Development of type 2 diabetes in women with comorbid gestational diabetes and common mental disorders in the Born in Bradford cohort

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ABSTRACT

Objectives To compare, in a population of women with gestational diabetes mellitus (GDM), the time to diagnosis of Type 2 diabetes in those with and without common mental disorder (CMD) (depression and/or anxiety) during pregnancy.

Design and setting Prospective study of the Born in Bradford cohort in Bradford, UK.

Participants 909 women diagnosed with GDM between 2007 and 2010, with linkage to their primary care records until 2017. The exposed population were women with an indicator of CMD during pregnancy in primary care records. The unexposed were those without an indicator.

Outcome measures Time to diagnosis of type 2 diabetes as indicated by a diagnosis in primary care records.

Analysis Time to event analysis using Cox regression was employed. Multiple imputation by chained equations was implemented to handle missing data. Models were adjusted for maternal age, ethnicity, education, preconception CMD and tobacco smoking during pregnancy.

Results 165 women (18%) were diagnosed with type 2 diabetes during a follow-up period of around 10 years. There was no evidence of an effect of antenatal CMD on the development of type 2 diabetes following GDM (adjusted HR 0.95; 95% CI 0.57 to 1.57).

Conclusions Women with CMD were not at an increased risk of type 2 diabetes following GDM. This is reassuring for women with these co-morbidities but requires replication in other study populations.

INTRODUCTION

Gestational diabetes mellitus (GDM) is defined as diabetes which occurs for the first time during pregnancy and affects between 5% and 10% of pregnant women. The common mental disorders (CMD) of anxiety and depression are also highly prevalent during pregnancy, affecting at least 10% of women. There is now evidence to support an association between GDM and antenatal (during pregnancy) depression, meaning that the two conditions may be frequently comorbid. Both conditions are associated with adverse obstetric, neonatal and long-term outcomes for women and their children.

Up to 60% of women with GDM will develop type 2 diabetes at some point in their lifetime following pregnancy. This is thought to be due to the pathological process of insulin resistance common to both GDM and type 2 diabetes. Pregnancy itself is a state of insulin resistance common to both GDM and type 2 diabetes. Pregnancy itself is a state of insulin resistance which may resolve following pregnancy, there is a risk of advancing insulin resistance. Other risk factors for development of type 2 diabetes include socioeconomic deprivation and non-white ethnicity.

Large cohort study of a multiethnic UK population of 909 women with gestational diabetes.

Comprehensive follow-up over a decade via linkage to primary care records.

The moderating effect of insulin use and levels of hyperglycaemia at diagnosis on the outcome of time to development of type 2 diabetes was also assessed.

Unable to study the influence of other factors related to mental health such as medication adherence and lifestyle management on the risk for type 2 diabetes.
There is also evidence of an increased risk in women whose GDM has required the use of insulin; this may be a marker of increased severity of insulin resistance, relative pancreatic insufficiency and/or poorer glycaemic control post diagnosis. In the non-pregnant population of those with type 2 diabetes, hyperglycaemia was significantly associated with depression in a meta-analysis of 24 studies. Indeed there is evidence for a relationship between depression and various factors known to impact glycaemic control; those with depression and type 2 diabetes may be less likely to adhere to lifestyle interventions, such as those involving diet and physical activity and also medication; both of which are also elements of GDM management. Thus, it may be hypothesised that in women with GDM, comorbid CMD during pregnancy could increase the risk of type 2 diabetes in the future due to poorer glycaemic control during pregnancy.

Despite this, none of the recent risk prediction models for the development of type 2 diabetes following GDM have included mental disorder. Greater understanding of the impact of antenatal CMD on risk for subsequent type 2 diabetes in women with GDM could provide further insights into the risk profile of women who are more likely to develop type 2 diabetes. Knowledge of such modifiable risk factors could inform interventions to reduce this risk. The aim of this study was to compare, in a population of women with GDM, the time to development of type 2 diabetes in those experiencing antenatal CMD, with those not experiencing antenatal CMD.

