Mental Health During Late Pregnancy and Postpartum in Mothers With and Without Type 1 Diabetes: The ENDIA Study

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OBJECTIVE

Pregnancy and type 1 diabetes are each associated with increased anxiety and depression, but the combined impact on well-being is unresolved. We compared the mental health of women with and without type 1 diabetes during pregnancy and postpartum and examined the relationship between mental health and glycemic control.

RESEARCH DESIGN AND METHODS

Participants were women enrolled from 2016 to 2020 in the Environmental Determinants of Islet Autoimmunity (ENDIA) study, a pregnancy to birth prospective cohort following children with a first-degree relative with type 1 diabetes. Edinburgh Postnatal Depression Scale (EPDS) and Perceived Stress Scale (PSS) were completed during the third trimester (T3) (median [interquartile range] 34 [32, 36] weeks) and postpartum (14 [13, 16] weeks) by 737 women (800 pregnancies) with ($n = 518$) and without ($n = 282$) type 1 diabetes.

RESULTS

EPDS and PSS scores did not differ between women with and without type 1 diabetes during T3 and postpartum. EPDS scores were marginally higher in T3: predicted mean (95% CI) 5.7 (5.4, 6.1) than postpartum: 5.3 (5.0, 5.6), independent of type 1 diabetes status ($P = 0.01$). HbA_{1c} levels in type 1 diabetes were 6.3% [5.8, 6.9%] in T3 and did not correlate with EPDS or PSS scores. Reported use of psychotropic medications was similar in women with ($n = 44$ of 518 [8%]) and without type 1 diabetes ($n = 17$ of 282 [6%]), as was their amount of physical activity.

CONCLUSIONS

Overall, mental health in late pregnancy and postpartum did not differ between women with and without type 1 diabetes, and mental health scores were not correlated with glycemic control.

Mood disorders and anxiety are detected up to twice as frequently in adults with type 1 diabetes compared with the general population (1,2). Their development may have a substantial impact on well-being, self-management, and glycemic control (3–5), and optimal mental health during pregnancy is a research priority for women with diabetes and health care professionals (6). Increased levels of stress

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are also common in pregnant women without type 1 diabetes (7–9), with ~10% reporting at least one depressive episode and 20% reporting anxiety during pregnancy or postpartum (10). A pregnancy and postpartum period with the additional demands of managing type 1 diabetes to control blood glucose levels as tightly as possible might be anticipated to reduce well-being and increase the risk of anxiety and/or depression further.

The level of hyperglycemia on oral glucose tolerance testing has been correlated to mood in women with gestational diabetes (11), and women with type 2 diabetes and symptoms of anxiety or depression have shown higher HbA_{1c} in late pregnancy than those without (12).

Small quantitative and qualitative studies suggest that mental health, in particular anxiety, may deteriorate during a pregnancy with type 1 diabetes, so that the demands of the pregnancy place a greater strain on these women compared with pregnant women without diabetes (13). Only two studies in Sweden, each of <20 women with type 1 diabetes, examine psychological well-being during pregnancy and postpartum, to our knowledge (14,15). Large, longitudinal studies of the mental health of women with type 1 diabetes during pregnancy and postpartum and with adequate control subjects without type 1 diabetes are lacking.

The Environmental Determinants of Islet Autoimmunity (ENDIA) Study is an Australia-wide observational pregnancy–birth cohort of 1,473 children at genetic risk on account of a first-degree relative with type 1 diabetes (16). The mother, father, or sibling of the unborn child has type 1 diabetes and women with and without type 1 diabetes have been followed prospectively from the pregnancy, with the last child born in July 2020.

We aimed to compare the mental health of women with and without type 1 diabetes, followed in ENDIA, during the third trimester (T3) of pregnancy and postpartum. We also aimed to examine the relationship between mental health and glycemic control in the women with type 1 diabetes. We so aimed to reconcile findings in preceding small and often uncontrolled studies that women with type 1 diabetes have less favorable mental health scores than those without type 1 diabetes during pregnancy and postpartum. We hypothesized that women with less optimal glycemic control would have more symptoms of depression or stress during pregnancy.

RESEARCH DESIGN AND METHODS

ENDIA began recruitment in 2014 and in December 2019 reached full recruitment of the mothers of 1,473 pregnancies, from which 1,461 live infants were born by July 2020. The assessment of maternal mental health was added to the protocol at T3 and postpartum visits in November 2016. From this time onwards, 846 unique women in 932 pregnancies were recruited consecutively and eligible for this study. Of these, 737 unique women in 800 pregnancies participated in the investigation of their mental health between November 2016 and November 2020. These women comprise the study population for this investigation (Fig. 1).

