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journal homepage: www.elsevier.com/locate/jpsychoresMental health and its associations with weight in women with gestational diabetes mellitus. A prospective clinical cohort study[☆]Leah Gilbert^{a,*}, Jean-Benoît Rossel^{a,b}, Dan Yedu Quansah^a, Jardena J. Puder^{a,1}, Antje Horsch^{c,d,1}^a Obstetric service, Department Woman-Mother-Child, Lausanne University Hospital, Lausanne, Switzerland^b Clinical Trials Unit, University of Bern, Bern, Switzerland^c Institute of Higher Education and Research in Healthcare (IUFERS), University of Lausanne, Lausanne, Switzerland^d Neonatology Service, Department Woman-Mother-Child, Lausanne University Hospital, Lausanne, Switzerland

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ABSTRACT

Objective: Despite the prevalence of depression in women with gestational diabetes mellitus (GDM) and the relationship between mental health (depression and well-being) and metabolic health, little is known about mental health or its metabolic impact in GDM pregnancy. This prospective clinical cohort study aimed to investigate associations between 1) well-being and depression, and 2) mental health and weight/weight gain in women with GDM.

Methods: We included 334 pregnant women with GDM treated at a Swiss University Hospital between January 2016 and December 2018. They completed two self-report questionnaires: The World Health Organization well-being index (WHO-5) at the first (29 weeks of gestation) and last (36 weeks of gestation) GDM visits during pregnancy and the Edinburgh Postnatal Depression Scale (EPDS) at the first GDM visit. A cut-off of ≥ 11 was selected for this questionnaire to indicate the presence of elevated depression scores.

Results: There was an inverse association between the well-being and depression total scores at the first GDM visit during pregnancy ($r = -0.55$; $p < 0.0001$). Elevated depression scores at the first GDM visit were associated with subsequent weight gain in GDM pregnancy ($\beta = 1.249$; $p = 0.019$).

Conclusion: In women with GDM, elevated depression scores during pregnancy are prospectively associated with weight gain. Depression symptoms should therefore be screened for and treated in women with GDM to reduce the risks associated with excessive weight gain during pregnancy.

1. Introduction

Gestational diabetes mellitus (GDM) can increase the burden of pregnancy as women are confronted to an increased risk of adverse maternal and neonatal outcomes and are asked to undergo several lifestyle changes to reduce these risks [1]. Depression in early pregnancy increases the risk of GDM [2] and women with GDM have up to a three-fold higher risk of developing depression during pregnancy compared to women without GDM [2–6]. Depression during pregnancy, and especially in women with GDM, is associated with important adverse

outcomes in the mother (higher rates of preeclampsia and hypertension) and the child (low birth weight, preterm delivery and higher risk of instrumental delivery) [7–12]. Some of the adverse effects associated with depression in pregnancy could be due to epigenetic modifications [13]. Firstly, some women have a genetic predisposition for depression in pregnancy [14]. Secondly, preceding adverse or stressful events in pregnancy may lead to epigenetic modifications of genes that regulate inflammatory pathways, increase levels of proinflammatory cytokines, and lower levels of oxytocin, all of which may increase maternal depressive symptoms and, in turn, be associated with adverse outcomes

Abbreviations: ADA, American Diabetes Association; BMI, Body mass index; EPDS, Edinburg Postnatal Depression Scale; WHO-5, World Health Organization Five-Well-Being Index.

[☆] The work was conducted at the Obstetric service, Department Woman-Mother-Child, Lausanne University Hospital, Lausanne, Switzerland

^{*} Corresponding author at: Avenue Pierre-Decker 2, 1011 Lausanne, Switzerland.

E-mail address: leah.gilbert@chuv.ch (L. Gilbert).

¹ Shared last authors.

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in the offspring [15]. After pregnancy, depression is associated with difficulties in breastfeeding [16] and poor attachment with the child [17]. Even though previous literature demonstrates there is a comorbidity between high BMI and depression in the general pregnant population [18] and that both of these elements have an impact on the risk of developing GDM [2] depression is still understudied in women with GDM, particularly with regards to its association with metabolic health, such as weight [19].

Another important mental health variable to consider in women with GDM is well-being. Well-being, more precisely, emotional well-being as measured by the World Health Organization – Five Well-Being Index (WHO-5) [20], can be described as “the emotional quality of an individual’s everyday experience—the frequency and intensity of experiences of joy, stress, sadness, anger, and affection that make one’s life pleasant or unpleasant” [21]. Similarly to higher symptoms of depression, well-being could also be lower in women with GDM than in the general pregnant population. As the prevalence of obesity is higher in women with GDM, lower well-being could result from frustrations related to obesity and potentially to multiple attempts to control weight [1,22]. On the other hand, well-being is associated with improved diabetes self-management, lifestyle behavior, and health outcomes in populations with diabetes, [23]. Therefore, if women with GDM have poorer well-being, this could lead to a poorer management of their diabetes, unhealthy lifestyle behaviours, and in turn, may impact their metabolic outcomes. Thus, we believe it is necessary to investigate this variable in women with GDM, as, to our knowledge, well-being has not been studied in this population. Investigating well-being may lead to a broader understanding of the potential impacts of mental health on metabolic outcomes, such as weight or weight gain. In order to understand mental health in a comprehensive way, we chose to investigate both depression and well-being in women with GDM. This would enable us to use the WHO-5 scale as another measure of depression symptoms, as proposed in other populations outside pregnancy [20,24–26].