**METHODS**

**Sample: women with GDM**

Born in Bradford (BiB) is a prospective longitudinal cohort of 12,450 women with 13,758 pregnancies in Bradford. Bradford is a city in the north of England and has high levels of deprivation; 60% of babies BiB are born into the poorest 20% of the English and Welsh population according to Index of Multiple Deprivation (IMD 2010). Its ethnic makeup is predominantly biethnic: Pakistani and white British. Pregnant women were recruited to the BiB cohort between 2007 and 2010, when attending a routine appointment for a 2-hour 75 g OGTT, as currently recommended by the UK’s National Institute for Health and Care Excellence as the gold standard for diagnosing GDM. It is offered to all women in Bradford, usually between 26 and 28 weeks gestation. Consent was obtained for record linkage to maternity and primary care records via SystmOne: a clinical computer system used by almost all general practices in Bradford and which provides primary care data on diagnoses and prescriptions.

GDM was diagnosed according to modified WHO criteria (either fasting glucose ≥6.1 mmol/L or 2-hour postload glucose ≥7.8 mmol/L). The sample used for analysis was women with GDM and linkage to primary care records (n=994; see figure 1). If women had more than one GDM affected pregnancy in the cohort, the first pregnancy (and its date of delivery) was used as the start of the ‘at risk’ period for type 2 diabetes. Women with unknown date of delivery also were excluded due to being unable to determine the start of their ‘at risk’ period. This gave a final sample of 909 women.

**Exposure: antenatal CMD**

As an indicator of CMD, Read codes (Clinical Terms V.3, CTV3) for diagnosis and/or treatment of CMD were extracted from general practitioner (GP) electronic health records (EHR) alongside medication prescriptions as per previously published methods. These relate to International Classification of Diseases (ICD-10) diagnostic groups F32 and F33 depressive episodes and recurrent depressive disorders and F41 anxiety disorders. The binary variable of antenatal CMD was defined as any indicator of CMD appearing in the primary care notes between the estimated date of conception (estimated from date of last menstrual period and/or booking scan) and the date of delivery. Further information on the codes used is provided in online supplemental material S1.

**Outcome: time to development of type 2 diabetes**

Read code (CTV3) for ‘type 2 diabetes mellitus’: X40J5 was used as an indicator of type 2 diabetes development. The outcome was time to the earliest recorded code in the primary care records after the date of delivery of the GDM affected pregnancy (in years).

**Covariates**

There were a number of variables identified as potential confounders due to their association with both GDM and
CMD but not on the causal pathway from exposure to outcome.23 These were maternal age24 at the time of the OGTT and tobacco smoking during pregnancy.25 26 CMD occurring prior to pregnancy (‘preconception’ CMD) was also measured using Read codes and medication prescriptions in the primary care record from the woman’s birth to the estimated date of conception of the woman’s first ever pregnancy (see online supplemental material S1). Also included were the sociodemographic characteristics of maternal ethnicity (as a three category variable of Pakistani, White British or other minority ethnic group) and socioeconomic status (SES).8 26 27; rather than using IMD28 to assign SES, a five category variable of maternal education was used as a proxy, as the high levels of deprivation in BiB result in a highly skewed distribution of participants across deprivation categories. It was also hypothesised that the continuous variable of fasting glucose on the OGTT and the binary variable of GDM treated with or without insulin may be effect modifiers.

**Statistical analysis**

Data were analysed using Stata V.15.29 Survival analysis using Cox regression was used to compare time to development of type 2 diabetes between exposed and unexposed groups, adjusting for relevant confounders, to produce a HR.30 The time window was date of delivery of GDM pregnancy to either date of type 2 diabetes development or date of the last EHR extraction (9 August 2017). Interaction terms for the hypothesised effect modifiers were also included in the models. Kaplan-Meier failure curves were produced showing time to development of type 2 diabetes between women with and without antenatal CMD.

Multiple imputation by chained equations was implemented to handle missing data.31 20 imputations were used according to the proportion of participants with any missing data.32 All analysis variables, including the time variable, were included in the imputation model.33 Estimates were obtained by pooling results using Rubin’s rules.34 Complete case analyses were also conducted.

A sensitivity analysis removing women with co-morbid severe mental illnesses (SMI) was also conducted. These relate to ICD-10 diagnostic groups F20-29 psychotic disorders including schizophrenia, F30-31 bipolar disorder and F60 personality disorders21 using GP EHR alongside medication prescriptions as per previously published methods.20 Further information on the codes used is provided in online supplemental material S2.