Inclusion criteria for ENDIA were a first-degree relative of the unborn child with type 1 diabetes and an adequate understanding of English to provide consent and responses to the questionnaires. There were no exclusion criteria other than miscarriage or stillbirth occurring prior to the mother's completion of the mental health questionnaires. Two women with type 2 diabetes and 40 women with gestational diabetes were included in the group designated "without type 1 diabetes" and later removed from the data in a sensitivity analysis.

All women were investigated according to the full ENDIA protocol at three monthly intervals during pregnancy from the time of recruitment (between the end of the first trimester and T3) and up until 6 months postpartum (16). Investigation included clinical measurements, biological samples (blood, stool, urine, breast milk, and swabs), and questionnaires interrogating lifestyle, nutrition, medications and exercise. The child is followed in ENDIA until 10 years of age, 3-monthly for the first 2 years and 6-monthly thereafter. All parents were informed of the small, increased lifetime risk of their child developing type 1 diabetes of 2–6% at the time of recruitment to the study.

Women with type 1 diabetes received care from their local multidisciplinary team during their pregnancy with ~2 to 4 weekly reviews, increasing to 2 weekly from 28 to 36 weeks' gestation and weekly thereafter, according to Australian guidelines (17).

Assessments of Mental Health

Participants were invited to complete two mental health questionnaires, the Edinburgh Postnatal Depression Scale (EPDS) and the Perceived Stress Scale (PSS), at their T3 visit and at their postpartum visit ~3 to 4 months after birth.

The EPDS is a 10-item questionnaire and is scored from 0–30. The respondent marks one of four possible answers that is closest to how she has felt during the past week. Responses are scored 0, 1, 2, and 3, with higher scores indicating higher levels of depressive symptoms. A total score >12 (out of 30) indicates prenatal or postpartum depressive symptoms at a level that is recommended for clinical assessment for intervention (18). As part of the study protocol, all participants that recorded an EPDS score >12 or answered "Yes, quite often," "Sometimes," or "Hardly ever" for the question about suicidal thoughts were referred for further assessment with their general practitioner, midwife, or obstetrician as soon as possible. The EPDS is a widely

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*A complete list of the members of the ENDIA Study Group can be found in the supplementary material online.

See accompanying article, p. 1027.

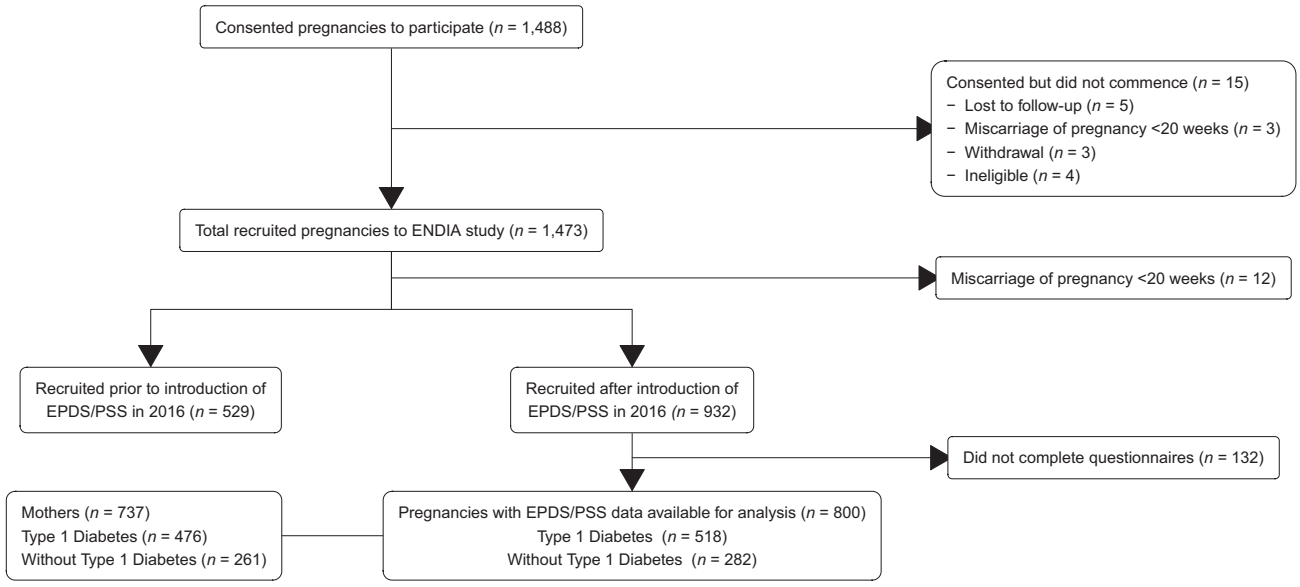

Figure 1—STROBE diagram.

used and well-validated (19,20) questionnaire during pregnancy and postpartum for depressive symptoms. It is recommended internationally as a screening tool for perinatal depression with a sensitivity of 83% and specificity of 90% for detecting clinical depression in pregnancy and sensitivity of 80% and specificity of 93% postpartum (21).