In the general pregnant population, mental health (depression and lower well-being) has been shown to be inversely associated with weight or weight gain. Indeed, in some studies, antepartum depression is associated with weight gain during pregnancy [27–29]. Furthermore, pregnant women experiencing depression and stress are more likely to consume energy-dense, nutrient-poor foods, thus decreasing their dietary quality and increasing their risk for excessive gestational weight gain and subsequent obesity [30]. Well-being, in the general pregnant population, and at five years postpartum has been associated with less weight retention [31]. Thus, well-being may be related to health behaviours that impact on weight in women with GDM. Women with GDM have a higher risk of increased weight gain than in the general pregnant population [22]. Weight gain can increase adverse outcomes, such as hypertensive disorders during pregnancy [32] and weight retention in the postpartum period may augment the risk of developing type 2 diabetes and cardiovascular disease later in life [33–36]. Excessive gestational weight gain in women with GDM may also lead to perinatal complications, including higher risk of preterm and caesarean delivery, macrosomia, and birth weight over the 90th percentile for age and sex [37–39]. Despite this, the association of mental health with weight has not been studied in women with GDM.

This study aimed to investigate the associations between depression and well-being during GDM pregnancy to capture mental health in a broad manner and secondly, to investigate the associations between depression and well-being with weight and weight gain during GDM pregnancy.

2. Materials and methods

2.1. Setting

This prospective clinical cohort study included pregnant women diagnosed with GDM after their first visit at the GDM clinic at a

University Hospital in Switzerland. During the first GDM visit that takes place at around 29 weeks of gestation ($Mean = 28.9 \pm SD = 3.3$), patients are generally seen by a clinical nurse specialist in GDM or a physician; they receive information on GDM, and are taught how to perform a capillary blood glucose test. Women are usually seen by a dietician one week later and then followed up by a nurse or a physician about once every two weeks. Women commonly attend their last GDM visit before giving birth at around 36 weeks of gestation ($Mean = 36.2 \pm SD = 1.9$).

2.2. Participant consent and recruitment

Women who were diagnosed with GDM according to the American Diabetes Association (ADA) guidelines and the International Association of the Diabetes and Pregnancy Study Groups (IADPSG) [34,40], were asked to take part in the GDM cohort by the research team and were given a consent form to sign containing further information on data usage. The Human Research Ethics Committee of the Canton de Vaud; our local ethics committee, approved the study protocol (study n° 326/15).

2.3. Inclusion and exclusion criteria

Subjects were eligible if they had a GDM diagnosis, were followed up in our clinic between January 2016 (when we started to routinely collect mental health data) and December 2018, and gave written consent to participate. Therefore, 334 consecutive women were included in this study.

2.4. Measures

2.4.1. Maternal depression symptoms

2.4.1.1. Edinburgh Postnatal Depression Scale (EPDS). This questionnaire, measuring symptoms of depression in the preceding seven days [41], was completed by participants during their first GDM visit. Each item is scored on a 4-point scale, the minimum and maximum scores being 0 and 30, respectively. The EPDS has been validated in pregnant women [42], as well as in a French sample of women in the postpartum period and the scale had good criterion validity and internal consistency (Cronbach’s alpha: 0.76) and good short term test-retest reliability (0.98) [43]. In this study, we used the EPDS score as a continuous variable (depression total score) and we also created a dichotomous variable with a cut-off of ≥ 11 , as a score of ≥ 11 can indicate the presence of a major depressive disorder in pregnancy [42]. This cut-off was chosen based on the high sensitivity and specificity it has in detecting symptoms of depression [42,44,41]. It is also considered as an optimal threshold when compared to detection of depression through the DSM-5 and ICD-10 [45]. Nonetheless, as the gold standard for depression screening is clinical interviewing [46], we interpreted a score of ≥ 11 as “elevated depression score”. This questionnaire was given to the patients in French or English. In order to ensure that we were accounting for the multi-ethnicity and diversity of women coming to our clinic, a professional certified translator assisted women who did not speak French or English to complete this questionnaire.

2.5. Maternal well-being index

2.5.1. World Health Organization - Five Well-Being Index (WHO-5)

This questionnaire was completed by participants during their first and last GDM visit. Well-being was measured with the WHO-5, which consists of 5 questions assessing the subjective well-being of the participants [47]. The items are unidimensional and measure well-being by statements such as: “I have felt cheerful and in good spirits” on a 5-point Likert scale ranging from 0 ‘at no time’ to 5 ‘all of the time’. The final

score is then calculated by multiplying the score by 4, thus the final total score ranges from 0 to 100. The WHO-5 was originally designed to measure positive well-being (coping with illness), negative well-being (depression and anxiety) and energy. As the relationship between well-being and metabolic health in GDM pregnancy has not been studied so far, we chose to use this questionnaire to measure positive well-being [48]. The scale has adequate validity, has good psychometric properties in French as the Cronbach's alpha is 0.88, confirming good internal consistency, it has been applied successfully across a wide range of study fields, though it has been used most extensively in endocrinology [47,49]. As the WHO-5 is validated in 31 different languages, we were able to distribute them to a variety of women from different ethnicities.

2.6. Maternal anthropometric, obstetric and sociodemographic variables

At the first GDM visit, women were weighed wearing light clothes and without shoes, and their height was measured. At the last GDM visit, their weight was measured again. The weight gain variable was thus calculated by subtracting the weight at the first GDM visit from the weight at the last GDM visit. Age, gestational age and educational level were assessed by interview or extracted from the patient's medical record. Additionally, patients answered questions about their social support (lives with partner vs lives alone) during the first GDM visit.

