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Prevalence of postpartum depression and its association with diabetes mellitus among mothers in public health facilities in Mbarara, Southwestern Uganda

Catherine Atuhaire[a], Kabanda Taseera[a], Esther C Atukunda[a], Daniel Atwine[b], Lynn T Matthews[c,d] and Godfrey Zari Rukundo[a]

[a]Faculty of medicine, Mbarara University of Science and Technology, Mbarara, Uganda; [b]Department of Clinical Research, Soar Research Foundation, Mbarara, Uganda; [c]Division of Infectious Diseases and Center for Global Health, Massachusetts General Hospital, Boston, MA, USA; [d]Division of Infectious Disease, University of Alabama at Birmingham, Birmingham, AL, USA

ABSTRACT

Postpartum Depression (PPD) is a major health challenge with potentially devastating maternal and physical health outcomes. Development of diabetes mellitus has been hypothesized as one of the potential adverse effects of PPD among mothers in the postpartum period, but this association has not been adequately studied especially in low resource settings. This study aimed at determining prevalence of postpartum depression and its association with diabetes mellitus among mothers in Mbarara District, southwestern Uganda. We conducted a facility based cross-sectional study of 309 mothers between 6th week to 6th month after childbirth. Using proportionate stratified consecutive sampling, mothers were enrolled from postnatal clinics of two health facilities, Mbarara Regional Referral Hospital and Bwizibwera Health center IV. PPD was diagnosed using the Mini-International Neuropsychiatric Interview (MINI 7.0.2) for the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5). Diabetes mellitus was diagnosed by measuring Hemoglobin A1c (HbA1c). Logistic regression was used to determine the association of PPD and diabetes mellitus among mothers. The study established that PPD prevalence of PPD among mothers of 6th weeks to 6th months postpartum period in Mbarara was 40.5% (95% CI: 35.1–45.1%) and it was statistically significantly associated with diabetes mellitus in mothers between 6 weeks and 6 months postpartum. The prevalence of diabetes mellitus among mothers with PPD was 28% compared to 13.6% among mothers without PPD. Mothers with PPD had 3 times higher odds of being newly diagnosed with diabetes as compared to those without PPD (aOR = 3.0, 95% CI: 1.62–5.74, $p = 0.001$). Mothers with PPD between 6 weeks and 6 months postpartum are more likely to have diabetes mellitus as compared to those without PPD. Well-designed prospective analytical studies are needed to conclude on the risk of diabetes mellitus in relation to PPD. Early screening of PPD may be considered in postpartum mothers.

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CONTACT Catherine Atuhaire catuhaire@must.ac.ug, Faculty of medicine, Mbarara University of Science and Technology, P.O. Box 1410, Mbarara, Uganda

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Background

Postpartum depression (PPD) has become a major maternal mental health challenge in globally (Liu et al., 2021). In high-income countries (HIC), the prevalence of PPD has been reported to be between 10% and 15% (Wubetu et al., 2020) but, it almost doubles in low-income countries (LIC). Some studies have reported a prevalence as high as 80% in LIC (Khalifa et al., 2015). Our recent study in southwestern Uganda revealed a PPD prevalence of 27% among mothers at 6 weeks postpartum (Atuhaire et al., 2021). PPD has several adverse medical and psychosocial outcomes in both the mothers and infants (Chinawa et al., 2016). It causes stress which makes the mother to develop negative perceptions about her child. This in turn escalates child neglect, which affects the child's psychological development thus causing intellectual deficiencies (Cicchetti & Valentino, 2015). In addition, PPD predisposes the mother to poor physical health including non-communicable diseases.

The World Health Organization (WHO) predicts that non-communicable diseases (NCDs) would account for 80% of the global burden of disease, causing seven out of every 10 deaths in LIC like Uganda (Organization, 2020). NCDs cause about half of the premature deaths under the age of 70 (Islam et al., 2014). Diabetes mellitus is one of the major non-communicable diseases that causes morbidity and mortality in the world today (Damé et al., 2017; Organization & Canada, 2005). Recent studies have shown that there is an increasing rate of diabetes mellitus and concurrent increase of psychological disorders in pregnancy and the postpartum period such as PPD (Alqahtani et al., 2024). However, little is known about the association between PPD and diabetes mellitus. Previous studies have proposed relationships between child birth and blood sugar regulation, including the sudden drop of oestrogen, progesterone and serotonin levels following childbirth (Lokuge et al., 2011).

