ORIGINAL ARTICLE

Gestational diabetes and mental health: longitudinal analysis of data from the GEMS randomized trial

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Abstract

Purpose There is limited high-quality evidence about perinatal mental health among women with gestational diabetes. We aimed to assess the risks and longitudinal changes in anxiety, depression, and health-related quality of life comparing women with gestational diabetes and those without among a contemporary cohort of pregnant women.

Methods Prospective cohort study of participants in the GEMS Trial. Women with a singleton pregnancy were eligible if they had a 75-g diagnostic oral glucose-tolerance test between 24 and 32 weeks' gestation, provided written informed consent, and completed questionnaires about anxiety, depression, and health-related quality of life at the study time points.

Results There were no differences in risk for anxiety (RR 1.13, 95% CI 0.86, 1.49; $p = 0.39$) or depression (RR 1.08, 95% CI 0.78, 1.50; $p = 0.64$) between the two groups at 36 weeks' gestation or 6 months postpartum [anxiety: (RR 1.21, 95% CI 0.90, 1.63; $p = 0.21$); depression: (RR 0.84, 95% CI 0.55, 1.28; $p = 0.43$]. However, at 36 weeks' gestation participants with gestational diabetes reported better physical functioning, and at 6 months postpartum, better mental functioning (mean difference (MD) in scores 1.28, 95% CI 0.25, 2.30; $p = 0.01$) although worse physical functioning (MD -2.99, 95% CI -3.90, -2.07; p = <0.001) compared to participants without.

Conclusion The risk for poor mental health during the perinatal period does not differ importantly among women diagnosed and treated for gestational diabetes compared to the general pregnant population.

Highlights

- In this prospective cohort of 3051 trial participants, we found a similar risk for anxiety and depression among participants with gestational diabetes compared to those without.
- However, participants with gestational diabetes had better mental health-related quality of life but worse physical health-related quality of life postnatally.
- Women with gestational diabetes may have suboptimal physical health related quality of life in the perinatal period, but clinicians and patients should be reassured that risk of anxiety and depression does not differ from the general pregnant population.

Introduction

Poor mental health outcomes are the most common disorders experienced by women in the antenatal period and after childbirth. A systematic review including studies from 34 countries reported, with high-certainty evidence, a prevalence of 22% for antenatal anxiety and 12% for postnatal anxiety up to six months after birth among healthy pregnant women (Dennis et al. 2017). Similarly, recent estimates from a review of systematic reviews found that 29% of pregnant women experience depression in the antenatal period and

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28% in the postnatal period (Al-abri et al. 2023). Perinatal mental disorders are associated with multiple adverse outcomes for mother and child in both the short and long-term. During pregnancy, poor mental health predisposes to an increased risk of gestational hypertension (Rusner et al. 2016), preterm birth (Dadi et al. 2020), and birth of a low birthweight baby (Rusner et al. 2016; Dadi et al. 2020). In the postpartum period, mental disorders are associated with poor maternal coping responses (George et al. 2013), and reduced ability to breastfeed (Ahmadinezhad et al. 2024). Children born to mothers with perinatal mental disorders have higher rates of mental distress, behavioral problems, and neurocognitive disorders in later life (O'Connor et al. 2002, 2003; Mennes et al. 2006). As a result of these adverse outcomes, perinatal mental disorders are associated with a significant economic burden. In the United Kingdom, lifetime costs of perinatal anxiety and depression was estimated to cost £6.6 billion(Bauer et al. 2016) and in the United States, perinatal mood and anxiety disorders was estimated to cost $14 billion from conception to 5 years postpartum (Luca et al. 2020).

Gestational diabetes mellitus (GDM), defined as carbohydrate intolerance of varying degree with first onset in pregnancy (World Health Organization 1999), is the commonest metabolic disorder in pregnancy, and is associated with adverse outcomes including maternal pre-eclampsia (Plows et al. 2018), induced labour (Plows et al. 2018; Shen et al. 2020), and birth of a large-for-gestational age baby (Plows et al. 2018). There is also an increased risk of poor mental health including depression (Arafa and Dong 2019; Azami et al. 2019; Riggin 2020), anxiety, and stress (Daniells et al. 2003). A concurrent diagnosis of GDM and poor mental health during pregnancy has been associated with increased rates of perinatal complications such as preterm birth, neonatal respiratory distress, gestational hypertension, and pre-eclampsia (Lee et al. 2020; Packer et al. 2021).

Most studies assessing perinatal mental health among women with GDM, have been cross-sectional or included small sample sizes.(Wilson et al. 2020) They have predominantly focused on anxiety and depression (Wilson et al. 2020; Ouyang et al. 2021), but health-related quality of life (HRQoL) also has been reported to deteriorate among women with GDM (Marchetti et al. 2017). Few studies have reported mental health in both antenatal and postnatal periods.

We aimed to compare the prevalence of risk for anxiety, vulnerability to depression, and HRQoL at 36 weeks' gestation and 6 months postpartum between women who were diagnosed with GDM and those without, in a large multi-ethnic randomized trial cohort, and to assess how these changed over time.

Methods

This is a secondary analysis of the GEMS Trial, a randomized trial that assessed the optimal glycemic thresholds for GDM diagnosis to improve perinatal outcomes (Crowther et al. 2022). Women with a singleton pregnancy were eligible if they had a 75-g oral glucose-tolerance test (OGTT) at 24 to 32 weeks' gestation and provided written informed consent. Women with diabetes mellitus or a history of gestational diabetes were ineligible. Women whose OGTT results indicated gestational diabetes based on their allocated criteria group were provided with GDM care comprising nutritional therapy and as-needed pharmacologic treatment, and women whose OGTT indicated no GDM received routine pregnancy care.

