>0.248</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn birth weight (kg)</td>
<td>3.3 ± 0.5</td>
<td>3.4 ± 0.6</td>
<td>0.019</td>
</tr>
<tr>
<td>Insulin therapy (%)</td>
<td>55 (28.5)</td>
<td>82 (23.4)</td>
<td>0.187</td>
</tr>
<tr>
<td>Pre-eclampsia (%)</td>
<td>5 (2.6)</td>
<td>10 (2.5)</td>
<td>0.996</td>
</tr>
<tr>
<td>Caesarean section (%)</td>
<td>39 (19.9)</td>
<td>101 (25.7)</td>
<td>0.119</td>
</tr>
<tr>
<td>Macrosomia (%)</td>
<td>23 (11.7)</td>
<td>64 (16.3)</td>
<td>0.142</td>
</tr>
<tr>
<td>Shoulder dystocia (%)</td>
<td>7 (3.6)</td>
<td>11 (2.8)</td>
<td>0.608</td>
</tr>
<tr>
<td>Pre-eclampsia, macrosomia or shoulder dystocia (%)</td>
<td>32 (16.3)</td>
<td>77 (19.6)</td>
<td>0.336</td>
</tr>
</tbody>
</table>

Data are expressed as numbers (percentages) or means ± standard deviation; EPICES: Evaluation of Precarity and Inequalities in Health Examination Centres; GDM: gestational diabetes mellitus; FINDRISC: Finnish Diabetes Risk Score.

circumference, physical activity, diet, use of antihypertensive medication, history of high blood glucose (such as a personal history of GDM), and family history of diabetes. The higher the FINDRISK, the higher the risk of incident and prevalent diabetes [12,14,15]. Sedentarity was defined as spending <30 min/day doing physical activity.

### 2.3. Statistical analysis

In the IMPACT study (using data from naïve women), continuous outcome variables were tested for normality, while independent-sample t-tests or Mann–Whitney U tests were used to compare between group differences and chi² tests were used to compare categorical variables. Univariate and multivariate regression analyses were performed to identify factors associated with having a post-partum screening test for glucose abnormalities. For the multivariate analysis, factors associated on univariate analysis with P values <0.10 were included. Also included were waist circumference in model 1 and obesity in model 2, as these were dependent variables. SAS version 9.2 software (SAS Institute Inc., Cary, NC, USA) was used for all statistical analyses.

### 3. Results

#### 3.1. Participants

Of the 1302 women eligible according to inclusion criteria, 719 could be contacted by phone and agreed to answer the study questions. Of these women, 130 were excluded because they were unable to provide an exact date for their screening test. These 130 women, compared to the 589 women who were included, had similar characteristics, such as age, BMI, ethnicity and working status, but had a history of previous GDM.
less often (10.8% vs 20.6%, respectively; \( P < 0.05 \)). The characteristics of the 589 women included are presented in Table 1. Briefly, their mean age was 33.4 ± 5.2 years, and their mean BMI was 27.6 ± 5.4 kg/m², with 30.1% considered obese. This was a multiethnic cohort (Table 1), with the majority of participants originating from North Africa (38.6%), Europe (28.0%), India/Pakistan/Asia (15.1%) and Sub-Saharan Africa (12.9%).

3.2. Screening rate and associated factors

During the post-partum 6-month period, 196 (33.3%) of our study participants underwent screening tests. The tests included measurement of FPG alone (51.9%, \( n = 83 \)), measurement of FPG and postprandial plasma glucose (41.2%, \( n = 66 \)), OGTT (6.3%, \( n = 10 \)) and HbA1c (0.6%, \( n = 1 \)). Thirty-six of the women did not know which test had been used. Of the women who had undergone screening, the number of those who consumed fruit and vegetables every day and who did not smoke was higher, while their infant’s birth weight was lower, than those who were not screened. In addition, the unscreened women had a trend towards lower BMI, waist circumference and FINDRISK (Table 1). While the screening rate was inversely correlated with the predefined EPICES quintiles (Fig. 1) [11], neither the mean EPICES score nor the percentage of deprived women differed between the two groups. The rate of screening also did not differ significantly according to FINDRISK ranges (Fig. 2).