2.7. Data analysis

All analyses were carried out with Stata/SE 15.0 (StataCorp LLC, TX, USA). Descriptive statistics were carried out for socio-demographic variables (please refer to Table 1). Ordinal outcomes were described as frequencies and percentages. For continuous variables, normality of distribution was graphically assessed with normal QQ-plots. Those variables were then described with their mean and standard deviation. Univariate linear regressions analyses were conducted for all aims (Model 1) in order to evaluate the raw associations between two variables of interest. These associations were then adjusted for confounding variables (Model 2, see below).

For the first aim, a paired *t*-test was conducted to study if well-being changed between the first GDM visit and the end of pregnancy (i.e., last GDM visit). Then, as our first aim was to investigate the association between well-being and depression total scores, we performed a linear regression where the independent variables were the depression total score and cut-off of ≥ 11 (i.e., elevated depression score) at the first GDM visit and the dependent variable was the well-being total score at the first GDM visit. For the second aim investigating the associations between mental health variables (depression and well-being) and weight (gain), linear regressions were performed. The independent variables were the depression total score and the cut-off of ≥ 11 and the well-being total score, all at the first GDM visit; the dependent variables were weight at the first GDM visit and weight gain between the first and last GDM visit.

In model 1, no adjustments for confounding factors were made. In model 2, adjustments for the following confounding variables were made for all linear regressions: maternal age, gestational age, educational level, and social support at the first GDM visit. For the first aim, we also added BMI (Body Mass Index) at the first GDM visit as a confounder. For the second aim, we only added BMI as a confounder when the dependent variable was weight gain. Gestational age was added as a confounder, as it can have an impact on the mother's weight [50]. Maternal educational level [51] and social support status [52] were added as confounders, as they have an impact on the mother's mental health.

At the first GDM visit, there were seven missing cases for height, 18 missing cases for weight, 19 missing cases for BMI, 53 missing cases for weight gain, two missing cases for gestational age, five missing cases for ethnicity of the patients, 25 missing cases for social support, 57 missing cases for educational level, 42 missing cases for the depression total

score and cut-off ≥ 11 , 39 missing cases for the well-being total score. At the last GDM visit, there were 120 missing cases for gestational age and 105 missing cases for the well-being total score. Based on the Missing at Random assumption, we conducted imputations by using the Multiple Imputation by Chained Equations method [53]. This led to similar results (data not shown; available upon request); thus, we chose to use the original data for the present analysis.

2.8. Data sharing statement

Data is available from the first author upon request.

3. Results

3.1. Sample characteristics

Sample characteristics are described in Table 1. At the first GDM visit, participants had a mean age of 33.4 ± 5.5 years, a mean gestational age of 28.9 ± 3.3 weeks, a mean weight of 78.3 ± 14.8 kg, a mean well-being total score of 60.1 ± 20.2 and a mean depression total score of 7.5 ± 5.5 , with 26.0% of women having an elevated depression score. At the last GDM visit, the mean gestational age was 36.2 ± 1.9 weeks, the mean weight was 80.6 ± 14.8 kg and the mean well-being total score 67.2 ± 18.3 .

3.2. Changes and associations between mental health variables during pregnancy

The well-being total score increased from 60.3 ± 20.5 at the first GDM visit to 67.4 ± 17.9 at the last GDM visit, indicating a 7.1 point (± 16.5) or an 11.8% increase on average in the well-being total score among study participants ($CI = 4.9-9.3$; $p < 0.0001$). An inverse strong association between the well-being total score and the depression total score ($\beta = -2.08$; $r = -0.55$; $p < 0.0001$) and an inverse moderate

Table 1

Sample characteristics: Maternal sociodemographic, anthropometric, obstetric, and mental health variables.

	Mean (SD)	n (%)
Maternal sociodemographic and anthropometric variables		
Age (years)	33.4 (5.5)	
Educational level		
Compulsory education not completed		20 (7.2%)
Compulsory education completed		58 (20.9%)
Secondary school		40 (14.4%)
Apprenticeship		52 (18.8%)
University degree		107 (38.6%)
Social support		
Lives with partner		280 (90.6%)
Lives alone		29 (9.4%)
Weight (kg) at the first GDM visit	78.3 (14.8)	
Weight (kg) at the last GDM visit	80.6 (14.8)	
Weight gain (kg) between the first and last GDM visit	2.4 (3.5)	
BMI at the first GDM visit	29.2 (5.3)	
Obstetric variables		
Gestational age (weeks) at first GDM visit	28.9 (3.3)	
Gestational age (weeks) at last GDM visit	36.2 (1.9)	
Mental health variables		
Depression total score at first GDM visit	7.5 (5.5)	
Depression cut-off ≥ 11 at first GDM visit		76 (26.0%)
Well-being total score at first GDM visit	60.3 (20.5)	
Well-being total score at last GDM visit	67.4 (17.9)	

BMI: body mass index, GDM: gestational diabetes mellitus, Kg: kilograms.

association between the well-being total score and the depression cut-off ≥ 11 (i.e., elevated depression score) at the first GDM visit ($\beta = -21.77$; $r = -0.47$; $p < 0.0001$, see Table 2) were found. These associations remained significant after adjustments for confounders ($\beta = -1.95$; $p < 0.0001$ and $\beta = -20.93$; $p < 0.0001$; see Table 2).