Eligible participants for this study were women who completed any questionnaire screening for anxiety, depression, and health-related quality of life (HRQoL) at study enrolment (baseline), 36 weeks' gestation, or 6 months postpartum.

Outcome measures

Anxiety was measured using the 6-item Spielberger State-Trait Anxiety Inventory (STAI), a valid alternative to the full version for use in research (Court et al. 2010), with scores > 15 indicating the presence of symptoms of anxiety (Crowther et al. 2005).

Depression was assessed using the Edinburgh Postnatal Depression Scale (EPDS), a validated tool for use among pregnant women (Cox et al. 1987). The tool comprises 10 items with each item scored on a 4-point scale (0–3) for a maximum score of 30. We used a score of > 12 to indicate vulnerability to depression, a cut-off shown to have the highest specificity in both the antenatal and postpartum period (Levis et al. 2020).

Health-related quality of life was assessed using the 36-Item Short-Form General Health Survey (SF-36), which assesses eight aspects of health status: general health, mental health, physical functioning, social functioning, role physical, role emotional, bodily pain, and vitality (Ware and Sherbourn 1992). Scores range from 0 to 100, with two summary measures, namely physical component summary (PCS) and mental component summary (MCS), with higher scores indicating higher levels of functioning (Ware 2000). The MCS has a standardized mean (standard deviation) of 50 ± 10 derived from the general healthy New Zealand population (The Ministry of Health New Zealand 1999). We assigned a cut-off score below minus one standard deviation (MCS < 40) as denoting poor mental HRQoL, as this adequately captures mental health outcomes and has good positive predictive value for poor mental health outcomes

compared to other validated psychological instruments (Ware, MA and Keller, 1993; Pfoh et al. 2016).

Statistical analyses

Baseline characteristics were compared between women who did and did not receive a diagnosis of GDM using Student's t-tests or chi-square tests. Mental health outcomes were analyzed both as continuous and categorical variables using generalized linear mixed-effects models (log-binomial regression for binary outcomes and normal distribution (identity link function) for continuous outcomes) to estimate relative risks (RR) and mean differences (MD) with their 95% confidence intervals (CIs). A two-sided p-value < 0.05 was considered statistically significant. No adjustment was made for multiple comparisons. Statistical analyses were conducted using SAS software version 9.4 (SAS Institute, Cary, North Carolina, United States of America).

Repeated measure analyses were undertaken using generalized linear mixed-effects models to determine if there was an interaction between GDM status (yes/no) and time. We fitted time and GDM status as main effects and included their interaction using the SAS proc mixed. An unstructured covariance type was assumed to allow for flexibility in the covariance structure. Additionally, analyses were performed with change from baseline as the dependent variable using analyses of covariance and including baseline values as covariates to present results independent of differences at baseline. Marginal least square means and their corresponding 95% confidence intervals (CI) are presented.

No imputation of missing data was performed since we could not necessarily meet the assumption of missing at random. However, the mixed-effects model approach used is robust for effectively handling missing data and does not omit data due to missingness.

Results

At study enrolment (baseline), 3051 participants (75.1% of the total GEMS Trial participants) completed the mental health questionnaires and were eligible for inclusion in this study. Of these, 313 (10.2%) were diagnosed with GDM. Questionnaires were completed by 2888/3051 (94.5%) at 36 weeks' gestation and 2082/3052 (68.2%) at 6 months after birth.

Baseline characteristics differed between the two groups, with more participants of Asian ethnicity in the GDM group (49% compared to 31%), and European ethnicity in those without GDM group (42% compared to 24%) (Table 1). Additionally, 50.8% of participants in the GDM group reported a family history of diabetes compared to 32.8%

in the no GDM group. Participants with GDM were older and had a mean $2kg/m^2$ higher body mass index (BMI) than those without.

Prevalence and risk for poor perinatal mental health

At baseline (median 27.3 weeks' gestation), a higher proportion of participants with GDM [43/313 (14%)] compared to participants without GDM [321/2718 (11.8%)] reported symptoms reflecting risk for anxiety, although this was not statistically significant [RR:1.17 (95% CI 0.87, 1.57)] (Table 2). The proportion of participants at risk of depression was similarly not different between groups, although the GDM group reported higher mean EPDS scores [MD:0.63 (0.12,1.14)]. In the SF-36 domains relating to mental health, participants with GDM had lower scores for social functioning, but the overall MCS measures were not significantly different between the two groups. In the SF-36 domains relating to physical health, the overall PCS measures were lower (worse) in the GDM group [PCS MD: -2.97 (-3.98, -1.97)], as were physical functioning, role physical, bodily pain, and general health.

At 36 weeks' gestation, the prevalence of risk for anxiety and depression were not significantly different between the two groups and both groups had similar STAI and EPDS scores. There was no overall difference between groups in HRQoL, although participants with GDM had lower SF-36 general health scores [MD: -3.58 (-5.69, 1.47)] and higher vitality scores [MD: 3.08 (1.34, 4.81)] compared to participants with no GDM.

At 6 months postpartum, the risk for anxiety and depression was not different between the two groups and both groups had similar STAI and EPDS scores. However, SF-36 vitality and the overall MCS measure were higher (better) among the GDM group [MCS MD: 1.28 (0.25, 2.30)], whereas physical functioning, role physical, bodily pain, general health, and social functioning, and the overall PCS measure were all lower in the GDM group [PCS MD: -2.99 (-3.90, -2.07)].