On multivariate analysis – which took into account large waist circumference, smoking habits, daily consumption of fruit and vegetables, FINDRISK and offspring birth weight – smoking habits, a lack of daily fruit and vegetable consumption, and higher birth weight were independently associated with the lack of screening (Table 2). In a similar model using obesity rather than waist circumference, smoking was the only factor independently associated with no screening (Table 2).

4. Discussion

In the present study, a low rate (33%) of post-partum screening for glucose abnormalities was found in a large cohort of multiethnic women with GDM. Independent risk factors of the lack of screening were smoking, low consumption of fruit and vegetables, and higher offspring birth weight, whereas neither social deprivation nor a priori risk of type 2 diabetes proved to be risk factors.

The low rate of screening reported – which was around one-third of our participants – is similar to those reported in previous studies and might be due to a low number of laboratory orders for...
post-partum screening. Indeed, the prevalence of screening was reported to increase from 9.0% to 57.8% over a 5-year period (1999–2004) in parallel with an increase in clinical prescriptions for FPG tests from 15.9% to 79.3% [16]. Similarly, in another large cohort (14,448 women), screening increased from 20.7% to 53.8% over 10 years. The screening rate was approximately 40% in many studies [6,16,17], but reached 72% in some [18,19]. In the present study, the rate of screening may have been underestimated, as women who could not confirm having been screened within the 6-month post-partum period were excluded.

Our study also identified factors associated with a lack of screening that have not been previously reported (smoking habits, low consumption of fruit and vegetables, and higher infant birth weight). In addition, it was found that, compared to women who were screened, unscreened women had babies with higher birth weights, although rates of macrosomia were not significantly different between the two groups. Ferrara et al. [21] reported that the prevalence of macrosomia was higher in women without post-partum screening, but the difference was no longer significant on multivariate analysis taking into account age, race, education, parity, treatment during pregnancy and post-partum visits. Moreover, neither smoking status nor fruit/vegetable consumption has been explored in other studies. These factors reflect unhealthy behaviours, and the lack of screening could be explained by fear of receiving a diabetes diagnosis, as reported voluntarily by women who had had GDM [8]. In one study exploring the health behaviours among women with and without a history of GDM, those with a GDM history were less likely to fulfill fruit/vegetable consumption guidelines and more likely to smoke than women without a history of GDM. For this reason, the study authors emphasized the discrepancy between unhealthy behaviour and higher risk for future diabetes [22]. Interestingly, a previous study had found an association between non-smoker status and adherence to bisphosphonate therapy for osteoporosis, as well as an association between non-smoker status and higher rates of mammography and coloscopy screening, suggesting a link between healthy behaviours, such as adherence to medication regimens and the use of preventative procedures [23]. In fact, lower socioeconomic status may be associated with unhealthy behaviours, including smoking, no physical activity, and a lack of daily consumption of fruit and vegetables [24].

It has also been shown that ethnicity can influence screening frequency. Interestingly, our population was multiethnic, with >40% of participants originating from North Africa, <30% from Europe and 15% from Asia, yet, ethnicity had no impact on post-partum screening. This result is important, as ethnic disparities in diabetes risk subsequent to GDM have been observed in the US state of California, with the highest risk of diabetes found in black women even after adjusting for pregravid BMI [25]. However, high rates of post-partum screening have been found for Asian and Hispanic women in the US, suggesting that clinicians are aware of the higher risk of diabetes in these ethnic groups [21]. However, lower screening rates were found for non-native English speakers in yet another American study [16]. The lack of association between ethnicity and screening in our present study might be explained by the fact that doctors were responsive to the multiethnicity found in this geographical area of France.