The PSS is a 14-item self-report questionnaire designed to measure the degree to which situations in the respondent's life are appraised as stressful and the degree to which respondents find their lives unpredictable, uncontrollable, and overloaded during the last month. The scale is scored from 0–50, with higher scores indicating higher levels of distress. The PSS is a well-validated (22) and widely used instrument for measuring the perception of stress that more accurately reflects the biological impact of psychosocial distress than simply measuring numbers of stressful life events (23). Validation studies of the 14-item PSS have demonstrated acceptable internal consistency (Cronbach $\alpha = 0.75$) as well as construct and convergent validity with other stress scales (reviewed in Ref. 22).

History of Anxiety or Mood Disorders and Psychotropic Medication Use

Participants also answered questionnaires at each of their pregnancy and postpartum visits regarding history of anxiety or mood disorders and use of psychotropic medication. Data were collected retrospectively for the use of psychotropic medication during the 3 months prior to conception.

Assessment of Physical Activity

Physical activity was measured during each trimester using the Pregnancy Physical Activity Questionnaire (24), a validated self-report instrument that measures the time spent participating in 32 activities. Each activity was assigned an intensity value in MET (where 1 MET is the energy expended at rest). Total energy expenditure (total physical activity) was calculated from all activities (expressed in MET * hours/week), and the average across trimesters was reported.

Sociodemographic profiles were assessed using the Australian Statistical Geography Standard Remoteness Structure and Socio-Economic Indexes for Areas Index of Relative Socio-economic Disadvantage (SEIFA IRSD) score (25); both were generated from postcodes according to the 2016 Australian Bureau of Statistics Population Census.

Laboratory Investigation

HbA_{1c} was measured using either point-of-care or laboratory testing methods, commonly a Vantage analyzer (Siemens Diagnostics, Camberley, U.K.) or a Variant analyzer (Bio-Rad Laboratories, Hercules, CA). All medical laboratories were accredited by the National Association of Testing Authorities, Australia against the international standard ISO 15189 Medical laboratories, which mandates that all analytes in a laboratory's test menu be subject to the Royal College of Pathologists of Australasia Quality Assurance Programs (26).

Coronavirus Disease 2019 Impact

A potential impact of the coronavirus disease 2019 pandemic in Australia was present in 76 of 800 pregnancies (52 with type 1 diabetes and 24 without type 1 diabetes), as these mothers were assessed either during pregnancy or postpartum from late March 2020, when social distancing restrictions were introduced in Australia.

Ethics

All participants provided written informed consent, and all experimental procedures were approved by the Women's and Children's Hospital Network Human Research Ethics Committee (HREC) as the lead HREC in South Australia, Queensland, New South Wales, Victoria, and regional Australia under the Australian National Mutual Acceptance Scheme (reference number HREC/16/WCHN/066). Conduct in Western Australia was approved by the Women and Newborn Health Service Ethics Committee (reference number RGS0000002639). The ENDIA study is registered on the Australia New Zealand Clinical Trials Registry (ACTRN1261300794707, www.anzctr.org.au).

Statistical Analysis

To compare women with and without type 1 diabetes during late pregnancy (T3 visit) and at the postpartum visit, linear mixed models were fitted, with the outcome as either EPDS or PSS score and the exposure variable as the interaction between type 1 diabetes status and visit (T3 vs. postpartum visit). This model determined whether type 1 diabetes status impacts the score differently at each visit (i.e., interaction) or whether there is a difference in score between visits (independent of type 1 diabetes status) or a difference in score according to type 1 diabetes status (independent of visit). The model included parity as a confounder and a pregnancy random effect to allow for correlation between the T3 and postpartum visits of the same pregnancy. We thus assumed that for mothers who were included in the study twice, their pregnancies were independent. We checked this assumption by fitting a model with participant rather than pregnancy as a random effect allowing correlation between all responses from the same mother, and the results were unaltered.

The variables age, parity, remoteness score, SEIFA IRD, and prescribed medication for anxiety or mood disorder were considered as possible confounders. By examining directed acyclic graph diagrams of these possible confounders with the EPDS/PSS score and type 1 diabetes status, we narrowed to one confounder: parity. Parity was an anticipated confounder as ENDIA enrolled unborn children who have a mother, father, or sibling with type 1 diabetes as the proband, so that more women without type 1 diabetes have a previous child than those with type 1 diabetes. A sensitivity analysis was performed after exclusion of the two women with type 2 diabetes and the 40 women with gestational diabetes from the group without type 1 diabetes.

To investigate whether HbA_{1c} level during late pregnancy was related to EPDS or PSS scores, linear regression models were fitted with the outcome as either EPDS or PSS score and the exposure variable as HbA_{1c} level. Analyses were adjusted for parity, and the time of collection of the HbA_{1c} tests, by including a categorical variable with levels relating to the gestational week of pregnancy.