Changes in mental health measures over time

Participants in both groups reported a similar trajectory for mean STAI scores over time (Table 3; Fig. 1). After adjustment for baseline scores, participants in both groups reported slightly better STAI scores at 36 weeks' gestation and a slight decline in scores at 6 months postpartum, with no significant time by group interaction effects.

For EPDS scores, participants with GDM reported a mean decline from baseline of 0.5 score at 36 weeks and around 1.5 score at 6 months postpartum, whereas participants with no GDM reported no significant changes from

Table 1 Baseline characteristics of study participants

Characteristics	Total study cohort ($N=3051$)	Participants with GDM ($N=313$)	Participants without GDM ($N=2738$)	p value[a]
Age (years), mean (SD)	32.0 (5.0)	32.3 (4.8)	31.9 (5.0)	0.18
<30	934 (30.6)	89 (28.4)	845 (30.9)	0.85
30 - <35	1200 (39.3)	126 (40.3)	1074 (39.2)	
35 - <40	721 (23.6)	77 (24.6)	644 (23.5)	
≥40	196 (6.4)	21 (6.7)	175 (6.4)	
Maternal ethnicity				<0.001*
European	1449 (47.5)	87 (27.8)	1362 (49.7)	
Māori	157 (5.1)	12 (3.8)	145 (5.3)	
Pacific peoples	334 (11.0)	39 (12.5)	295 (10.8)	
Asian	936 (30.7)	151 (48.2)	785 (28.7)	
Other	175 (5.7)	24 (7.7)	151 (5.5)	
BMI (kg/m²), mean (SD)	27.4 (6.1)	29.2 (6.8)	27.2 (6.0)	<0.001*
<25	1266 (41.5)	85 (27.2)	1181 (43.1)	<0.001*
25.0 - <30	1018 (33.4)	112 (35.8)	906 (33.1)	
≥30	767 (25.1)	116 (37.1)	651 (23.8)	
Parity				0.42
0	1524 (49.9)	167 (53.3)	1357 (49.6)	
1	909 (29.8)	85 (27.2)	824 (30.1)	
≥2	618 (20.3)	61 (19.5)	557 (20.3)	
Any previous perinatal death[b] ($N=1601$)	55 (3.4)	7 (4.5)	48 (3.3)	0.44
Gestational age at OGTT (weeks), median (IQR)	27.3 (26.3–28.3)	27.4 (26.3–28.4)	27.1 (26.3–28.1)	0.03*
Family history of diabetes	1069 (35.0)	160 (51.1)	909 (33.2)	<0.001*
OGTT results (mmol/L), median (IQR)				
Fasting	4.3 (4.1–4.6)	4.9 (4.4–5.4)	4.3 (4.1–4.5)	<0.001*
1-hour postprandial	7.5 (6.3–8.5)	10.1 (9.2–11.0)	7.4 (6.1–8.1)	<0.001*
2-hour postprandial	6.1 (5.2–7.1)	8.7 (7.2–9.6)	5.9 (5.1–6.8)	<0.001*

[a] comparison between women with GDM and women without GDM

[b] Among women with previous pregnancy of 20 weeks' or more

Data presented as number (%), unless otherwise indicated. p-values<0.05 denoted with asterisks (*)

BMI– body mass index; IQR– Interquartile range; OGTT– oral glucose tolerance test; SD– standard deviation

baseline at 36 weeks' gestation and 6 months postpartum (interaction p-value 0.003).

The direction of change in the overall MCS and PCS measures was similar for participants in both groups. For MCS, both groups experienced an improvement from baseline of around one score at 36 weeks' gestation. At 6 months postpartum, there was a decline in MCS scores, with the GDM group experiencing less of a decline (better functioning) compared to the no GDM group (interaction p-value=0.03). For PCS, both groups reported a decline in mean scores at 36 weeks' gestation but participants with GDM reported less of a decline (better physical functioning) compared to those without GDM. At 6 months postpartum, mean PCS scores had improved for both groups, but the GDM group reported less improvement (worse functioning) from 36 weeks' gestation compared to the no GDM group (interaction p-value=<0.001).

Discussion

In this multi-ethnic cohort of more than 3000 participants, we found no difference in risk for anxiety or depression among participants with GDM compared to participants without GDM in late gestation and 6 months after birth. However, participants in the GDM group reported higher EPDS scores at study enrolment and these declined over time compared to participants in the no GDM group. Both physical and mental HRQoL differed between the two groups. In late gestation, participants in the GDM group reported better physical HRQoL, and in the postnatal period, better mental HRQoL but worse physical HRQoL compared to participants in the no GDM group.