3.3. Associations between mental health and weight variables

We found no significant associations between the depression total score and the cut-off ≥ 11 (i.e., elevated depression score) at the first GDM visit and weight at the same moment ($\beta = 0.05$; $p = 0.76$ and $\beta = 0.78$; $p = 0.69$), even after adjustments for confounders ($\beta = 0.04$ and $\beta = 1.53$; both $p \geq 0.49$; see Table 3a). There were no significant associations between the depression total score at the first GDM visit and subsequent weight gain, regardless of adjustments ($\beta = 0.06$; $p = 0.19$ in Model 1 and $\beta = -0.01$; $p = 0.82$ in Model 2). On the other hand, positive and significant associations between the depression cut-off ≥ 11 at the first GDM visit and subsequent weight gain during pregnancy were found ($\beta = 1.25$; $p = 0.02$). After controlling for confounders, this association did not remain significant ($\beta = 0.24$; $p = 0.69$; see Table 3b).

The associations between the well-being total score at first GDM visit with concurrent weight and subsequent weight gain ($\beta = -0.06$; $p = 0.19$ and $\beta = 0.007$; $p = 0.53$) were not significant. After adjustments, there was a trend towards an inverse association between the well-being total score and weight at the first GDM visit, but not with weight gain ($\beta = -0.09$; $p = 0.07$ and $\beta = 0.01$; $p = 0.38$; see Tables 3a and 3b).

4. Discussion

In this prospective clinical cohort study of women with GDM, well-being after GDM diagnosis (first GDM visit) was inversely associated with the depression total score and the depression cut-off ≥ 11 (i.e., elevated depression score). The elevated depression score was positively associated with subsequent weight gain during pregnancy, whereas, neither well-being nor depression total scores in general were associated with weight or weight gain.

In this cohort, well-being increased by 11.8% between the first GDM visit after diagnosis and the last GDM visit before delivery (during a mean of seven weeks); a context of significant changes for pregnant women with GDM. A study conducted in a general pregnant population demonstrated that women had a mean WHO-5 third trimester total score of 58.4 ± 22 [54], which is lower than the total score in our population. This suggests that women in the current cohort had the capacity to recover from the initial diagnosis of GDM, and that the diagnosis itself did not have a major impact on their well-being. Another study investigated the change in well-being in a primary care setting of psychiatric patients [48] and showed that a change of 11 points on the WHO-5 scale demonstrated a clinically significant change in well-being. The increase of 7.1 points between the first and last GDM visit in our patients, could

Table 2
Association between mental health variables in women with GDM.

	Model 1	Model 2
	β -Coefficient (95% confidence interval)	β -Coefficient (95% confidence interval)
	Well-being total score at the first GDM visit	
Depression total score at the first GDM visit	-2.08 (-2.45 to -1.71)	-1.95 (-2.37 to -1.53)
Depression cut-off ≥ 11 at the first GDM visit	-21.77 (-26.50 to -17.04)**	-20.93 (-26.20 to -15.62)**

* $p < 0.05$, ** $p < 0.01$.

GDM: gestational diabetes mellitus.

Model 1 was an unadjusted linear regression model. Model 2 was a linear regression model with adjustments for: Maternal age, gestational age, educational level, social support and BMI at the first GDM visit.

Table 3a
Association between mental health variables and weight in women with GDM.

	Model 1	Model 2
	β -Coefficient (95% confidence interval)	β -Coefficient (95% confidence interval)
	Weight (kg) at the first GDM visit	
Depression total score at the first GDM visit	0.05 (-0.26 to 0.36)	0.04 (-0.31 to 0.39)
Depression cut-off of ≥ 11 at the first GDM visit	0.78 (-3.01 to 4.57)	1.53 (-2.79 to 5.86)
Well-being total score at the first GDM visit	-0.06 (-0.14 to 0.03)	-0.09 (-0.18 to 0.01)

* $p < 0.05$, ** $p < 0.01$.

GDM: gestational diabetes mellitus, Kg: kilograms.

Model 1 was an unadjusted linear regression model. Model 2 was a linear regression model with adjustments for: Maternal age, gestational age, educational level and social support at the first GDM visit.

Table 3b
Associations between mental health variables and weight gain in women with GDM.

	Model 1	Model 2
	β -Coefficient (95% confidence interval)	β -Coefficient (95% confidence interval)
	Weight gain (kg) between the first and last GDM visit	
Depression total score at the first GDM visit	0.06 (-0.03 to 0.14)	-0.01 (-0.10 to 0.08)
Depression cut-off of ≥ 11 at the first GDM visit	1.25 (0.20 to 2.29)*	0.24 (-0.91 to 1.38)
Well-being total score at the first GDM visit	0.01 (-0.02 to 0.03)	0.01 (-0.01 to 0.04)

* $p < 0.05$, ** $p < 0.01$.

GDM: gestational diabetes mellitus, Kg: kilograms.

Model 1 was an unadjusted linear regression model. Model 2 was a linear regression model with adjustments for: Maternal age, gestational age, educational level, social support and BMI at the first GDM visit.

be due to the help offered by various professionals, who counsel, accompany and help them with regards to their understanding of the GDM diagnosis, their lifestyle and glucose management. This might bring some reassurance to these women, as they might feel cared for. This is corroborated by a study, which showed improvement in mood, quality of life, and decreased rates of postpartum depression in women with GDM who received dietary advice, blood glucose monitoring, and insulin therapy, as needed, from 24 to 34 weeks of gestation, compared to a routine care group [55]. In our patients, this improvement in mental health already occurred earlier, i.e., during pregnancy. It would therefore be interesting to investigate further possible changes in well-being in the postpartum period.