All analyses were conducted using the statistical software R v4.0.4 (R core Team 2021). The package lme4 v1.1.26 (27) was used to fit the linear mixed model. The level for statistical significance was 5%.

It was assumed that if the questions for history and medication were left blank that there was no history of anxiety and mental illness and no psychotropic medication taken. Partially missing responses were present in 5 of 1,203 (0.4%) visits for EPDS and 12 of 1,276 (0.9%) visits for PSS. We imputed the scores at these visits using individual mean data (28).

Data and Resource Availability

The data that support the findings of this study are available on request from the ENDIA Steering Committee via the senior author (J.J.C., jennifer.couper@adelaide.edu.au). The data are not publicly available as they contain information that could compromise participant privacy or consent.

RESULTS

A total of 737 women had 800 pregnancies (518 with type 1 diabetes, 282 without type 1 diabetes) during which they completed the EPDS and PSS questionnaires at T3 and postpartum (Figs. 2 and 3). EPDS was completed at median gestational age of 34.1 (interquartile range [IQR] 32.1, 35.6) weeks and postpartum at median 14.0 (IQR 12.7, 16.0) weeks after the date of delivery. PSS was completed at median gestational age of 34.0 (IQR 32.1, 35.6) weeks and at median of 13.4 (IQR 11.6, 15.7) weeks postpartum.

The women's characteristics and those of their offspring are shown in Table 1. The 800 pregnancies (737 unique women) were comparable with those of the full ENDIA cohort recruited since 2014 (1,461 pregnancies, 1,219 total unique women), including the relative proportion of women with and without type 1 diabetes. The full ENDIA cohort was aged mean 32.3 (SD 4.6) years, with median parity of 1 [IQR 0, 1], 1,149 were Australian born (79%), 63% of women have type 1 diabetes, and distribution of remoteness categories was 81% in a major city (n = 1,186), 17% regional (n = 247) and 1% remote (n = 14) locations.

Within this study of mental health, women with and without type 1 diabetes had a similar sociodemographic profile, similar prevalence of history of a mental health disorder, and similar self-reports of physical activity (Table 1). Women with type 1 diabetes were marginally younger and more likely to be nulliparous (Table 1), as anticipated as women without type 1 diabetes had a partner or child with type 1 diabetes according to the ENDIA inclusion criteria. T3 questionnaires were completed by the women before the delivery of the five stillbirths in all cases, and the data were included in the study. These women did not complete postpartum questionnaires.

Reports of use of psychotropic medications were of similar frequency in women with (44 of 518 [8%]) and without type 1 diabetes (17 of 282 [6%]) (Table 1). Psychotropics prescribed to the women before or during the pregnancy included: selective serotonin reuptake inhibitors (n = 42), serotonin and norepinephrine reuptake inhibitors (n = 10), norepinephrine reuptake inhibitors (n = 1), tricyclic antidepressants (n = 2), benzodiazepines (n = 2), stimulants (dextroamphetamine, n = 2; methylphenidate, n = 1), and a mood stabilizer (lamotrigine, n = 1).

Comparison of EPDS and PSS Between Women With and Without Type 1 Diabetes

EPDS did not differ between women with and without type 1 diabetes at T3 (mean 5.7 [95% CI 5.3, 6.1]; 5.8 [5.2, 6.3], respectively) or postpartum visits (mean 5.2 [95% CI 4.8, 5.6]; 5.4 [4.9, 5.9], respectively). PSS did not differ between women with and without type 1 diabetes at T3 (mean 19.9 [95% CI 19.2, 20.7]; 19.4 [18.4, 20.4], respectively) or at postpartum visits (19.4 [18.7, 20.1]; 19.2 [18.3, 20.2], respectively). The sensitivity analysis that removed women with type 2 diabetes and women with gestational diabetes from the group of women without type 1 diabetes did not alter any of these findings.

Comparison of EPDS and PSS Between T3 and Postpartum Visits

EPDS scores on average decreased from mean 5.7 [95% CI 5.4, 6.1] at T3 to 5.3 [5.0, 5.6] at postpartum visits, independent of type 1 diabetes status (P = 0.01).