Anxiety

Around one in eight women self-reported symptoms of risk for anxiety in both groups over the assessed time periods. Studies which have reported a higher prevalence of anxiety

Table 2 Comparison of perinatal mental health between GDM group and no GDM group

Outcome	GDM		No GDM			
	N	n (%) or mean (SD)	N	n (%) or mean (SD)	Relative risk or mean difference (95% CI)	p value
Time of study enrolment (baseline)						
Any mental disorder [a]	313	70 (22.4)	2738	516 (18.9)	1.19 (0.95, 1.48)	0.13
Anxiety (STAI>15)	308	43 (14.0)	2718	321 (11.8)	1.17 (0.87, 1.57)	0.29
STAI score	308	10.6 (3.4)	2718	10.3 (3.3)	0.38 (-0.01, 0.77)	0.06
Depression (EPDS>12)	308	36 (11.7)	2714	257 (9.5)	1.23 (0.89, 1.71)	0.22
EPDS score	308	7.1 (4.4)	2714	6.5 (4.3)	0.63 (0.12, 1.14)	0.01*
Poor mental HRQoL (MCS<40)	308	40 (13.0)	2714	304 (11.2)	1.16 (0.85, 1.57)	0.36
SF-36 scores:						
Physical functioning	309	65.6 (21.5)	2728	72.8 (20.6)	-7.33 (-9.67, -4.89)	<0.001*
Role physical	312	58.4 (41.2)	2729	66.4 (38.0)	-7.97 (-12.46, -3.47)	<0.001*
Bodily pain	312	66.3 (20.5)	2738	70.7 (20.1)	-4.50 (-6.86, -2.13)	<0.001*
General health	313	72.2 (18.4)	2733	75.2 (17.0)	-2.94 (-4.94, -0.94)	0.004*
Vitality	313	56.5 (13.7)	2733	55.2 (13.6)	1.22 (-0.37, 2.81)	0.13
Social functioning	314	77.1 (21.1)	2739	81.7 (20.6)	-4.53 (-6.94, -2.12)	<0.001*
Role emotional	312	82.6 (32.2)	2728	85.6 (29.4)	-3.03 (-6.50, 0.45)	0.09
Mental health	312	69.7 (11.2)	2737	70.3 (10.8)	-0.67 (-1.94, 0.60)	0.30
PCS	308	43.6 (8.6)	2714	46.6 (8.5)	-3.01 (-4.02, -2.00)	<0.001*
MCS	308	49.4 (7.7)	2714	49.0 (7.3)	0.38 (-0.48, 1.24)	0.39
36 weeks' gestation						
Any mental disorder [a]	298	72 (24.2)	2590	573 (22.1)	1.09 (0.88, 1.35)	0.42
Anxiety (STAI>15)	295	47 (15.9)	2586	365 (14.1)	1.13 (0.86, 1.49)	0.39
STAI score	296	10.7 (3.4)	2586	10.7 (3.4)	0.07 (-0.34, 0.47)	0.74
Depression (EPDS>12)	296	35 (11.0)	2588	282 (10.9)	1.08 (0.78, 1.50)	0.64
EPDS score	317	6.7 (4.5)	2588	6.6 (4.5)	0.16 (-0.38, 0.71)	0.55
Poor mental HRQoL (MCS<40)	296	38 (12.8)	2590	321 (12.4)	1.03 (0.75, 1.41)	0.84
SF-36 scores:						
Physical functioning	296	58.2 (20.7)	2590	58.9 (21.8)	-0.78 (-3.38, 1.83)	0.56
Role physical	297	46.7 (41.5)	2590	42.4 (39.6)	4.32 (-0.46, 9.10)	0.08
Bodily pain	297	61.6 (22.1)	2590	60.8 (20.4)	0.82 (-1.65, 3.30)	0.51
General health	297	70.7 (19.1)	2590	74.3 (17.4)	-3.58 (-5.69, -1.47)	0.001*
Vitality	297	54.2 (14.8)	2590	51.2 (14.4)	3.08 (1.34, 4.81)	<0.001*
Social functioning	297	75.5 (21.3)	2590	75.8 (21.5)	-0.27 (-2.85, 2.31)	0.84
Role emotional	297	79.5 (35.4)	2590	79.4 (35.3)	0.04 (-4.20, 4.29)	0.99
Mental health	297	69.7 (11.8)	2590	69.6 (11.3)	0.03 (-1.33, 1.40)	0.96
PCS	296	40.2 (9.0)	2590	40.1 (9.1)	0.10 (-0.99, 1.19)	0.86
MCS	296	49.9 (7.9)	2590	49.7 (7.8)	0.18 (-0.77, 1.12)	0.71
6 months postpartum						
Any mental disorder [a]	302	71 (23.5)	1780	417 (23.4)	1.00 (0.80, 1.25)	0.97
Anxiety (STAI>15)	301	45 (14.9)	1777	219 (12.3)	1.21 (0.90, 1.63)	0.21
STAI score	301	10.6 (3.3)	1777	10.4 (3.3)	0.22 (-0.19, 0.63)	0.29
Depression (EPDS>12)	300	23 (7.7)	1779	161 (9.0)	0.84 (0.55, 1.28)	0.43
EPDS score	300	6.0 (4.4)	1779	5.9 (4.5)	0.13 (-0.41, 0.68)	0.63
Poor mental HRQoL (MCS<40)	298	46 (15.4)	1777	331 (18.6)	0.83 (0.62, 1.10)	0.18
SF-36 scores:						
Physical functioning	300	81.8 (22.8)	1779	89.2 (16.4)	-7.44 (-9.58, -5.30)	<0.001*
Role physical	300	81.1 (31.9)	1778	85.6 (29.2)	-4.53 (-8.16, -0.91)	0.01*
Bodily pain	301	75.3 (21.9)	1780	79.6 (20.0)	-4.26 (-6.73, -1.78)	<0.001*
General health	300	73.6 (19.0)	1780	76.6 (17.1)	-2.99 (-5.12, -0.86)	0.006*
Vitality	300	59.0 (14.2)	1780	55.4 (14.5)	3.52 (1.74, 5.29)	<0.001*
Social functioning	301	81.8 (21.1)	1780	85.5 (19.6)	-3.67 (-6.10, -1.25)	0.003*
Role emotional	300	85.2 (30.1)	1778	84.3 (31.2)	0.92 (-2.88, 4.72)	0.63