It seems compelling that the well-being total score was inversely associated with the depression total score and the depression cut-off ≥ 11 as previous studies have demonstrated that well-being was lower in non-pregnant populations suffering from major depression compared to individuals with no depression [24]. We also showed that the well-being total score only explained around 25% of our two depression variables (both r around 0.5). This means that depression and well-being items also give distinct information and, thus, are both important to investigate in women with GDM. This finding is corroborated by another study concluding that, while mild and moderate levels of depression were negatively associated with well-being, the WHO-5 demonstrates inefficacy in detecting severe and extreme forms of depression [25].

Despite the fact that depression has been shown to be associated with metabolic health, especially with weight, in the general pregnant population [27–29,56], we did not find any associations between the depression variables and weight in our cohort. The prospective

association we found between the depression cut-off ≥ 11 at first GDM visit and subsequent weight gain is interesting and in line with previous studies. These previous studies show that depression measured by the EPDS or by the DASS (Depression Anxiety Stress Scales), using cut-off scores, was associated with excessive weight gain in pregnancy and in the general population [28,29]. However, the association we found between the depression cut-off ≥ 11 and weight gain did not remain significant when we controlled for confounding factors, such as maternal age, gestational age, educational level, social support and BMI at the first GDM visit. Furthermore, we did not find an association between the depression total score and subsequent weight gain, which contradicts previous research. In previous studies, in obese non-pregnant individuals, depression was associated with over-eating, which led to weight gain [57]. Our findings may hint to a non-linear association between mental health and weight gain in pregnancy that is only present above a certain cut-off when elevated depression scores arise. In women with GDM, there might even be a synergistic effect of depression and weight gain that amplifies adverse outcomes in the mother and the infant. Nevertheless, the 7 weeks' time interval in which we measured the association between depression and weight (gain) might also have been too short to show sufficient significant changes regarding this relationship. Thus, it would be helpful to investigate this topic in larger studies and over a longer time period.

Finally, we found no association between the well-being total score and weight or weight gain. Our results are in conflict with other studies, in which well-being was inversely associated with weight in non-pregnant individuals [58] and with weight retention in the postpartum period [31]. It seems that other clinical factors might have played a role and thus, future research should investigate the relationship between well-being and weight (gain), especially since our results showed a trend towards an inverse association between the well-being total score and weight at the first GDM visit.

4.1. Clinical implications

Our results showing that well-being augmented by 11.8% between the first and last GDM visit is of clinical relevance. Indeed, this may suggest that a good and comprehensive clinical follow-up may counteract the negative emotional impact of a GDM diagnosis [4], although this would need to be confirmed by an RCT. Our findings demonstrating that well-being was inversely correlated to depression and explained around 25% of its variance imply that other factors might impact both mental health variables and that it is more informative to measure them both in women with GDM.

Of further clinical relevance is the association of the depression cut-off ≥ 11 (i.e., elevated depression score) with subsequent weight gain during GDM pregnancy. This highlights the importance of screening women's mental health during pregnancy, as recommended by the National Institute for Health and Clinical Excellence [59] and the ADA [60]. As weight gain in pregnancy and in women with GDM may have a deleterious impact on the mother and the child [30,51,61–64], actions may be taken to lower their depressive symptoms as a means to restricting weight gain during pregnancy. Given our results and the results of a recent review together [19], women with GDM may not only benefit from being screened but also treated for mental health symptoms early after their GDM diagnosis. Furthermore, this study suggests that future studies should investigate the effect of mental health variables on other metabolic parameters in women with GDM during pregnancy and in the postpartum, as weight gain may not be the only variable that is influenced by elevated depression scores.

4.2. Strengths and limitations

This study has many strengths, including the prospective design investigating a “real-life” clinical cohort of consecutive women, the use of validated self-report questionnaires, and the inclusion of influential

confounding variables. This study also included women speaking other languages than French and English, thus increasing generalizability and reflecting the GDM population in Switzerland. Nevertheless, some limitations need to be addressed. First, a longer time period might have yielded more pronounced results regarding the relationship between mental health and weight gain, as weight gain was only 2.4 kg during the short time-frame studied in our cohort. It would also be interesting to investigate these relationships up to the postpartum period and therefore to evaluate the potential effect of mental health on weight retention after delivery. Second, additional confounders that could not be accounted for might have affected our results, such as diet and physical activity behaviours, as well as ethnicity and potential psychotropic medication use [19]. Third, these women also met different professionals during their pregnancy, advising them about their diet and lifestyle behavior, which might have influenced their weight gain. Fourth, as this paper has an explorative nature, we did not account for previous mental health diagnosis, as is the case for similar papers in this domain [4]. Finally, there may be a high attrition rate, as this study took place in a clinical setting.

5. Conclusion

This prospective clinical cohort study indicated that in women with GDM, well-being increased by 11.8% after GDM diagnosis until the end of pregnancy. The well-being total score was inversely related to the depression total score and cut-off of ≥ 11 (i.e., elevated depression score) and explained around 25% of their variability. This shows that positive emotional health should be fostered and integrated in the care of women with GDM. Furthermore, the depression cut-off ≥ 11 was associated with subsequent weight gain, showing the importance of screening mental health in women with GDM.

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Competing interest statement

The authors have no competing interests to report.