A total of 72 of 737 (9.8%) women reported EPDS scores greater than the threshold of 12 for clinical referral at

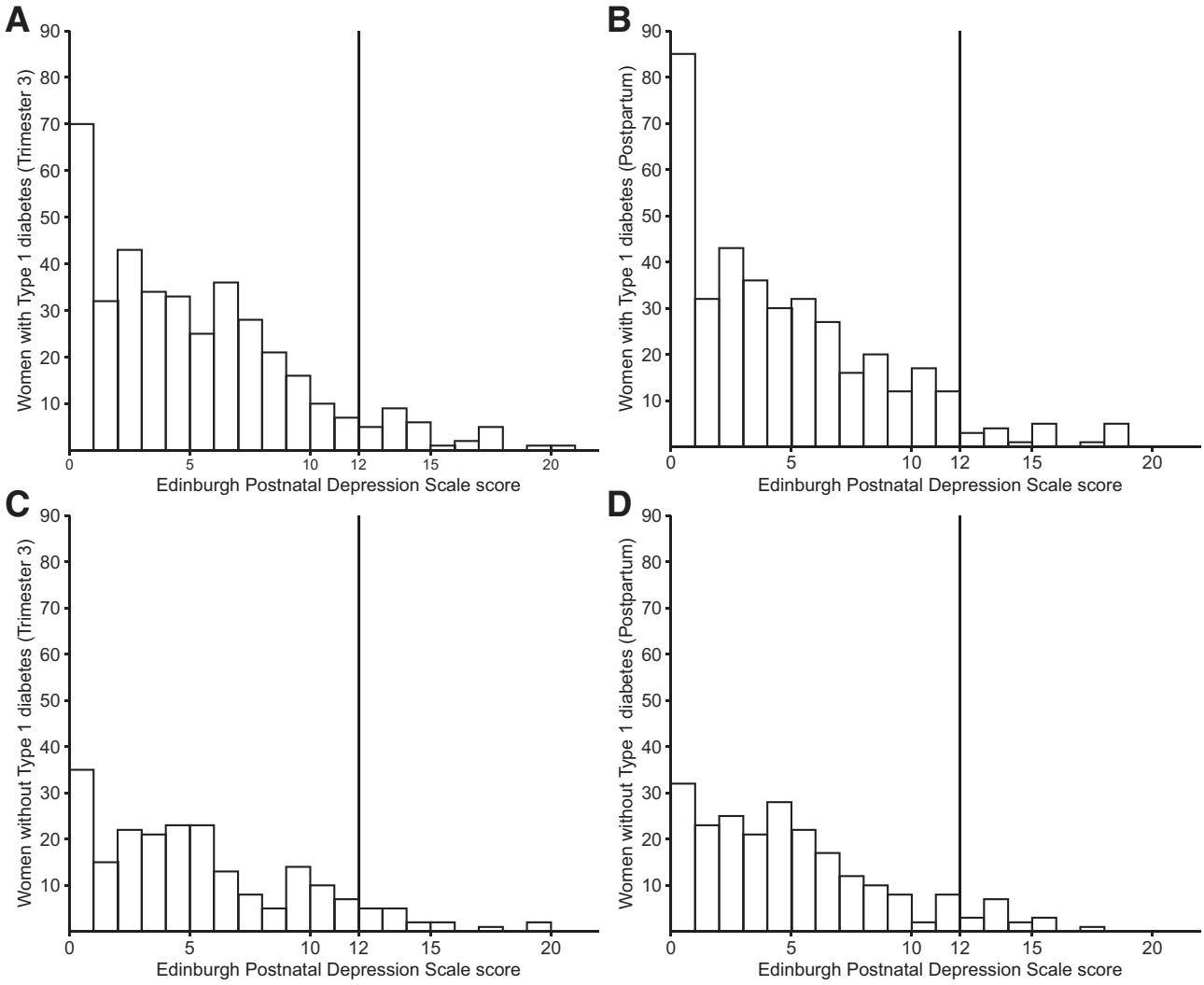

Figure 2—EPDS scores in mothers with type 1 diabetes at T3 (*A*) and postpartum (*B*) and in mothers without type 1 diabetes at T3 (*C*) and postpartum (*D*). Of a total of 1,203 visits, women with type 1 diabetes were assessed at 385 T3 visits and 381 postpartum visits (123 completed T3 assessments only and 119 postpartum only); women without type 1 diabetes were assessed at 213 T3 visits and 224 postpartum visits (52 completed T3 assessments only and 63 postpartum only). The vertical line represents the score of 12, above which clinical assessment for intervention was recommended.

T3, postpartum, or both visits. From T3 to postpartum, EPDS scores for 25 women (15 with type 1 diabetes) reduced to less than the threshold, 10 women (7 with type 1 diabetes) remained greater than the threshold, 15 women (7 with type 1 diabetes) increased to greater than the threshold, 12 women (8 with type 1 diabetes) with only T3 visits were greater than the threshold, and 10 women (5 with type 1 diabetes) with only postpartum visits were greater than the threshold. Of these 72 women (42 with type 1 diabetes), only 13 (9 with type 1 diabetes) received psychotropic medications.

PSS scores did not alter between T3 mean 19.7 (95% CI 19.0, 20.3) and postpartum 19.3 (18.7, 19.9) visits ($P = 0.17$).