**Patient and public involvement**

Women with lived experience of GDM and/or mental disorder during pregnancy were consulted from study inception to completion of the analysis. They indicated that the research question was important to them. They also informed interpretation of the study’s results; for example by indicating that they found the findings reassuring. These women came from the Service User Advisory Group of the Section of Women’s Mental Health at King’s College London and the BiB Parent Governors Group. The authors thank them for their contribution.

**RESULTS**

Characteristics of women included in this analysis, stratified by development of type 2 diabetes, are presented in table 1. Fifty-nine per cent of women with data on ethnicity were of Pakistani ethnic origin and mean maternal age was 30 years (SD 5.5). Twenty-eight per cent of women with data on education had higher than A level (secondary school) qualifications. Nine per cent of women self-reported tobacco smoking at some point during their pregnancy. Eleven per cent had an indicator of antenatal CMD. Fifteen per cent of those with available data had an indicator of preconception CMD. Eighteen per cent of women with GDM developed type 2 diabetes during the follow-up period. Pakistani ethnicity, older age and lower education were associated with the development of type 2 diabetes.

The median time taken for 15% of women to develop type 2 diabetes in the group unexposed to antenatal CMD was 6.5 years (95% CI 4.9 to 7.9) vs 7.4 years (95% CI 3.6 to 7.9) in the exposed group. Table 2 displays the unadjusted and adjusted results of the Cox regression for type 2 diabetes in women with and without an indicator of antenatal CMD, using imputed data. There was no evidence of an effect of antenatal CMD on the development of type 2 diabetes following GDM on unadjusted or adjusted analyses. These findings are illustrated in figure 2, which shows Kaplan-Meier failure curves for time to development of type 2 diabetes between women with and without antenatal CMD. Results of complete case analyses mirrored those of the imputed results (see online supplemental material S3). There was no evidence for an interaction between antenatal CMD and fasting glucose (p=0.553) or between antenatal CMD and insulin-treated GDM (p=0.680). Removal from the sample of 57 women with comorbid SMI resulted in little change to the effect estimate (unadjusted HR 0.95 (95% CI 0.55 to 1.65) and adjusted HR 0.89 (95% CI 0.51 to 1.56).

**DISCUSSION**

There was no evidence in this cohort of women with GDM that antenatal CMD increased the risk of subsequent type 2 diabetes. The proportion of women in this sample developing type 2 diabetes was similar to that observed in a number of previous studies, which report between 10% and 20% of women with GDM developing type 2 diabetes over similar follow-up periods of around 10 years.35–37 There was also no evidence that fasting glucose at the time of GDM diagnosis or insulin use, as indicators of the severity of insulin resistance, modified associations between antenatal CMD and type 2 diabetes. This is the first study to investigate the impact of mental disorder during pregnancy in women with GDM on subsequent type 2 diabetes risk. It is also one of the
largest samples in the UK reporting type 2 diabetes risk following GDM. The sample was drawn from an urban, deprived and multi-ethnic population. While older women and women of Pakistani ethnicity were relatively over-represented in this sample compared with both the BiB cohort as a whole and the city of Bradford, this is representative of those women at risk of GDM so is not unexpected. These same demographic predictors of type 2 diabetes and the proportions of the sample with CMD and type 2 diabetes indicate face validity of the measures of both exposure and outcome.

Nonetheless, measures taken from primary care records are reliant on individuals attending primary care services. For example, a number of studies have documented the underdiagnosis of CMD in primary care, including during the perinatal period. Previously published papers in this cohort have discussed the ethnic differences in detection of CMD within primary care, with some evidence that women of Pakistani ethnicity may be less likely to seek help for mental ill health. Type 2 diabetes diagnoses in primary care records may also merely reflect the likelihood of screening; a recent systematic review, although