Moreover, child birth itself is associated with stress and other psychosocial challenges. In order to cope, there is stimulation of the neuro-endocrine system which causes an increase in corticosteroids as well as adrenaline. These are likely to cause insulin resistance and vasoconstriction, which may predispose these mothers to diabetes mellitus (Lokuge et al., 2011). The depressed mother may fail to engage in desired lifestyle activities or may resort to over-eating and frequent alcohol use, which impairs glucose tolerance (Nicklas et al., 2013; Rustad et al., 2011; Snoek et al., 2015). In other scenarios, a woman suffering from diabetes mellitus may experience disturbance of the hypothalamic – pituitary – adrenal axis, inflammatory changes, problems in serotonergic regulation which can cause PPD (Azami et al., 2019; Schmidt et al., 2019; Sharma et al., 2016).

Few studies have been carried out on the association between PPD and diabetes mellitus and none has been conducted in LIC such as Uganda where PPD is highly prevalent. There is scanty data on the development of diabetes mellitus after being diagnosed with postpartum depression. What is notable is that the number of women affected by diabetes mellitus during pregnancy and after delivery is increasing (Coton et al., 2016; Veeraswamy et al., 2012). In 2015, it was reported that over 21 million births were affected by hyperglycemia during pregnancy and 10–15% of these cases were within the post-partum period (Coton et al., 2016). This study is therefore aimed at determining the prevalence of PPD and its association with diabetes mellitus among mothers in Mbarara District, southwestern Uganda.

Methods

Study design

It was a facility-based cross-sectional study design employing quantitative methods of data collection to investigate the prevalence of postpartum depression and its association with diabetes mellitus among mothers in Mbarara District, southwestern Uganda.

Study setting

This study was conducted at two government owned health facilities: Mbarara Regional Referral Hospital (MRRH) in Mbarara city and Bwizibwera health center IV (BHCIV) in Mbarara District in southwestern Uganda. MRRH has a bed capacity of 350 and serves a population of over four million people in its catchment area. Every weekday, over 100 mothers are evaluated at the Maternal and Child Health (MCH) Unit. The MCH has subsections of postnatal, young child, family planning, and gynecology clinics. The postnatal clinic has 10 staff members and an average daily attendance of 30 mothers. Services offered include immunization, family planning, health education, infant growth monitoring, and examination of postpartum mothers. Approximately 650 postpartum mothers visited MRRH in the previous 6 months (MRRH records).

BHC IV largely serves the rural community of Kashari county, Mbarara District. It has eight midwives and an average daily attendance of 14 mothers. Approximately 350 postpartum mothers visited BHC IV in the previous 6 months (health facility records).

Study population and period

Data were collected from 8 February 2022 to 28 July 2022 from mothers who were 6 weeks to 6 months' postpartum as they visited the health facilities.

Inclusion and exclusion criteria

Mothers were considered eligible if they had a live baby and were visiting the postnatal clinic for their 6th week to 6th month visit postpartum. Women were excluded if they were not the biological mother of the child brought for immunization, had a known diagnosis of diabetes mellitus in the recent pregnancy, were very sick and unable to respond to questions or were taking drugs that reduce cortisol levels.

Sample size estimation

It was determined using a formula for single population proportion with correction for a finite population (Daniel & Cross, 2018). That is:

$n = N^*X/(X + N - 1)$,

Where, $X = Z_{\alpha/2}{}^2 * p*(1\text{-}p)/MOE^2$,

And $Z_{\alpha/2}$ is the critical value of the Normal distribution at $\alpha/2$ for α of 0.05 = 1.96,

MOE is the margin of error considered at 5%.

p = Proportion of mothers with PPD between their 6th week and 6 months post-delivery = 0.5.