Table 2 (continued)

Outcome	GDM		No GDM			
	N	n (%) or mean (SD)	N	n (%) or mean (SD)	Relative risk or mean difference (95% CI)	p value
Mental health	300	70.2 (12.0)	1780	70.1 (11.6)	0.09 (-1.33, 1.52)	0.90
PCS	298	50.6 (8.6)	1777	53.6 (7.3)	-2.99 (-3.90, -2.07)	<0.001*
MCS	298	47.7 (8.0)	1777	46.4 (8.4)	1.28 (0.25, 2.30)	0.01*

[a]Any of anxiety (STAI>15), vulnerability to depression (EPDS>12) or poor mental health-related quality of life (MCS<40)

EPDS- Edinburgh Postnatal Depression Scale; HRQoL– health-related quality of life; MCS- mental component score; PCS– physical component score; SF-36–36-Item Short-Form General Health Survey; STAI– Spielberger State-Trait Anxiety Inventory

p-values<0.05 denoted with asterisks (*)

in women with GDM have suggested that the perception of high-risk pregnancy and the stressful treatment regimen associated with GDM management contributes to this increase (Hui et al. 2014; Ouyang et al. 2021). However, a meta-analysis of observational studies reported no difference in the odds for anxiety in women with GDM compared to women without GDM (Delanerolle et al. 2021), and a recent study assessing prevalence of antenatal anxiety symptoms in a small cohort of women with GDM reported that anxiety symptomatology was not significantly associated with glycemic control (Munda et al. 2021). These findings are consistent with our finding of similar anxiety prevalence in participants with and without GDM.

The prevalence of anxiety symptoms may also depend on the time of assessment. GDM diagnosis may be associated with some reactive anxiety during pregnancy which settles in late gestation and in the postpartum period due to reassurance from care (Daniells et al. 2003). The changes in anxiety scores over time in our study support this, with the GDM group having higher scores at baseline but decreasing by 36 weeks.

Depression

Around one in ten participants reported symptoms of vulnerability to depression in both groups over the assessed time periods, an estimate which is consistent with previous findings in New Zealand (Underwood et al. 2017), and other high-income countries (Woody et al. 2017). No difference was found in the risk for vulnerability to depression between the two groups. However, participants with GDM reported a one EPDS score higher than participants without GDM at baseline. Shared biological mechanisms such as dysregulation of the hypothalamic-pituitary axis (HPA) (Zhao et al. 2022) and psychosocial risk factors including stress associated with treatment adherence have been implicated in the link between diabetes and depressive symptoms (Holt et al. 2014). Among women with GDM, HPA dysregulation results in elevated concentrations of cortisol, a hormone implicated in depression (Keller et al. 2017). Additionally, recent qualitative evidence suggests that

around the time of GDM diagnosis, limited knowledge and misconceptions about the diagnosis affects women's psychological well-being negatively (Benton et al. 2024). Our finding of a higher EPDS score at baseline may be linked to a higher proportion of participants with GDM being obese (BMI≥30 kg/m^2). Obesity in the antenatal period has been reported to increase the risk for depressive symptoms. A 1.05 increase in EPDS score per kg/m^2 increase in BMI was reported among a pregnancy cohort in Australia (Sominsky et al. 2023). Additionally, the higher proportion of women with GDM reporting a family history of diabetes may be contributing to the higher EPDS score at baseline. Half of the participants with GDM in our study reported a family history of diabetes compared to one in three participants without GDM. Some evidence suggests family history predisposes to insulin resistance (Ong et al. 2022), which has been positively associated with depressive symptoms (Kan et al. 2013). However, the extent to which this may have contributed to the higher baseline EPDS scores in participants with GDM in our study is difficult to determine as we did not assess insulin resistance.

The decline in EPDS scores in late gestation and up to 6 months after birth in participants with GDM is consistent with evidence that the increased care and access to information associated with GDM care results in reduced depressive symptoms in the postpartum period (Crowther et al. 2005).

Health-related quality of life

Assessing health related quality of life in the perinatal period is increasingly important to understand the physical and mental changes associated with this period, and hence may play an important role in clinical decision making to provide relevant and appropriate care in the perinatal period (Wu et al. 2021).

In our study, quality of life related to mental health and functioning was similar for participants in both groups in the antenatal period and declined six months after birth, but with better mental HRQoL in participants with GDM compared to those without. Other studies have reported inconsistent results. A small cohort study in Italy reported worse

Table 3 Longitudinal changes in mental health measures: Group by time interactions