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References

- [1] I. Blumer, E. Hadar, D.R. Hadden, L. Jovanović, J.H. Mestman, M.H. Murad, et al., Diabetes and pregnancy: an endocrine society clinical practice guideline, *J. Clin. Endocrinol. Metab.* 98 (11) (2013) 4227–4249.
- [2] S.N. Hinkle, G.M. Buck Louis, S. Rawal, Y. Zhu, P.S. Albert, C. Zhang, A longitudinal study of depression and gestational diabetes in pregnancy and the postpartum period, *Diabetologia* 59 (12) (2016) 2594–2602.
- [3] A. Arafa, J.-Y. Dong, Depression and risk of gestational diabetes: a meta-analysis of cohort studies, *Diabetes Res. Clin. Pract.* 156 (2019) 107826.
- [4] P. Damé, K. Cherubini, P. Goveia, G. Pena, L. Galliano, C. Façanha, et al., Depressive symptoms in women with gestational diabetes mellitus: the LINDA-Brazil study, *J. Diabetes Res.* 2017 (2017).
- [5] H.A. Bennett, A. Einarson, A. Taddio, G. Koren, T.R. Einarson, Prevalence of depression during pregnancy: systematic review, *Obstet. Gynecol.* 103 (4) (2004) 698–709.
- [6] K.W. Lee, S.M. Ching, N.K. Devaraj, S.C. Chong, S.Y. Lim, H.C. Loh, et al., Diabetes in pregnancy and risk of antepartum depression: a systematic review and meta-analysis of cohort studies, *Int. J. Environ. Res. Public Health* 17 (11) (2020) 3767.