There was no evidence that women undertaking questionnaires during the time of the coronavirus disease 2019 pandemic had higher EPDS or PSS scores than women undertaking them before the pandemic. None of the participants contracted severe acute respiratory syndrome coronavirus 2 during the study.

Relationship Between HbA_{1c} and EPDS and PSS Scores in Women With Type 1 Diabetes

HbA_{1c} values were recorded in 398 of 405 (98.3%) of women with type 1 diabetes at median 31.4 (IQR 26.0, 34.1) weeks' gestation. Median HbA_{1c} was 6.3% [IQR 5.8, 6.9], with no relationship between HbA_{1c} level and EPDS score ($R^2 = 0.01$; $P = 0.2$) or PSS score ($R^2 = 0.02$; $P = 0.4$).

CONCLUSIONS

We report for the first time that 737 women with and without type 1 diabetes followed prospectively through 800 pregnancies had similar levels of depressive symptoms and perceived stress, both in T3 and postpartum. Consistent with this, there was no relationship detected between glycemic control and mental health scores in T3. Their use of psychotropic medications was also comparable, as was their reported exercise during pregnancy.

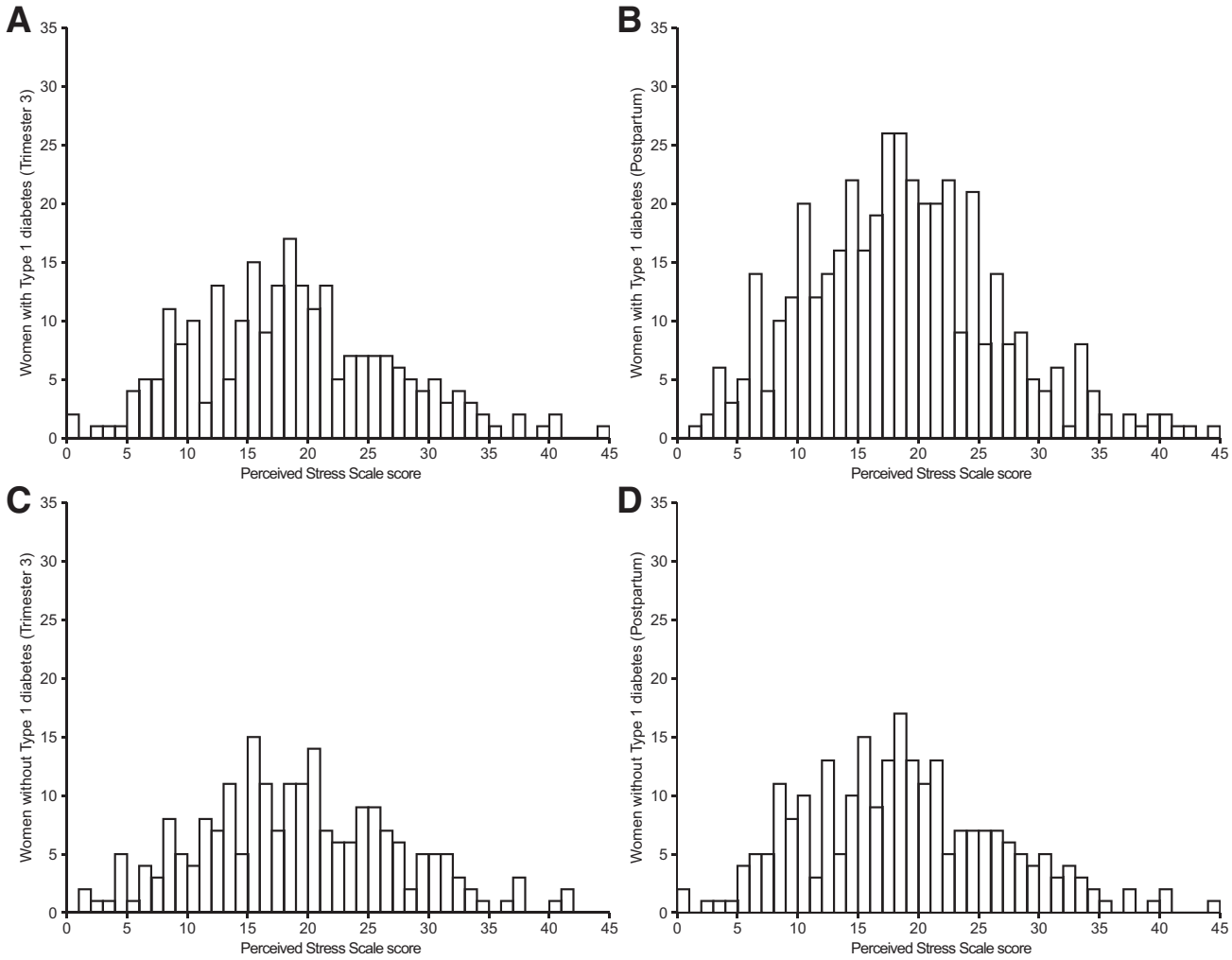

Figure 3—PSS scores in women with type 1 diabetes at T3 (*A*) and postpartum (*B*) and in mothers without type 1 diabetes at T3 (*C*) and postpartum (*D*). Of 1,276 total visits, women with type 1 diabetes were assessed at 399 T3 visits and 421 postpartum visits (94 completed T3 assessments only and 116 postpartum only). Women without type 1 diabetes were assessed at 214 T3 visits and 242 postpartum visits (38 completed T3 assessments only and 66 postpartum only).