	GDM	No GDM			
	Mean scores or *n/N* (%) (95% CI)	Mean scores or *n/N* (%) (95% CI)	Mean difference or relative risk (95% CI)	*p* value	*p* value for interaction
Anxiety					
STAI score					
Time of enrolment	10.6 (10.3, 11.0)	10.3 (10.2, 10.4)	0.34 (-0.04, 0.71)	0.08	0.29
36 weeks' gestation	10.8 (10.4, 11.2)	10.7 (10.6, 10.8)	0.08 (-0.31, 0.47)	0.68	
6 months postpartum	10.6 (10.3, 11.0)	10.6 (10.4, 10.7)	0.06 (-0.34, 0.45)	0.77	
STAI>15					
Time of enrolment (*N*=3026)	43/308 (13.9) (10.1, 17.8)	321/2718 (11.8) (10.6, 13.0)	1.18 (0.88, 1.58)	0.28	0.94
36 weeks' gestation (*N*=2882)	47/296 (15.9) (11.7, 20.0)	365/2586 (14.1) (12.8, 15.5)	1.13 (0.85, 1.49)	0.41	
6 months postpartum (*N*=2078)	45/302 (14.9) (10.9, 18.9)	219/1777 (12.3) (10.8, 13.9)	1.21 (0.90, 1.63)	0.21	
Depression					
EPDS score					
Time of enrolment	7.3 (6.9, 7.8)	6.6 (6.5, 6.8)	0.71 (0.22, 1.20)	0.005*	0.003*
36 weeks' gestation	6.9 (6.4, 7.4)	6.7 (6.5, 6.8)	0.23 (-0.28, 0.75)	0.37	
6 months postpartum	6.1 (5.6, 6.6)	6.3 (6.1, 6.5)	-0.19 (-0.73, 0.34)	0.48	
EPDS>12					
Time of enrolment (*N*=3022)	36/308 (11.6) (8.1, 15.2)	257/2714 (9.5) (8.4, 10.6)	1.23 (0.89, 1.71)	0.22	0.38
36 weeks' gestation (*N*=2885)	35/297 (11.8) (8.1, 15.4)	282/2588 (10.9) (9.7, 12.1)	1.08 (0.78, 1.50)	0.64	
6 months postpartum (*N*=2079)	23/301 (7.6) (4.6, 10.6)	161/1779 (9.1) (7.8, 10.4)	0.84 (0.55, 1.28)	0.43	
Health related quality of life					
SF-36 scores					
Physical functioning					
Time of enrolment	65.3 (63.0, 67.6)	72.7 (71.9, 73.4)	-7.37 (-9.75, -4.98)	<0.001*	<0.001*
36 weeks' gestation	56.9 (54.5, 59.4)	58.3 (57.5, 59.1)	-1.36 (-3.92, 1.20)	0.30	
6 months postpartum	81.3 (79.4, 83.3)	88.3 (87.5, 89.0)	-6.95 (-9.06, -4.84)	<0.001*	
Role physical					
Time of enrolment	57.9 (53.7, 62.1)	66.2 (64.7, 67.6)	-8.29 (-12.72, -3.85)	<0.001*	<0.001*
36 weeks' gestation	45.4 (40.9, 49.9)	42.0 (40.5, 43.6)	3.36 (-1.34, 8.07)	0.16	
6 months postpartum	81.1 (77.7, 84.4)	85.2 (83.8, 86.5)	-4.11 (-7.71, -0.51)	0.02*	
Bodily pain					
Time of enrolment	66.4 (64.2, 68.6)	70.7 (69.9, 71.4)	-4.30 (-6.62, -1.98)	<0.001*	0.001*
36 weeks' gestation	60.8 (58.6, 63.1)	60.4 (59.6, 61.2)	0.45 (-1.99, 2.84)	0.73	
6 months postpartum	75.2 (73.0, 77.5)	78.8 (77.9, 79.7)	-3.58 (-6.03, -1.14)	0.004*	
General health					
Time of enrolment	71.9 (70.1, 73.7)	74.9 (74.3, 75.6)	-3.01 (-4.93, -1.09)	0.002*	0.12
36 weeks' gestation	70.1 (68.2, 72.0)	73.9 (73.3, 74.6)	-3.83 (-5.85, -1.83)	<0.001*	
6 months postpartum	73.6 (71.8, 75.5)	75.4 (74.7, 76.1)	-1.76 (-3.78, 0.27)	0.09	
Vitality					
Time of enrolment	56.5 (55.1, 58.0)	55.3 (54.8, 55.8)	1.22 (-0.32, 2.75)	0.12	0.005*
36 weeks' gestation	54.4 (52.8, 55.9)	51.3 (50.8, 51.8)	3.09 (1.44, 4.74)	<0.001*	
6 months postpartum	59.3 (57.7, 60.9)	55.5 (54.9, 56.1)	3.78 (2.07, 5.49)	<0.001*	
Social functioning					
Time of enrolment	76.6 (74.4, 78.9)	81.2 (80.5, 82.0)	-4.60 (-6.96, -2.23)	<0.001*	0.01*
36 weeks' gestation	74.6 (72.2, 76.9)	75.3 (74.5, 76.1)	-0.75 (-3.26, 1.76)	0.56	
6 months postpartum	81.7 (79.5, 83.9)	84.2 (83.3, 85.1)	-2.53 (-4.92, -0.15)	0.04*	
Role emotional					

Table 3 (continued)