N is the population size, that is, the number of postpartum mothers attending MRRH and BHC IV over a recent six months' period = 1000.

To cater for attrition, an additional 10% was added to the sample size, hence a minimum sample size of 309 postpartum mothers was recruited.

Sampling procedure

We used proportionate stratified sampling method, to determine the sample size for each of the two sites. Mothers within each site were selected consecutively based on eligibility criteria until the sample size of 309 was attained. This was based on the number of women that had given birth in each health facility the previous 6 months (hospital records).

Study variables

The main outcome measure was diabetes mellitus among mothers clinically diagnosed with postpartum depression and the exposure variable was postpartum depression.

Measurements

Hemoglobin A1c testing

To diagnose mothers with diabetes mellitus and establish their glycemic levels during the preceding 3 months, Hemoglobin A1c (HbA1c) was measured according to the standard operating procedure of the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) reference using an automated high performance liquid chromatography analyzer (Bio-Rad Diamat, Milan, Italy). The upper limit of normal was 5.6%. The reference range for HbA1c to be considered pre-diabetic was from 5.7% to 6.4% (Maser et al., 2003). If the HbA1C was above 6.5% then the mother was diagnosed with Diabetes mellitus based on an *International Classification of Diseases, Ninth Revision (ICD-9)* code (World Health Organization, 1988). The results of these mothers were given to the nurse in-charges who then referred them for treatment as routine care.

Diagnosis of postpartum depression

A mother was clinically diagnosed with postpartum depression if she was found to be positive using the Mini-International Neuropsychiatric Interview (MINI 7.0.2) for the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) (Segre et al., 2007). Mothers suffering from PPD were referred for further management.

Data collection procedure

All eligible mothers attending any of the study sites were consented and enrolled by the study nurses. They were then clinically evaluated by an experienced registered mental health clinician for PPD using the MINI according to the DSM-5 criteria. A pre-coded and pre-tested questionnaire was administered to evaluate for socio-demographic characteristics, clinical signs and symptoms of diabetes mellitus. Anthropometric measurements such as weight in kilograms using a weighing scale machine and height in meters using a stadiometer mounted

against a vertical wall were also measured to the nearest 0.1 kg or 0.1 m, respectively. The participants then had blood drawn for laboratory investigations of HbA1C.

Data analysis

The coded data were manually checked, cleaned and double entered into EPI Info software version 7.2 by two trained database assistants. After data entry, appropriate data validation and cleaning was done prior to exportation to STATA software version 15·0 (Stata Corp, College Station, TX, U.S.A.) for analysis. Descriptive analysis of participants' characteristics was done and descriptive statistics were presented as means and standard deviations for continuous variables and frequency and percentages for categorical variables. The prevalence of PPD was calculated as a proportion of mothers diagnosed with postpartum depression using the MINI out of all mothers enrolled into the study and expressed as a percentage with its corresponding 95% confidence interval (CI).

The proportion of mothers with diabetes mellitus among those with PPD was calculated as a fraction of mothers diagnosed with diabetes mellitus out of all mothers enrolled into the study with a PPD diagnosis and was expressed as a percentage. In the same way, the proportion of mothers with diabetes mellitus among those without PPD was calculated as a fraction of mothers diagnosed with diabetes mellitus out of all mothers enrolled into the study but had no PPD diagnosis and was also expressed as a percentage. Using Pearson Chi-square test, the two percentages were compared so as to establish if there was a significant difference in the prevalence of diabetes mellitus among mothers with and without PPD at a significance level of 5%.

Bivariate analysis was done to evaluate the associations between independent (PPD) and dependent (diabetes mellitus) variables using chi-square and logistic regression. A similar analysis was performed on other maternal factors (independent variables) to establish their association with diabetes mellitus and identify possible confounders to adjust in the relationship between PPD and diabetes mellitus. Variables which were found to be statistically significant in the bivariate analysis (associated with p value ≤ 0.05), those with $p < 0.1$ and those with biological plausibility (age) with regard to diabetes mellitus were included in the multivariable model building that utilizing a manual backward stepwise elimination method. PPD was locked in the model for its effect on diabetes mellitus to be adjusted for other confounders. In addition to PPD, all other variables in the final model were reported together with their adjusted OR with the corresponding 95% confidence intervals at a significance level of 5%.