- [7] N.K. Grote, J.A. Bridge, A.R. Gavin, J.L. Melville, S. Iyengar, W.J. Katon, A meta-analysis of depression during pregnancy and the risk of preterm birth, low birth weight, and intrauterine growth restriction, *Arch. Gen. Psychiatry* 67 (10) (2010) 1012–1024.
- [8] S. Grigoriadis, E.H. VonderPorten, L. Mamisashvili, G. Tomlinson, C.-L. Dennis, G. Koren, et al., The Impact of Maternal Depression during Pregnancy on Perinatal Outcomes: A Systematic Review and Meta-Analysis, 2013.
- [9] C.D. Schetter, L. Tanner, Anxiety, depression and stress in pregnancy: implications for mothers, children, research, and practice, *Curr. Opin. Psychiatr.* 25 (2) (2012) 141.
- [10] C.H. Packer, R.A. Pilliod, L.R. Chatroux, A.B. Caughey, A.M. Valent, Increased rates of adverse perinatal outcomes in women with gestational diabetes and depression, *J. Matern. Fetal Neonatal Med.* (2019) 1–5.
- [11] T.K. Chung, T.K. Lau, A.S. Yip, H.F. Chiu, D.T. Lee, Antepartum depressive symptomatology is associated with adverse obstetric and neonatal outcomes, *Psychosom. Med.* 63 (5) (2001) 830–834.
- [12] K.W. Lee, S.M. Ching, F.K. Hoo, V. Ramachandran, S.C. Chong, M. Tusimin, et al., Neonatal outcomes and its association among gestational diabetes mellitus with and without depression, anxiety and stress symptoms in Malaysia: a cross-sectional study, *Midwifery* 81 (2020) 102586.
- [13] V. Stonawski, S. Frey, Y. Golub, G.H. Moll, H. Heinrich, A. Eichler, Affektive Belastungen der Mutter in der Schwangerschaft und assoziierte epigenetische Veränderungen beim Kind: Eine Übersicht, *Zeitschrift für Kinder- und Jugendpsychiatrie und Psychotherapie* 46 (2017) 155–167.
- [14] N. Engineer, L. Darwin, D. Nishigandhi, K. Ngianga-Bakwin, S.C. Smith, D. K. Grammatopoulos, Association of glucocorticoid and type 1 corticotropin-releasing hormone receptors gene variants and risk for depression during pregnancy and post-partum, *J. Psychiatr. Res.* 47 (9) (2013) 1166–1173.
- [15] L. Garfield, H.L. Mathews, L.W. Janusek, Inflammatory and epigenetic pathways for perinatal depression, *Biol. Res. Nurs.* 18 (3) (2016) 331–343.
- [16] K. Cato, S.M. Sylven, M.K. Georgakis, N. Kollia, C. Rubertsson, A. Skalkidou, Antenatal depressive symptoms and early initiation of breastfeeding in association with exclusive breastfeeding six weeks postpartum: a longitudinal population-based study, *BMC Preg. Childbirth* 19 (1) (2019) 49.
- [17] A.S. Carter, F.E. Garrity-Rokous, R. Chazan-Cohen, C. Little, M.J. Briggs-Gowan, Maternal depression and comorbidity: predicting early parenting, attachment security, and toddler social-emotional problems and competencies, *J. Am. Acad. Child Adolesc. Psychiatry* 40 (1) (2001) 18–26.
- [18] N. Cattane, K. Räikkönen, R. Anniverno, C. Mencacci, M.A. Riva, C.M. Pariante, et al., Depression, obesity and their comorbidity during pregnancy: effects on the offspring's mental and physical health, *Mol. Psychiatry* (2020) 1–20.
- [19] L. Gilbert, J. Gross, S. Lanzi, D.Y. Quansah, J. Puder, A. Horsch, How diet, physical activity and psychosocial well-being interact in women with gestational diabetes mellitus: an integrative review, *BMC Preg. Childbirth* 19 (1) (2019) 60.
- [20] T.R. Hajos, F. Pouwer, S. Skovlund, B.L. Den Ouden, P. Geelhoed-Duijvestijn, C. Tack, et al., Psychometric and screening properties of the WHO-5 well-being index in adult outpatients with type 1 or type 2 diabetes mellitus, *Diabet. Med.* 30 (2) (2013) e63–e9.
- [21] D. Kahneman, A. Deaton, High income improves evaluation of life but not emotional well-being, *Proc. Natl. Acad. Sci.* 107 (38) (2010) 16489–16493.
- [22] K.S. Gibson, T.P. Waters, P.M. Catalano, Maternal weight gain in women who develop gestational diabetes mellitus, *Obstet. Gynecol.* 119 (3) (2012) 560–565.
- [23] S.M. Robertson, M.A. Stanley, J.A. Cully, A.D. Naik, Positive emotional health and diabetes care: concepts, measurement, and clinical implications, *Psychosomatics* 53 (1) (2012) 1–12.
- [24] H. Wersebe, R. Lieb, A.H. Meyer, M. Mische, T. Mikoteit, C. Imboden, et al., Well-being in major depression and social phobia with and without comorbidity, *Int. J. Clin. Health Psychol.* 18 (3) (2018) 201–208.
- [25] T. Krieger, J. Zimmermann, S. Huffziger, B. Ubl, C. Diener, C. Kuehner, et al., Measuring depression with a well-being index: further evidence for the validity of the WHO well-being index (WHO-5) as a measure of the severity of depression, *J. Affect. Disord.* 156 (2014) 240–244.
- [26] V. Henkel, R. Mergl, R. Kohnen, W. Maier, H. Möller, U. Hegerl, The WHO-5 wellbeing index performed the best in screening for depression in primary care, *Evid. Based Med.* 8 (5) (2003) 155.
- [27] A.D. Altazan, L.M. Redman, J.H. Burton, R.A. Beyl, L.E. Cain, E.F. Sutton, et al., Mood and quality of life changes in pregnancy and postpartum and the effect of a behavioral intervention targeting excess gestational weight gain in women with overweight and obesity: a parallel-arm randomized controlled pilot trial, *BMC Preg. Childbirth* 19 (1) (2019) 50.
- [28] J. Matthews, J. Huberty, J. Leiferman, M. Buman, Psychosocial predictors of gestational weight gain and the role of mindfulness, *Midwifery* 56 (2018) 86–93.
- [29] S. McPhie, H. Skouteris, M. Fuller-Tyszkiewicz, B. Hill, F. Jacka, A. O'Neil, Relationships between mental health symptoms and body mass index in women with and without excessive weight gain during pregnancy, *Midwifery* 31 (1) (2015) 138–146.
- [30] E.R. Fowles, C. Murphey, R.J. Ruiz, Exploring relationships among psychosocial status, dietary quality, and measures of placental development during the first trimester in low-income women, *Biol. Res. Nurs.* 13 (1) (2011) 70–79.
- [31] E. O'Brien, A.A. Geraghty, E. O'Sullivan, J. Riordan, M.K. Horan, E. Larkin, et al., Five-year follow up of a low glycaemic index dietary randomised controlled trial in pregnancy—no long-term maternal effects of a dietary intervention, *BJOG Int. J. Obstet. Gynaecol.* 126 (4) (2019) 514–524.
- [32] Gestational diabetes: Linking epidemiology, excessive gestational weight gain, adverse pregnancy outcomes, and future metabolic syndrome, in: C. Durnwald (Ed.), *Seminars in Perinatology*, Elsevier, 2015.
- [33] Pregnancy as a window to future health: Excessive gestational weight gain and obesity, in: L.A. Gilmore, M. Klempel-Donchenko, L.M. Redman (Eds.), *Seminars in Perinatology*, Elsevier, 2015.