| Table 1 | Characteristics of the sample (N=909 women) |
|---------|------------------------------------------|
|         | Total (N=909) | Type 2 diabetes (N=165 (18.2%)) | No type 2 diabetes (N=744 (81.8%)) | P value* |
| Ethnicity |                    |                           |                               |          |
| Pakistani | 472 (51.9) | 102 (61.8) | 370 (49.7) | <0.001 |
| White British | 198 (21.8) | 15 (9.1) | 183 (24.6) |          |
| Other minority ethnic group | 128 (14.1) | 24 (14.6) | 104 (14) |          |
| Missing | 111 (12.2) | 24 (14.6) | 87 (11.7) |          |
| Maternal age (years) |    |                           |                               |          |
| Mean (SD) | 30.3 (5.5) | 32.2 (5.3) | 29.9 (5.5) | <0.001 |
| Maternal education |    |                           |                               |          |
| Less than 5 General Certificate of Secondary Education (GCSE) equivalents | 206 (22.7) | 55 (33.3) | 151 (20.3) | <0.001 |
| 5 GCSE equivalents | 218 (24.0) | 37 (22.4) | 181 (24.3) |          |
| A level equivalents | 87 (9.6) | 12 (7.3) | 75 (10.1) |          |
| Higher than A level | 223 (24.5) | 24 (14.6) | 199 (26.8) |          |
| Other | 63 (6.9) | 13 (7.9) | 50 (6.7) |          |
| Missing | 112 (12.3) | 24 (14.6) | 88 (11.8) |          |
| Maternal tobacco smoking in pregnancy |    |                           |                               |          |
| Yes | 73 (8.0) | 15 (9.1) | 58 (7.8) | 0.470 |
| No | 722 (79.4) | 124 (75.2) | 598 (80.4) |          |
| Missing | 114 (12.5) | 26 (15.8) | 88 (11.8) |          |
| Preconception CMD |    |                           |                               |          |
| Yes | 123 (13.5) | 14 (8.5) | 109 (14.7) | 0.056 |
| No | 710 (78.1) | 131 (79.4) | 579 (77.8) |          |
| Missing | 76 (8.4) | 20 (12.1) | 56 (7.5) |          |
| Antenatal CMD |    |                           |                               |          |
| Yes | 95 (10.5) | 17 (10.3) | 78 (10.5) | 0.945 |
| No | 814 (89.5) | 148 (89.7) | 666 (89.5) |          |
| Fasting glucose (mmol/L) |    |                           |                               |          |
| Mean (SD) | 5.2 (1.09) | 6.2 (1.5) | 5 (0.83) | <0.001 |
| Missing | 41 (4.5) | 7 (4.2) | 34 (4.6) |          |
| Insulin treated GDM |    |                           |                               |          |
| Yes | 420 (46.2) | 47 (28.5) | 373 (50.1) | <0.001 |
| No | 489 (53.8) | 118 (71.5) | 371 (49.9) |          |

*On $\chi^2$ for categorical variables and t-test for continuous variables comparing groups with and without type 2 diabetes for complete cases with no missing data on exposure.

CMD, common mental disorders; GDM, gestational diabetes mellitus.
Table 2 Cox regression of type 2 diabetes in women with versus without an indicator of antenatal CMD (N=909 women)

|                          | Type 2 diabetes |          |          |
|--------------------------|-----------------|----------|----------|
|                          | HR (95% CI)     | P value  |          |
| Unadjusted               |                 |          |          |
| Antenatal CMD Reference category=no indicator | 0.95 (0.57 to 1.57) | 0.839 |          |
| Antenatal CMD indicator  |                 |          |          |
| Antenatal CMD Reference category=no indicator | 0.94 (0.56 to 1.58) | 0.823 |          |

Models using imputed data.
*Adjusted for maternal age, education, ethnicity, smoking and preconception CMD.
CMD, common mental disorders.

only using studies of US women, found that Asian women were more likely to be tested for type 2 diabetes following GDM than White women; pooled proportion being screened was 50% in Asian and 35% in White. However, if an indicator of CMD or type 2 diabetes in primary care records merely did reflect a tendency to engage with health services, there would have been more evidence of an association between the two measures. Nonetheless, while in the UK it is recommended that women who have experienced GDM undergo glucose monitoring at 6 weeks postpartum and annually thereafter, evidence suggests patchy implementation of this guidance. Therefore there is possible underdiagnosis of type 2 diabetes following GDM among women in the UK.