Results

We enrolled a total of 309 mothers who had a live baby and were visiting the postnatal clinic for their 6th week to 6th month postpartum period at Mbarara Regional Referral Hospital ($n = 185$) and Bwizibwera Health Center IV ($n = 124$). They had a mean age of 26.7 ± 5.7 years with the majority (88.3%) below 35 years, banyankore (78.3%), married (93.2%), with at least secondary level of education (63.7%), never drunk alcohol (93.5%) and were of the Christian faith (92.2%). In addition, more than half were urban residents (57.9%) and had given birth at least twice (57%) as shown in Table 1.

Table 1. Participants' characteristics ($N = 309$).

Characteristics	n (%)	No PPD, n (%)	PPD, n (%)	p-value
Health Facility				0.502
MRRH	185 (59.9)	113 (61.4)	72 (57.6	
BHCIV	124 (40.1)	71 (38.6)	53 (42.4)	
Residence type				0.204
Rural	130 (42.1)	72 (39.1)	58 (46.4)	
Urban	179 (57.9)	112 (60.9)	67 (53.6)	
Mean age in years (SD)	26.7 (5.7)	26.2 (5.3)	27.5 (6.1)	0.0598
Age category in years				0.337
17-19	20 (6.5)	14 (7.6)	6 (4.8)	
20-24	107 (34.6)	66 (35.9)	41 (32.8)	
25-34	146 (47.3)	87 (47.3)	59 (47.2)	
35-49	36 (11.7)	17 (9.2)	19 (15.2)	
Parity				0.005
Primigravida (1)	133 (43.0)	86 (46.7)	47 (37.6)	
Low parity (2–4)	152 (49.2)	91 (49.5)	61 (48.8)	
Multipara (>5)	24 (7.8)	7 (3.8)	17 (13.6)	
Level of education				0.073
None/Primary	112 (36.3)	58 (31.5)	54 (43.2)	
Secondary	103 (33.3)	64 (34.8)	39 (31.2)	
Tertiary	94 (30.4)	62 (33.7)	32 (25.6)	
Marital Status				0.251
Unmarried	21 (6.8)	15 (8.2)	6 (4.8)	
Married	288 (93.2)	169 (91.9)	119 (95.2)	
Occupation				0.012
Unemployed	77 (24.9)	45 (24.5)	32 (25.6)	
Agricultural work	65 (21.0)	29 (15.8)	36 (28.8)	
Business	126 (40.8)	79 (42.9)	47 (37.6)	
Professional	41 (13.3)	31 (16.9)	10 (8.0)	
Ever drink alcohol				0.668
No	289 (93.5)	173 (94.0)	116 (92.8)	
Yes	20 (6.5)	11 (6.0)	9 (7.2)	
Participation in vigorous physical activity				0.007
No	210 (68.0)	136 (73.9)	74 (59.2)	
Yes	99 (32.0)	48 (26.1)	51 (40.8)	

MRRH, Mbarara Regional Referral Hospital; BHCIV, Bwizibwera Health Center IV.

Table 2. Participants medical factors ($N = 309$).

`	n (%)	No PPD, n (%)	PPD, n (%)	p-value
HIV sero-status				0.477
Positive	27 (8.7)	16 (8.7)	11 (8.8)	
Negative	281 (90.9)	168 (91.3)	113 (90.4)	
Not known	1 (0.3)	0 (0.0)	1 (0.8)	
Family history of depression				0.059
No	281 (90.9)	172 (93.5)	109 (87.2)	
Yes	28 (9.1)	12 (6.5)	16 (12.8)	
Family history of diabetes mellitus				0.850
No	239 (77.3)	143 (77.7)	96 (76.8)	
Yes	70 (22.7)	41 (22.3)	29 (23.2)	
Family history of hypertension				0.576
No	212 (68.6)	124 (67.4)	88 (70.4)	
Yes	97 (31.4)	60 (32.6)	37 (29.6)	
Hypertension				0.568
No	292 (94.5)	175 (95.1)	117 (93.6)	
Yes	17 (5.5)	9 (4.9)	8 (6.4)	

In addition, of the 309 mothers enrolled, (8.7%) were HIV sero positive, majority reported no known family history of depression (90.9%), no known family history of diabetes mellitus (77.3%) and no known family history of hypertension (68.6%) as shown in Table 2.