These largely reassuring results for the women with type 1 diabetes, given the added burden of aiming for optimal control during pregnancy, were unexpected. Importantly, EPDS and PSS scores do not provide data on levels of diabetes specific distress (29), which may have been increased. However, our findings do not support small studies in which anxiety and depressive symptoms were more frequent in women with type 1 diabetes during pregnancy and in some cases increased further in the postpartum period (13,30,31). There are several possible explanations for this. The ENDIA women had consented to enter a longitudinal study, which may indicate that they had more robust well-being at recruitment than the broader population of pregnant women. EPDS scores that are measured routinely at 6 weeks postpartum in Australia (10) report marginally higher percentages of women with scores >12 (7.5%) than we did in 35 of 605 (5.8%) postpartum visits (32). In addition, the women with type 1 diabetes received frequent review and support from a multidisciplinary team during their pregnancy. Exercise levels throughout pregnancy were similar for those with and without type 1 diabetes, which is noteworthy, as depressive symptoms have been related to reduced leisure time physical activity in adults with type 1 diabetes (3). The women with type 1 diabetes had marginally lower median HbA_{1c} levels (6.3%) than those reported in a recent study of Australian women with type 1 diabetes during pregnancy (33) and clearly lower levels than those reported in a very large U.K. cohort over a comparable time (34).

The small statistical improvement in EPDS scores between T3 and the postpartum visit in women with and without type 1 diabetes was independent of type 1 diabetes status, but of doubtful clinical significance (35). Approximately half of the women in either group with an EPDS score >12 in T3 fell into the normal range at their postpartum visit, and a similar number of women stayed >12 or rose above this threshold postpartum. We can conclude from these data that overall mental health certainly did not worsen between T3 and postpartum, as has been described. Interestingly, the prescription of psychotropics was only reported by 13 (9 with type 1 diabetes) of a total of 72 women who had an EPDS score >12 at T3 and/or postpartum.

Table 1—Characteristics of the women, pregnancies, and infants in the mental health study

	Type 1 diabetes	Without type 1 diabetes
Number of pregnancies*	518	282
Age at date of delivery (years), mean (SD)	31.9 (4.4)	33.1 (4.4)
Born in Australia	421 (81)	222 (79)
Remoteness area		
Major city	421 (81)	231 (82)
Regional	88 (17)	49 (17)
Remote	6 (1)	0 (0)
SEIFA IRSD		
Quintile 1	56 (11)	37 (13)
Quintile 2	70 (14)	32 (11)
Quintile 3	104 (20)	63 (22)
Quintile 4	132 (25)	67 (24)
Quintile 5	151 (29)	81 (29)
Parity, median (IQR)	1.0 (0, 1.0)	1.0 (0, 1.0)
0	250 (48)	113 (40)
1	192 (37)	103 (37)
≥2	76 (15)	66 (23)
Multiple birth		
Singleton	511 (99)	280 (99)
Twin/triplet	7 (1)	2 (1)
Stillborn	5 (1)	0 (0)
Preconception BMI (kg/m^2), mean (SD)	26.8 (5.6)	25.6 (5.7)
Physical activity during pregnancy (MET hours/week), median (IQR)	251 (194, 330)	253 (195, 328)
Preexisting maternal comorbidities		
Anxiety	95 (18)	58 (21)
Mood disorder	44 (8)	17 (6)
Arthritis	17 (3)	5 (2)
Asthma	62 (12)	50 (18)
Celiac disease	37 (7)	5 (2)
Epilepsy	5 (1)	5 (2)
High blood pressure	35 (7)	10 (4)
Kidney disease	8 (2)	2 (1)
Polycystic ovary syndrome	40 (8)	16 (6)
Inflammatory bowel disease	5 (1)	8 (3)
Thyroid problems	130 (25)	32 (11)
Other autoimmune disorders	21 (4)	14 (5)
Pregnancy outcomes		
Preeclampsia	88 (17)	8 (3)
Postpartum hemorrhage	58 (11)	42 (15)
Congenital abnormalities	45 (9)	12 (4)
Prematurity (<37 weeks)	211 (41)	20 (7)
Type 1 diabetes duration at date of delivery (years), median (IQR)	17.5 (10.0, 23.3)	
Insulin delivery		
CSII	271 (52)	
MDI	154 (30)	
CSII and MDI	3 (1)	
CSII or MDI and oral	12 (2)	
HbA_{1c} (mmol/mol), median (IQR)	45.0 (40.0, 51.7)	
HbA_{1c} (%), median (IQR)	6.3 (5.8, 6.9)	
Number of infants**	520	285
Mode of delivery		
Cesarean	364 (70)	103 (36)
Vaginal	143 (28)	174 (61)
Gestational age at birth (weeks), mean (SD)	36.7 (1.7)	39.0 (1.6)