	GDM	No GDM			
	Mean scores or n/N (%) (95% CI)	Mean scores or n/N (%) (95% CI)	Mean difference or relative risk (95% CI)	p value	p value for interaction
Time of enrolment	82.6 (79.3, 85.8)	85.3 (84.2, 86.4)	-2.72 (-6.16, 0.72)	0.12	0.15
36 weeks' gestation	78.3 (74.4, 82.3)	79.0 (77.7, 80.4)	-0.70 (-4.88, 3.49)	0.74	
6 months postpartum	85.1 (81.6, 88.6)	83.3 (81.9, 84.7)	1.80 (-1.97, 5.64)	0.35	
Mental health					
Time of enrolment	69.6 (68.4, 70.7)	70.1 (69.8, 70.5)	-0.62 (-1.85, 0.61)	0.32	0.13
36 weeks' gestation	69.6 (68.3, 70.8)	69.5 (69.1, 69.9)	0.06 (-1.24, 1.37)	0.92	
6 months postpartum	70.1 (68.8, 71.4)	69.3 (68.8, 69.8)	0.77 (-0.63, 2.16)	0.28	
PCS					
Time of enrolment	43.5 (42.6, 44.4)	46.6 (46.3, 46.9)	-3.07 (-4.05, -2.09)	<0.001*	<0.001*
36 weeks' gestation	39.6 (38.6, 40.6)	39.8 (39.5, 40.2)	-0.20 (-1.27, 0.87)	0.71	
6 months postpartum	50.5 (49.7, 51.3)	53.3 (52.9, 53.6)	-2.75 (-3.65, -1.85)	<0.001*	
MCS					
Time of enrolment	49.3 (48.5, 50.1)	48.9 (48.6, 49.2)	0.41 (-0.43, 1.25)	0.34	0.03*
36 weeks' gestation	49.9 (49.0, 50.7)	49.7 (49.4, 50.0)	0.19 (-0.73, 1.10)	0.69	
6 months postpartum	47.7 (46.7, 48.6)	46.1 (45.7, 46.4)	1.63 (0.62, 2.64)	0.002*	
MCS<40					
Time of enrolment (N=3022)	40/308 (12.9) (9.2, 16.7)	304/2714 (11.2) (10.0, 12.4)	1.16 (0.85, 1.57)	0.36	0.27
36 weeks' gestation (N=2886)	38/297 (12.8) (9.0, 16.6)	321/2590 (12.4) (11.1, 13.7)	1.03 (0.75, 1.41)	0.84	
6 months postpartum (N=2075)	46/299 (15.4) (11.3, 19.5)	331/1777 (18.6) (16.8, 20.4)	0.83 (0.62, 1.10)	0.18	

EPDS- Edinburgh Postnatal Depression Scale; HRQoL– health-related quality of life; MCS- mental component score; PCS– physical component score; SF-36–36-Item Short-Form General Health Survey; STAI– Spielberger State-Trait Anxiety Inventory

p-values<0.05 denoted with asterisks (*)

mental HRQoL two months after the birth in participants who were diagnosed with GDM compared to controls, and suggested that this was due to a persisting sense of poor health due to possible knowledge about long-term risks associated with the diagnosis (Dalfrà et al. 2012). Other studies have reported no difference in psychological quality of life comparing pregnant women who had GDM to pregnant women without complications (Mautner et al. 2009; Halkoaho et al. 2010). In our study, the finding of better mental HRQoL among participants with GDM could be due to the additional pregnancy and postpartum care they receive. This is consistent with randomized clinical trial evidence which reported improved health-related quality of life (including both physical and mental health domains) three months postpartum for participants who received treatment for GDM compared to those who received routine antenatal care (Crowther et al. 2005).

In the postpartum period, exercise and increased access to information and support has also been linked to improved quality of life and self-rated health (Haas et al. 2005; Campolong et al. 2018). Due to the increased risk for future cardiometabolic disorders, it is recommended that women whose pregnancies are complicated by GDM continue to receive lifestyle management in the postnatal period (American Diabetes Association 2022). This extra care and access to information could be contributing to the findings in this cohort as well. Those not diagnosed with GDM are less likely to continue with healthy lifestyle choices when there is less access to information and support (Bagherzadeh et al. 2021).

Participants with GDM reported a lower physical HRQoL at baseline compared to those with no GDM. This could be due to factors such as obesity, and increasing age which can predispose pregnant women to developing GDM and are also associated with poor physical HRQoL during pregnancy (Emmanuel and Sun 2014; Lagadec et al. 2018; Lee et al. 2018). Participants in the GDM group were older and a higher proportion were obese compared to participants in the no GDM group. Additionally, the lower physical HRQoL among participants with GDM could be related to the higher EPDS scores found at baseline in this group. Setse et al. found a longitudinal association between depressive symptoms and poor physical functioning in the first and second trimesters among pregnant women and suggested that this association could be bidirectional, with depression predisposing to lesser HRQoL, and the perception of a poor quality of life contributing to depressive symptoms via shared psychosocial risk factors (Setse et al. 2009), emphasizing

Fig. 1 Comparison of mental health scores and changes over time between participants with GDM and those without GDM. GDM; gestational diabetes mellitus, 36w; 36 weeks gestation, 6 m PP; 6 months postpartum