Table 3. Prevalence of postpartum depression in mothers between 6 weeks and 6 months postpartum.

Postpartum depression Prevalence type	Overall, N	Frequency, n	% (95% CI)	P
Overall prevalence	309	125	40.5 (35.1–45.1)	
Mother's age specific prevalence				0.337
17-19 years	20	6	30.0 (13.1–55.0)	
20-24 years	107	41	38.3 (29.5–48.0)	
25-34 years	146	59	40.4 (32.7–48.7)	
35-49 years	36	19	52.8 (36.0–69.0)	
Specific Postpartum duration prevalence				0.257
6-8 weeks	92	40	43.5 (33.6–53.9)	
9-12 weeks	69	24	34.8 (24.3–47.0)	
13-20 weeks	87	31	35.6 (26.1–46.4)	
21 weeks and above	61	30	49.2 (36.6–61.9)	

Association between postpartum depression and diabetes mellitus in mothers between 6 weeks and 6 months postpartum in Mbarara District, Uganda.

Prevalence of postpartum depression diabetes mellitus

Of the 309 mothers enrolled in the study, 125 were diagnosed with PPD based on the DSM-5, hence a prevalence of 40.5% (95% CI: 35.1–45.1%). We noted an increasing trend in prevalence of PPD with age but was not statistically significant, $p = 0.337$. PPD was also highest at 21 weeks to 6 months: 49.2% (95% CI: 36.6–61.9%) and least from 9 to 12 weeks: 34.8% (95% CI: 24.3–47.0%) See Table 3.

Of the 309 enrolled mothers, 60 were diagnosed with diabetes during postnatal visits between 6 weeks and 6 months postpartum, giving a prevalence of diabetes of 19.4% (95% CI: 15.4–24.2%). Diabetes was diagnosed in 28% (35/125) versus 13.6% (25/184) of mothers with and without PPD respectively, and this difference was statistically significant, $p = 0.002$.

In bivariate analysis, postpartum depression was significantly associated with the diagnosis of diabetes mellitus in mothers between 6 weeks and 6 months postpartum (OR = 2.5, 95% CI:1.39-4.39, $p = 0.0018$). At multivariate analysis, PPD remained significantly associated with diabetes mellitus diagnosis after adjusting for health facility, education, age and HIV serostatus. Mothers with PPD had 3 times higher odds of being diagnosed with diabetes mellitus between 6 weeks and 6 months postpartum as compared to those without PPD during the same period after adjusting for other factors in the multivariable analysis model, (OR = 3.0, 95% CI: 1.62–5.74, $p = 0.001$) as shown in Table 4.

Other factors that showed an independent significant association with diabetes mellitus were Health facility level where the mother was getting postnatal care ($p < 0.001$) and having at least a secondary level of education ($p < 0.01$). Although marital status was significantly associated with diabetes mellitus in bivariate analysis, it lost its association in multivariate analysis and was excluded from the final model.

Mothers receiving postnatal services at a regional referral hospital of Mbarara had 4.9 times higher odds of being diagnosed with diabetes mellitus as compared to those at a health center IV in Bwizibwera, aOR = 4.9, (95% CI: 2.30–10.50). Also, mothers having at least a secondary level of education and above had 3 times higher odds of being diagnosed with diabetes mellitus as compared to those with no or primary education (See Table 4).

Table 4. Results of bivariate and multivariate analysis for the association between postpartum depression and diabetes mellitus, and also with other factors in mothers between 6 weeks and 6 months postpartum in Mbarara District, Uganda.