Continued on p. 1089

Table 1—Continued

	Type 1 diabetes	Without type 1 diabetes
Apgar (1 min), mean (SD)	7.8 (1.8)	8.5 (1.3)
Apgar (5 min), mean (SD)	8.7 (1.0)	9.0 (0.8)
Birth weight (g), mean (SD)	3,570 (676)	3,403 (526)
Neonatal hypoglycemia (<2.6 mmol/L)	262 (50)	24 (8)

Data are *n* (%) unless otherwise indicated. CSII, continuous subcutaneous insulin infusion; MDI, multiple daily injections. *Total of 800 pregnancies from 737 unique women (476 women with type 1 diabetes and 261 women without type 1 diabetes). **Excludes the five stillborn that were born after the collection of T3 mental health data.

Strengths of this study are that it is the largest longitudinal prospective study of mental health in pregnant women with type 1 diabetes, to our knowledge, with ∼5- to 10-fold more women with type 1 diabetes than in previous studies (13,36). Participation rate was high at 86%. Women with and without type 1 diabetes were closely comparable in sociodemographic status. A small difference between their mean ages was anticipated due to the design of ENDIA in which mothers without type 1 diabetes have either a partner or a previously born child with type 1 diabetes. Combined, their age, parity, and sociodemographic status were comparable to the whole ENDIA cohort, and their age and parity were comparable to contemporary pregnant women with and without type 1 diabetes in Australia (33).

The study also has several limitations. First, women who were recruited prior to the introduction of the EPDS and PSS in the ENDIA protocol at the end of 2016 were not able to be included. However, their characteristics did not differ from those recruited after this time point. Second, the EPDS has been used extensively within perinatal screening programs for women, but some limitations are recognized (37). Of particular relevance to this study, EPDS may not be as good at detecting anxiety in pregnancy (38). Other measures of well-being that focus on diabetes-specific stressors may have revealed stressors in women with type 1 diabetes that we could not detect with EPDS and PSS. Third, the analysis of the relationship between HbA_{1c} and mental health scores was based on only one HbA_{1c} measurement in T3 close to the time of EPDS and PSS investigation. Different stressors in early pregnancy may have affected women with type 1 diabetes differently. The relatively narrow range of HbA_{1c} in our cohort may have prevented a relationship with mental health scores from being detected. Finally, HbA_{1c}, while being a practical measure of glycemic control, cannot assess glycemic variability. Continuous glucose monitoring would have provided a more thorough assessment of glycemic control in those women taking up this technology, but these metrics were not available to us; the majority of women were studied prior to the widespread rollout of continuous glucose monitoring during pregnancy in Australia in 2020.

In conclusion, we detected no greater depression or perceived stress in women with type 1 diabetes, compared with women without, during late pregnancy and postpartum. It is encouraging that when glycemic control was within the range achieved in this cohort, there were no substantial differences in mental health imposed on pregnant women with type 1 diabetes. This is not to say that women with type 1 diabetes do not need increased support during their pregnancy; this cohort received substantially increased support according to routine practice for the care of type 1 diabetes during pregnancy in Australia. Any anxiety or depressive symptoms, including diabetes-specific distress, could have a considerable impact on their well-being at a time when the management of their type 1 diabetes is particularly demanding. The slightly higher levels of depressive symptoms in T3 also indicate the need for mental health assessment and support throughout pregnancy, in addition to the postpartum period.

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Author Contributions. R.L.T. and J.J.C. conceived the study. M.Hal., H.O., M.A.S.P., R.L.T., and J.J.C. designed the study. M.Hal., K.M., A.J.A., P.G.C., M.E.C., E.A.D., M.Har., L.C.H., A.H., C.M., G.S., P.J.V., J.M.W., R.L.T., and J.J.C. collected data required for the study and oversaw implementation of ethical practice and the ENDIA protocol at the clinical sites. H.O. performed the statistical analysis. R.O.S. supervised the storage and maintenance of all data for the study. M.Hal., H.O., R.L.T., and J.J.C. wrote the manuscript. All authors provided critical revision of the manuscript and approved the final version. H.O. and J.J.C. are the guarantors of this work and, as such, had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

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