While the variables of fasting glucose at the time of the OGTT and insulin use were investigated as potential moderators, there were no other measures of factors also known to be affected by the presence of CMD and which may impact on type 2 diabetes risk, such as adherence with medication and lifestyle interventions. However, while most of the evidence of the adverse influence of depression on these behaviours comes from the type 2 diabetes population, as discussed in the introduction, there remains very little evidence in women with GDM that mental health affects these behaviours. For example, a study of 400 women with GDM in Iran found no correlation between symptoms of anxiety and depression and ‘self-care behaviours’ such as dietary monitoring, physical activity and blood glucose monitoring. Moreover, dietary and physical activity interventions trialled in obese pregnant women (although prior to the development of GDM) have not found antenatal depression to be a significant barrier to adherence. Similarly, there are factors occurring in the postnatal period which may be associated with antenatal CMD, which may mediate the risk of type 2 diabetes and which were not explored. These include events in subsequent pregnancies such as future episodes of GDM and/or CMD, breast feeding, postnatal CMD and changes made to diet and levels of physical activity in the postpartum which in turn may influence weight.

While not the focus of this study, future research could focus on investigating the relationship between maternal mental health and these other factors known to influence metabolic risk beyond the antenatal period. Future research may also examine the impact of treatment of CMD on type 2 diabetes risk in women with GDM, in light of some evidence that treatment of depression in those with type 2 diabetes may improve their glycaemic control. While it could be argued that an indicator of CMD in primary care records makes it likely that the CMD was treated, such differences in outcomes between treated and untreated CMD could not be explored with the measures available in this sample. Nonetheless, the findings from this analysis that women with antenatal CMD are not at greater risk of type 2 diabetes following GDM than women without antenatal CMD could provide reassurance to these women, particularly if replicated in other samples.

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Contributors CAW conceived the research question, designed the study analysis plan analysed the data and wrote the first draft of the manuscript. GS extracted

Figure 2 Kaplan-Meier failure curves for time to development of type 2 diabetes (years) between women with (red line) and without (blue line) antenatal CMD. CMD, common mental disorders.
the data from primary care records, approved the data analysis plan and critically revised the draft. RR, ES, LH and KI approved the data analysis plan and critically revised the draft. All authors (CAW, GS, RR, ES, LH and KI) have approved the final version and agree to be accountable for all aspects of the work. CAW is the manuscript’s guarantor.

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**REFERENCES**

1. Behboudi-Gandevani S, Amir M, Bidhendi Yarandi R, et al. The impact of diagnostic criteria for gestational diabetes on its prevalence: a systematic review and meta-analysis. *Diabetol Metab Syndr* 2019;11:11.

2. Zhu Y, Zhang C. Prevalence of gestational diabetes and risk of progression to type 2 diabetes: a global perspective. *Curr Diab Rep* 2016;16:7.

3. Gavin NI, Gaynes BN, Lohr KN, et al. Perinatal depression: a systematic review of prevalence and incidence. *Obstet Gynecol* 2005;106:1071–83.

4. Howard LM, Molyneaux E, Dennis C-L, et al. Non-psychotic mental disorders in the perinatal period. *Lancet* 2014;384:1775–88.

5. Wilson CA, Newham J, Rankin J, et al. Is there an increased risk of perinatal mental disorder in women with gestational diabetes? A systematic review and meta-analysis. *Diabet Med* 2020;37:802–22.

6. Kamppinni U, Madsen LR, Skajaao GO, et al. Gestational diabetes: a clinical update. *World J Diabetes* 2015;6:1065–72.

7. Noctor E, Dunne FP. Type 2 diabetes after gestational diabetes: the influence of changing diagnostic criteria. *World J Diabetes* 2015;6:234.

8. Di Cianni G, Lacaria E, Lencioni C, et al. Preventing type 2 diabetes and cardiovascular disease in women with gestational diabetes: - The evidence and potential strategies. *Diabetes Res Clin Pract* 2018;145:184–92.

9. Ratner RE, Cheng YJ, Metzger BE, et al. Prevention of diabetes in women with a history of gestational diabetes: effects of metformin and lifestyle interventions. *J Clin Endocrinol Metab* 2008;93:4774–9.

10. Yefet E, Schwartz N, Sliman B, et al. Good glycemic control of gestational diabetes mellitus is associated with the attenuation of future maternal cardiovascular risk: a retrospective cohort study. *Cardiovasc Diabetol* 2019;18:75.