The main facilitator of post-partum screening, as described in the literature, is related to post-partum visits [15,16] and, more generally, the quality of healthcare provider contact [20] in terms of number of post-partum visits [17] and consultation with an endocrinologist during or after pregnancy [19]. These findings highlight the importance of providing information on GDM to GPs, one of the goals of the IMPACT campaign now being initiated. The screening tests consisted mostly of FPG measurements alone whereas, according to a recent report, only 6.3% of the women underwent the recommended OGTT [5]. This statistic reveals a deplorable lack of adherence to new recommendations by these major medical centres. In fact, most clinicians consider the OGTT too time-consuming for patient compliance. However, it is expected that the interventional phase of the IMPACT study will also improve our medical prescriptions.

Obesity and higher parity have been reported as barriers to post-partum screening [21]. These data contrast with the results of Morrison et al. [19], who found that overweight/obesity was not associated with post-partum screening following GDM, but was in fact related to a greater perception of type 2 diabetes risk [26]. In the present study, weight and height were self-reported, and this may have led to a potential bias. Other factors repeatedly associated with post-partum screening include older age, higher education level, more severe GDM, earlier GDM diagnosis and/or use of diabetes medications during pregnancy [5,6]. As already suggested, some of these factors reflect healthy behaviours. Thus, these results suggest that general public-health policies and preventative medicine are failing to influence the behaviours of women at highest risk.

It was hypothesized that deprivation and a low risk of type 2 diabetes were associated with a low rate of post-partum screening, but no clear role was identified for these factors. The women with the highest EPICES scores had lower rates of post-partum screening than those with the lowest EPICES scores (0–7.1), but very few women had the lowest score. Also, more than half our study population (51.6%, or 209 of the 405 women assigned EPICES scores) was deprived. Thus, psychosocial status does not appear to affect post-partum screening rates. This is in line with the lack of association between post-partum screening and working status.

There was no link between the FINDRISK and attitudes toward screening. One explanation might be that the FINDRISK was calculated after delivery. At any time, the doctors aware of a particular patient’s level of diabetes risk could have communicated the importance of post-partum screening to that patient. It may be useful to calculate the risk of diabetes for each pregnant woman with GDM to reinforce the particular importance of screening in those with the highest risk [27].

Our study had both strengths and limitations. The main strength is our type of cohort, which was a multiethnic cohort of women recruited at four public or private maternity departments. All interviews were done by the same person, thereby,
precluding biases. However, the main drawback of this study was its retrospective design. Much of the data were self-reported by the women themselves and obtained via a phone call. It was also decided to exclude women who could not precisely confirm whether they had undergone a screening test and/or whether the test had been done post-partum within the first 6 months. This decision may have underestimated the prevalence of post-partum screening.

5. Conclusion

In our region, one-third of the women with a history of GDM underwent screening for dysglycaemia within 6 months of delivery. This screening rate was better than expected, but is still inadequate. Moreover, screening was mainly by measurement of FPG alone, whereas the OGTT is known to be more sensitive. The interventional phase of the IMPACT study is expected to increase post-partum screening rates. However, this observational phase has identified an association between lack of screening and higher infant birth weights, higher rates of smoking, and lower rates of daily consumption of fruit and vegetables, while factors of vulnerability and risk of diabetes did not influence post-partum screening rates. This means that knowledge and awareness need to be further reinforced in women with these particular risk factors.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Acknowledgements

H.B. researched data and wrote the manuscript; E.C. and P.V. directed research, researched data, contributed to the discussion and reviewed/edited the manuscript; G.R. contributed to the discussion and reviewed/edited the manuscript; L.V., C.K., L.C., D.L., H.D. and A.L. researched data and contributed to the discussion; and F.F. researched data. The authors acknowledge the statistical assistance of Anne Ourliac and Delphine Dubois at Umanis, Paris.

This research was supported by a grant from Novo Nordisk France. The programme was sponsored by the Société Franco-phone de DiabétoLOGIE, the Réseau pour la prise en charge et la prévention de l’obésité en pédiatrie (Network for the management and prevention of paediatric obesity), Seine-Saint-Denis (93), the Assurance Maladie Seine-Saint-Denis (Seine-Saint-Denis Health Insurance), the National Order of Pharmacists, and the University of Paris 13—Paris Sorbonne.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.diabete.2013.12.002.

References