Variable	No Diabetes mellitus n (%)	Diabetes mellitus n (%)	Unadjusted OR (95% CI)	p	Adjusted OR (95% CI)	p
PPD				0.0018		
No	159 (86.4)	25 (13.6)	1.0		1.0	
Yes	90 (72.0)	35 (28.0)	2.5 (1.39-4.39)		3.0 (1.62-5.74)	0.001
Health Facility				0.0002		
MRRH	136 (73.5)	49 (26.5)	3.7 (1.84-7.45)		4.9 (2.30-10.50)	0.000
BHCIV	113 (91.1)	11 (8.9)	1.0		1.0	
Residence type				0.0002		
Rural	117 (90.0)	13 (10.0)	1.0			
Urban	132 (73.7)	47 (26.3)	3.2 (1.65-6.22)			
Age category in years				0.3549		
17-19	16 (80.0)	4 (20.0)	1.0		1.0	
20-24	92 (86.0)	15 (14.0)	0.7 (0.19-2.22)		0.4 (0.09-1.84)	0.246
25-34	113 (77.4)	33 (22.6)	1.2 (0.37-3.73)		0.8 (0.19-3.36)	0.749
35-49	28 (77.8)	8 (22.2)	1.1 (0.30-4.40)		1.2 (0.23-5.77)	0.862
Number of children given birth to				0.9362		
1	107 (80.5)	26 (19.6)	1.0			
2-4	122 (80.3)	30 (19.7)	1.0 (0.56-1.82)			
5 or +	20 (83.3)	4 (16.7)	0.24 (0.26-2.61)			
Tribe				0.7778		
Munyankore	195 (80.6)	47 (19.4)	1.0			
Muganda	15 (88.2)	2 (11.8)	0.6 (0.12-2.50)			
Mukiga	24 (80.0)	6 (20.0)	1.0 (0.40-2.68)			
Others	15 (75.0)	5 (25.0)	1.4 (0.48-4.00)			
Level of education				0.0552		
None/Primary	98 (87.5)	14 (12.5)	1.0		1.0	
Secondary	80 (77.7)	23 (22.3)	2.0 (0.97-4.16)		3.1 (1.40-7.00)	0.006
Tertiary	71 (75.5)	23 (24.5)	2.3 (1.09-4.71)		3.1 (1.38-7.18)	0.007
Marital Status				0.0434		
Unmarried	20 (95.2)	1 (4.8)	1.0			
Married	229 (79.5)	59 (20.5)	5.2 (0.68-39.18)			
Religion of affiliation				0.4847		
Christian	231 (81.1)	54 (19.0)	1.0			
Moslem	18 (75.0)	6 (25.0)	1.4 (0.54-3.76)			
Occupation				0.6771		

(*Continued*)

Table 4. (Continued).

Variable	No Diabetes mellitus n (%)	Diabetes mellitus n (%)	Unadjusted OR (95% CI)	p	Adjusted OR (95% CI)	p
Unemployed	62 (80.5)	15 (19.5)	1.0			
Peasant	54 (83.1)	11 (6.9)	0.8 (0.36-2.00)			
Business	98 (77.8)	28 (22.2)	1.2 (0.58-2.39)			
Professional	35 (85.4)	6 (14.6)	0.7 (0.25-2.00)			
Ever drink alcohol				0.2363		
No	231 (79.9)	58 (20.1)	1.0			
Yes	18 (90.)	2 (10.0)	0.4 (0.10-1.96)			
Vigorous physical activity				0.8113		
No	170 (81.0)	40 (19.1)	1.0			
Yes	79 (79.8)	20 (20.2)	1.1 (0.59-1.96)			
HIV sero-status				0.0731		
Positive	25 (92.6)	2 (7.41)	0.3 (0.07-1.37)		0.3 (0.06-1.22)	0.088
Negative	224 (79.7)	57 (20.3)	1.0		1.0	
Not known	0 (0.0)	1 (100.0)	1 (NA)		1.0 (NA)	
Family history of diabetes mellitus				0.3641		
No	190 (79.5)	49 (20.5)	1.0			
Yes	59 (84.3)	11 (15.7)	0.7 (0.35-1.48)			
Family history of hypertension						
No	170 (80.2)	42 (19.1)	1.0	0.7952		
Yes	79 (81.4)	18 (18.6)	0.9 (0.50-1.70)			
Body Mass Index in Kg per m2						
<18.5	12 (75.0)	4 (25.0)	1.0	0.3832		
18.5-25	157 (78.50)	43 (21.5)	0.8 (0.25-2.68)			
26-29	49 (84.5)	9 (15.5)	0.6 (0.14-2.10)			
≥30	31 (88.6)	4 (11.43)	0.4 (0.08-1.80)			