11. Alialou A, Nalla A, Prentice KJ, et al. A predictive metabolic signature for the transition from gestational diabetes mellitus to type 2 diabetes. *Diabetes* 2016;65:2529–39.

12. Rayanagoudar G, Hashi AA, Zamora J, et al. Quantification of the type 2 diabetes risk in women with gestational diabetes: a systematic review and meta-analysis of 95,750 women. *Diabetologia* 2015;58:1403–11.

13. Lustman PJ, Anderson RJ, Freedland KE, et al. Depression and poor glycemic control: a meta-analytic review of the literature. *Diabetes Care* 2000;23:394–42.

14. Lin EHB, Katon W, Von Korff M, et al. Relationship of depression and diabetes self-care, medication adherence, and preventive care. *Diabetes Care* 2004;27:2154–60.

15. Odegard PS, Capoccia K. Medication taking and diabetes. *Diabetes Educ* 2007;33:1014–29.

16. NICED. Diabetes in pregnancy: management from preconception to the postnatal period (NG9). 2020. Available: https://www.nice.org.uk/guidance/ng9 [Accessed 16 Jan 2021].

17. Lamain-de Ruiter M, Kwee A, Naaktgeboren CA, et al. Prediction models for the risk of gestational diabetes: a systematic review. *Diagn Progn Res* 2017;1:3.

18. Wright J, Small N, Raynor P, et al. Cohort profile: the born in Bradford multi-ethnic family cohort study. *Int J Epidemiol* 2013;42:978–91.

19. Farrar D, Fairley L, Santorelli G, et al. Association between hyperglycaemia and adverse perinatal outcomes in South Asian and white British women: analysis of data from the born in Bradford cohort. *Lancet Diabetes Endocrinol* 2015;3:795–804.

20. Prady SL, Pickett KE, Petherick ES, et al. Evaluation of ethnic disparities in detection of depression and anxiety in primary care during the maternal period: combined analysis of routine and cohort data. *Br J Psychiatry* 2018;208:453–61.

21. WHO. The ICD-10 classification of mental and behavioural disorders: clinical descriptions and diagnostic guidelines. Geneva: World Health Organisation. 1990. [https://www.who.int/classifications/icd/en/bluebookpdf](https://www.who.int/classifications/icd/en/bluebookpdf)

22. NICED. Diagnosis of type 2 diabetes in adults, 2021. Available: [https://cks.nice.org.uk/topics/diabetes-type-2/diagnosis/diagnosis-in-adults/](https://cks.nice.org.uk/topics/diabetes-type-2/diagnosis/diagnosis-in-adults/) [Accessed 17 Dec 2021].

23. VanderWeele TJ. Principles of confounder selection. *Eur J Epidemiol* 2019;34:211–9.

24. McManus S, Bebbington P, Jenkins R. Mental health and wellbeing in England: adult psychiatric morbidity survey 2014. NHS Digital: Leeds, 2018. [https://assets.publishing.service.gov.uk/government/upload/system/uploads/attachment_data/file/556596/apms-2014-full-rpt.pdf](https://assets.publishing.service.gov.uk/government/upload/system/uploads/attachment_data/file/556596/apms-2014-full-rpt.pdf)

25. Howard LM, Bekele D, Rowe M, et al. Smoking cessation in pregnant women with mental disorders: a cohort and nested qualitative study. *BJOG* 2013;120:362–70.

26. Bellou V, Belbasi L, Tzoulaki I, et al. Risk factors for type 2 diabetes mellitus: an exposure-wide umbrella review of meta-analyses. *PloS One* 2018;13:e0194127.

27. Bhui K, Bhugra D, Goldberg D, et al. Cultural influences on the prevalence of common mental disorder, general practitioners’ assessments and help-seeking among Punjabi and English people visiting their general practitioner. *Psychol Med* 2001;31:815–25.

28. Department for Communities and Local Government. The *English indices of deprivation 2015*. London: UK Government, 2015. [https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015](https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015).

29. StataCorp LP. *Stata data analysis and statistical software*. Special Edition Release 2007;10:733.

30. Cox DR. Regression models and Life-Tables. *Journal of the Royal Statistical Society: Series B* 1972;34:187–202.

31. White IR, Royston P. *Multiple imputation using chained equations: issues and guidance for practice*. *Stat Med* 2011;30:377–99.