Legend

——— GDM – – – No GDM
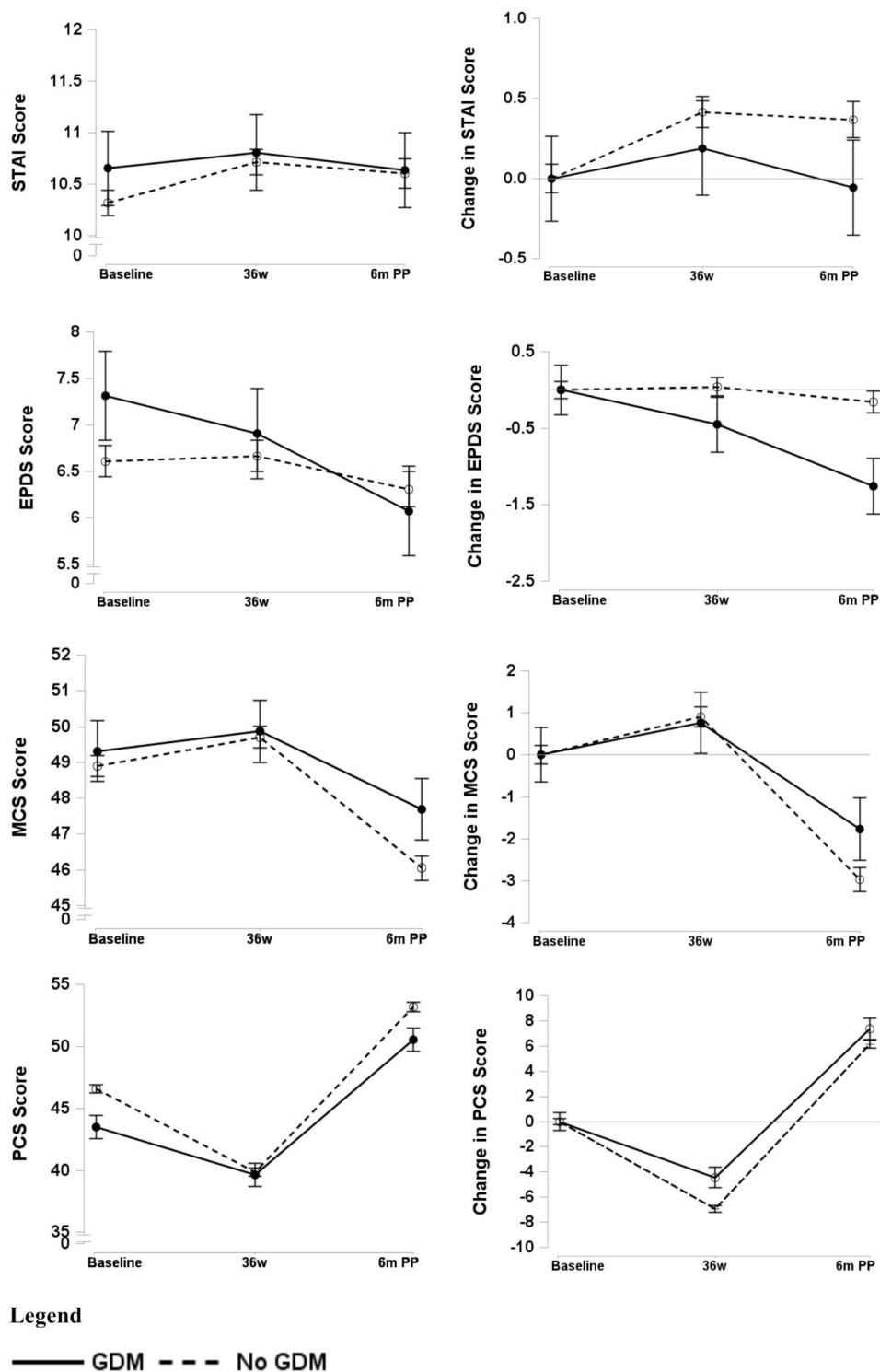
the comorbid nature of poor perinatal mental health among women with GDM.

For all participants, physical HRQoL declined in late pregnancy and improved six months after birth. This decline in late gestation has been associated with pregnancy symptoms including indigestion and poor sleep quality (Haas et

al. 2005). However, participants with GDM experienced less decline in overall physical HRQoL in late gestation than those without GDM, possibly related to the emphasis on lifestyle management in GDM care which may promote efforts in better physical functioning among participants in

the GDM group. This is consistent with evidence from other studies (Dalfrà et al. 2012).

In the postpartum period, physical quality of life improved in both groups, likely due to physical recovery from childbirth (Emmanuel and Sun 2014). Although participants with GDM reported lower mean scores for physical HRQoL at 6 months postpartum, both groups experienced a similar improvement in physical HRQoL from late gestation to the postpartum period. Hence, this difference in scores was likely due to the difference in baseline scores.

Strengths and limitations

The main strength of this study is use of prospectively collected longitudinal data from a large multi-ethnic trial, making our results generalisable to the New Zealand population and ensuring appropriate comparison groups of women with and without GDM. We were also able to examine different aspects of mental health in the antenatal and postnatal periods and undertake longitudinal analysis of changes over time.

However, the assessment tools used in screening for perinatal disorders, although validated for this population, are not the gold standard to diagnose these disorders.

The lack of data on pre-pregnancy mental health status of participants in our study, a factor which can predict perinatal mental disorders (Guintivano et al. 2018), may also be a limitation to interpretation of our results. Additionally, we did not adjust for possible confounders relating to low socioeconomic status and lack of social support as data on these factors were not collected as part of the study. Furthermore, no adjustment for multiplicity was performed, hence, significant p-values should be interpreted with caution.

Conclusion

In this longitudinal analysis involving a large cohort of pregnant women, participants who were diagnosed and treated for GDM had similar risk of anxiety and vulnerability to depression compared with participants who were not diagnosed with GDM. However, participants with GDM reported better mental health-related quality of life but poorer physical health-related quality of life in the postnatal period. Future studies should explore the determinants of perinatal mental health among pregnant women to assess if they differ by GDM status.

Our findings are consistent with evidence suggesting that treatment of GDM may improve women's quality of life and reduce their vulnerability to depression into the postnatal period, providing reassurance for health professionals. However, additional support around the perinatal period may be needed to ensure optimal physical functioning for women with GDM.

Data availability The data sets generated and/or analysed during the current study are not publicly available as ethical approval for this study did not include sharing of individual data. The corresponding author is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

Consent to participate Informed consent was obtained from all individual participants included in the study.

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