Discussion

This study aimed at determining prevalence of postpartum depression and its association with diabetes mellitus among mothers in Mbarara District, southwestern Uganda. Of the 309 mothers enrolled in the study, 125 (40.5%) were diagnosed with PPD based on the DSM-5. Similarly, the prevalence of diabetes mellitus was 19.4%, 28% in mothers with PPD and 13.6% among mothers without PPD.

Prevalence of postpartum depression based on the DSM-5

The present study clinically diagnosed PPD among mothers of 6th week to 6th month postpartum period using the DSM-5. It reported a prevalence of 40.5% (95% CI: 35.1–45.1%). The prevalence rate reported by the present study is much higher than prevalence of 27.1% (95% CI: 22.2–32.5) previously reported in the same area of study which also used the same method of diagnosis (Atuhaire et al., 2021). The difference in prevalence from the previous study is largely attributed to the different postpartum period considered by the two studies. While the current study considered a postpartum period of 6th week to 6th month, the previous study looked at 6 weeks postpartum. Studies from other countries in Africa have also shown discrepancies in PPD prevalence. One study carried out in Nigeria among 6 weeks postpartum mothers reported a prevalence of 35.6% which is in same range as the present study (Adeyemo et al., 2020). The highest reported prevalence of 61.8% and 50.4% within 12 months postpartum were reported in Lime, Cameroon and DRC respectively (Adama et al., 2015; Ghogomu et al., 2016). Generally, studies carried out in African countries such as South Africa, Ethiopia, Zimbabwe and Cameroon have reported varying but lower rates of 31.7%, 22.9%, 33% and 31%, respectively (Chibanda et al., 2010; Hung et al., 2014; Toru et al., 2018). Variations in timeframes used in diagnosis of PPD by numerous studies remain the main explanation for variances in prevalence rates reported. It is argued that a longer postpartum period leads to increased exposure of mothers to other risk factors of depression other than childbirth explaining the higher prevalence. Variations in the PPD prevalence is also attributed to varying tools of diagnosis and cut-off points, differences in geographical locations, study designs and units of analysis. Study results imply that mothers between 6^{th} weeks to 6^{th} months after childbirth in Mbarara District had a high risk of developing postpartum depression.

Additionally, study results also show that the risk of PPD increases with increase in age of the mothers. Study results are in support of the study carried out by (Luke et al., 2009; Silverman et al., 2017) which also found out that the risk of PPD increased with advanced age whereby mothers aged 30 years and above were at a higher risk of PPD as compared to those aged below 30 years. Contrary to the study's findings (Lanzi et al., 2009), found out that adolescents were at a higher risk for PPD. Study results may not be similar to that done by Lanzi et al. because these studies were conducted in different populations and it may also be attributed to unequal participants in groups which may report significant differences.

Association between postpartum depression and diabetes mellitus in mothers between 6 weeks and 6 months postpartum

We observed a statistically significant association between postpartum depression and diabetes mellitus in mothers between 6 weeks and 6 months postpartum. The prevalence of diabetes mellitus among mothers with PPD was 28% compared to 14% among those without PPD. It implies that prevalence was 2.5 times higher among mothers with PPD compared to the mothers without PPD at bivariate level. After adjusting for other associated factors, the study found that mothers with PPD had 3 times higher odds of being diagnosed with diabetes mellitus between 6 weeks and 6 months postpartum as compared to those without PPD during the same period. This is so because during pregnancy and after child birth, there is a dramatic drop in the production of estrogen and progesterone hormones (Lokuge et al., 2011) which leads to postpartum depression. Studies revealed that as mothers try to cope with stress associated with childbirth, there is stimulation of the neuro endocrine system thereby increasing corticosteroids and adrenaline which leads to insulin resistance and vasoconstriction (Lokuge et al., 2011). It is also argued that during the postpartum period, mothers are likely to be withdrawn from their desired lifestyle activities or to adopt to high risky activities such as over eating that impair glucose tolerance (Nicklas et al., 2013; Rustad et al., 2011; Snoek et al., 2015).