- [34] American Diabetes Association, 13. Management of diabetes in pregnancy: standards of medical care in diabetes-2018, *Diabetes Care* 41 (Suppl. 1) (2018) S137.
- [35] L. Bellamy, J.-P. Casas, A.D. Hingorani, D. Williams, Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis, *Lancet* 373 (9677) (2009) 1773–1779.
- [36] M. Dalfrà, A. Lapolla, M. Masin, G. Giglia, B.B. Dalla, R. Toniato, et al., Antepartum and early postpartum predictors of type 2 diabetes development in women with gestational diabetes mellitus, *Diabetes Metab.* 27 (6) (2001) 675–680.
- [37] S.Y. Kim, A.J. Sharma, W. Sappenfield, H.G. Wilson, H.M. Salihu, Association of maternal body mass index, excessive weight gain, and gestational diabetes mellitus with large-for-gestational-age births, *Obstet. Gynecol.* 123 (4) (2014) 737.
- [38] Y.W. Cheng, J.H. Chung, I. Kurbisch-Block, M. Inturrisi, S. Shafer, A.B. Caughey, Gestational weight gain and gestational diabetes mellitus: perinatal outcomes, *Obstet. Gynecol.* 112 (5) (2008) 1015–1022.
- [39] T.A. Hillier, K.L. Pedula, K.K. Vesco, M.M. Schmidt, J.A. Mullen, E.S. LeBlanc, et al., Excess gestational weight gain: modifying fetal macrosomia risk associated with maternal glucose, *Obstet. Gynecol.* 112 (5) (2008) 1007–1014.
- [40] B.E. Metzger, S.G. Gabbe, B. Persson, T.A. Buchanan, P.A. Catalano, P. Damm, et al., International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy, *Diabetes Care* 33 (3) (2010) 676–682.
- [41] J.L. Cox, J.M. Holden, R. Sagovsky, Detection of postnatal depression. Development of the 10-item Edinburgh postnatal depression scale, *Br. J. Psychiatry* 150 (6) (1987) 782–786.
- [42] A. Bunevicius, L. Kusminskas, V.J. Pop, C.A. Pedersen, R. Bunevicius, Screening for antenatal depression with the Edinburgh depression scale, *J. Psychosom. Obstet. Gynecol.* 30 (4) (2009) 238–243.
- [43] N. Guedeney, J. Fermanian, Validation study of the French version of the Edinburgh postnatal depression scale (EPDS): new results about use and psychometric properties, *European Psychiatr.* 13 (2) (1998) 83–89.
- [44] B. Levis, Z. Negeri, Y. Sun, A. Benedetti, B.D. Thombs, Accuracy of the Edinburgh Postnatal Depression Scale (EPDS) for screening to detect major depression among pregnant and postpartum women: systematic review and meta-analysis of individual participant data, *bmj* 371 (2020).
- [45] J. Smith-Nielsen, S. Matthey, T. Lange, M.S. Væver, Validation of the Edinburgh postnatal depression scale against both DSM-5 and ICD-10 diagnostic criteria for depression, *BMC Psychiatry* 18 (1) (2018) 1–12.
- [46] L.C. Watson, S. Zimmerman, L.W. Cohen, R. Dominik, Practical depression screening in residential care/assisted living: five methods compared with gold standard diagnoses, *Am. J. Geriatr. Psychiatr.* 17 (7) (2009) 556–564.
- [47] C.W. Topp, S.D. Østergaard, S. Søndergaard, P. Bech, The WHO-5 well-being index: a systematic review of the literature, *Psychother. Psychosom.* 84 (3) (2015) 167–176.
- [48] E.A. Newnham, G.R. Hooke, A.C. Page, Monitoring treatment response and outcomes using the World Health Organization's wellbeing index in psychiatric care, *J. Affect. Disord.* 122 (1–2) (2010) 133–138.
- [49] G. Hochberg, S. Pucheu, L. Kleinebreil, S. Halimi, C. Fructuoso-Voisin, WHO-5, a tool focusing on psychological needs in patients with diabetes: the French contribution to the DAWN study, *Diabetes Metab.* 38 (6) (2012) 515–522.
- [50] J.M. Nicklas, L.A. Barbour, Optimizing weight for maternal and infant health: tenable, or too late? *Expert. Rev. Endocrinol. Metab.* 10 (2) (2015) 227–242.
- [51] I. Bjelland, S. Krokstad, A. Mykletun, A.A. Dahl, G.S. Tell, K. Tambs, Does a higher educational level protect against anxiety and depression? The HUNT study, *Soc. Sci. Med.* 66 (6) (2008) 1334–1345.
- [52] B.W. Penninx, T. van Tilburg, A.J.P. Boeke, D.J. Deeg, D.M. Kriegsman, J.T.M. van Eijk, Effects of social support and personal coping resources on depressive symptoms: different for various chronic diseases? *Health Psychol.* 17 (6) (1998) 551.
- [53] I.R. White, P. Royston, A.M. Wood, Multiple imputation using chained equations: issues and guidance for practice, *Stat. Med.* 30 (4) (2011) 377–399.
- [54] F. Mortazavi, S.-A. Mousavi, R. Chaman, A. Khosravi, Validation of the World Health Organization-5 well-being index; assessment of maternal well-being and its associated factors, *Turk Psikiyatri Dergisi* 26 (1) (2015) 1–7.
- [55] C.A. Crowther, J.E. Hiller, J.R. Moss, A.J. McPhee, W.S. Jeffries, J.S. Robinson, Effect of treatment of gestational diabetes mellitus on pregnancy outcomes, *N. Engl. J. Med.* 352 (24) (2005) 2477–2486.
- [56] B. Blaine, Does depression cause obesity? A meta-analysis of longitudinal studies of depression and weight control, *J. Health Psychol.* 13 (8) (2008) 1190–1197.
- [57] J.M. Murphy, N.J. Horton, J.D. Burke Jr., R.R. Monson, N.M. Laird, A. Lesage, et al., Obesity and weight gain in relation to depression: findings from the Stirling County study, *Int. J. Obes.* 33 (3) (2009) 335.
- [58] C.D. Ryff, G.D. Love, H.L. Urry, D. Muller, M.A. Rosenkranz, E.M. Friedman, et al., Psychological well-being and ill-being: do they have distinct or mirrored biological correlates? *Psychother. Psychosom.* 75 (2) (2006) 85–95.
- [59] National Collaborating Centre for Mental Health, Antenatal and Postnatal Mental Health: The NICE Guideline on Clinical Management and Service Guidance, 2014.
- [60] American Diabetes Association, Standards of medical care in diabetes—2014, *Diabetes Care* 37 (Supplement 1) (2014) S14–S80.
- [61] J.D. Parker, B. Abrams, Prenatal weight gain advice: an examination of the recent prenatal weight gain recommendations of the institute of medicine, *Obstet. Gynecol.* 79 (5 (Pt 1)) (1992) 664–669.

- [62] M.M. Hedderson, E.P. Gunderson, A. Ferrara, Gestational weight gain and risk of gestational diabetes mellitus, *Obstet. Gynecol.* 115 (3) (2010) 597.
- [63] G. Kac, M.H. Benício, G. Velásquez-Meléndez, J.G. Valente, CuJ Struchiner, Gestational weight gain and prepregnancy weight influence postpartum weight retention in a cohort of Brazilian women, *J. Nutr.* 134 (3) (2004) 661–666.
- [64] A. Horsch, L. Gilbert, S. Lanzi, J.S. Kang, Y. Vial, J.J. Puder, Prospective associations between maternal stress during pregnancy and fasting glucose with obstetric and neonatal outcomes, *J. Psychosom. Res.* 125 (2019) 109795.