32. Bodner TE. What improves with increased missing data Imputations? *Structural Equation Modeling: A Multidisciplinary Journal* 2008;15:651–75.

33. White IR, Royston P. Imputing missing covariate values for the COX model. *Stat Med* 2009;28:1982–98.

34. Rubin DB. *Multiple imputation for nonresponse in surveys*. John Wiley & Sons, Inc, 1987.

35. Feg DG, Zimman B, Wang X, et al. Risk of development of diabetes mellitus after diagnosis of gestational diabetes. *CMAJ* 2008;179:229–34.
36 Grant PT, Oats JN, Beischer NA. The long-term follow-up of women with gestational diabetes. *Aust N Z J Obstet Gynaecol* 1986;26:17–22.

37 Kim C, Newton KM, Knopp RH. Gestational diabetes and the incidence of type 2 diabetes: a systematic review. *Diabetes Care* 2002;25:1862–8.

38 Cepoiu M, McCusker J, Cole MG, et al. Recognition of depression by non-psychiatric physicians—a systematic literature review and meta-analysis. *J Gen Intern Med* 2008;23:25–36.

39 John A, McGregor J, Fone D, et al. Case-Finding for common mental disorders of anxiety and depression in primary care: an external validation of routinely collected data. *BMJ Med Inform Decis Mak* 2016;16:35.

40 Wilson CA, Santorelli G, Dickerson J, et al. Is there an association between anxiety and depression prior to and during pregnancy and gestational diabetes? an analysis of the born in Bradford cohort. *J Affect Disord* 2020;276:345–50.

41 Herrick CJ, Puri R, Rahaman R, et al. Maternal Race/Ethnicity and postpartum diabetes screening: a systematic review and meta-analysis. *J Womens Health* 2020;29:609–21.

42 Ward RJ, Fryer AA, Hanna FW, et al. Inadequate postpartum screening for type 2 diabetes in women with previous gestation diabetes mellitus: A retrospective audit of practice over 17 years. *Int J Clin Pract* 2021;75:e14447.

43 Kordi M, Heravan MB. The relationship of depression, anxiety, and stress with selfcare behaviors in women with gestational diabetes. *Journal of Midwifery & Reproductive Health* 2020;8:2083–94.

44 Molyneaux E, Begum S, Briley AL, et al. Do elevated symptoms of depression predict adherence and outcomes in the upbeat randomised controlled trial of a lifestyle intervention for obese pregnant women? *BMC Pregnancy Childbirth* 2018;18:378.

45 Bogaerts AFL, Devlieger R, Nyuits E, et al. Effects of lifestyle intervention in obese pregnant women on gestational weight gain and mental health: a randomized controlled trial. *Int J Obes* 2013;37:814–21.

46 Tanase-Nakao K, Arata N, Kawasaki M, et al. Potential protective effect of lactation against incidence of type 2 diabetes mellitus in women with previous gestational diabetes mellitus: a systematic review and meta-analysis. *Diabetes Metab Res Rev* 2017;33:e2875.

47 Dias CC, Figueiredo B. Breastfeeding and depression: a systematic review of the literature. *J Affect Disord* 2015;171:142–54.

48 Knippen KL, Sheu J-J, Oza-Frank R, et al. Predictors of Health-Protective behavior and glyemia after gestational diabetes, NHANES 2007–2014, *Diabetes Educ* 2019;45:408–19.

49 Nicklas JM, Miller LJ, Zera CA, et al. Factors associated with depressive symptoms in the early postpartum period among women with recent gestational diabetes mellitus. *Matern Child Health J* 2013;17:1665–72.

50 Ferrari U, Banning F, Freibotho I, et al. Depressive symptoms, impaired glucose metabolism, high visceral fat, and high systolic blood pressure in a subgroup of women with recent gestational diabetes. *J Psychiatr Res* 2018;97:89–93.

51 Moulton CD, Hopkins CWP, Ismail K, et al. Repositioning of diabetes treatments for depressive symptoms: a systematic review and meta-analysis of clinical trials. *Psychoneuroendocrinology* 2018;94:91–103.

52 Petrak F, Baumeister H, Skinner TC, et al. Depression and diabetes: treatment and health-care delivery. *Lancet Diabetes Endocrinol* 2015;3:472–85.