There are generally few studies to refer to in order to collaborate and validate the findings of this study as a big proportion of the available literature have focused on gestational diabetes mellitus during pregnancy as a risk factor of depression during pregnancy and postpartum period. Literature on the association between PPD and diabetes mellitus is largely missing. However, a few studies have revealed the existence of a bidirectional relationship between postpartum depression and diabetes mellitus among mothers (Fischer & Morales-Suárez-Varela, 2023). Studies reveal that mothers with postpartum depression or other depressive disorders during pregnancy and postpartum period had a high risk of developing diabetes mellitus (Fischer & Morales-Suárez-Varela, 2023; Hinkle et al., 2016). Similarly, in a study conducted to assess the risk factors for postpartum depression, results showed that gestational diabetes mellitus was strongly associated with increased risk for PPD in women regardless of their depression history (n = 707,701) while pre-gestational (type 1 and type 2) diabetes mellitus represented an increased risk only in women with a history of depression (Silverman et al., 2017). Also, in a study conducted to examine the association between diabetes mellitus and perinatal depression among mothers from LICs (n = 11,024) who were continuously enrolled in Medic aid for 6 months prior to delivery and 1 year after giving birth, results showed that after controlling for the effects of age, race, year of delivery and perinatal birth, women with diabetes mellitus had double odds of experiencing PPD during the perinatal period compared to those who were not diabetic (Kozhimannil et al., 2009). All these studies comply with the study findings, because they have been conducted in similar populations who were either pregnant women or women who had given birth within 1 years' time. Contrary to study findings, in a study by (Pace et al., 2018), results showed that in the first-year postpartum, there was no association between diabetes mellitus and depression. However, after first year postpartum, women with diabetes

mellitus had a nearly twofold greater risk of being diagnosed with depression compared to those without diabetes mellitus during the prenatal period.

Other factors associated with diabetes mellitus in mothers between 6 weeks and 6 months postpartum in Mbarara District, Uganda

This study also examined the association between diabetes mellitus and socio-demographic characteristics and medical factors. Socio-demographic characteristics examined included age, residence, marital status, education level, health facility attended, number of children, occupation of mother, physical activity and alcohol drinking habits. Medical factors examined were HIV sero-status, having a family history of hypertension, depression or diabetes mellitus, BMI and being hypertensive. The multivariate analysis revealed that two other factors were associated with being diagnosed with diabetes mellitus between 6 weeks and 6 months postpartum. The study reported having at least a secondary level of education to be independently associated with diabetes mellitus ($p < 0.01$) agreeing with the findings of another study of 373 postpartum gestational diabetes mellitus patients carried out at a major academic centre in U.S.A. that reported an OR of 2.77 (95% CI: 09–9.00) for patients with high school education when compared to those with advanced degrees (Mathieu et al., 2014). This implies that education level affects the awareness and management of diabetes mellitus in that mothers with higher education levels are exposed to websites, reading materials and other sources that can provide all the relevant information about the preventive and management ways of diabetes mellitus hence reducing the chances of developing diabetes mellitus. However, the reverse is true for mothers with low education level. In addition, Health facility level was independently associated at $p < 0.001$) whereby women in Mbarara Regional Referral Hospital (MRRH) had 4.9 increased odds of being diagnosed with diabetes mellitus as compared to women in HCIV in Bwizibwera. Health facility level was found out to be associated with diabetes mellitus because the level of a health facility in Uganda corresponds with the nature of health services being offered at that particular health facility. In this case, women who had gone in MRRH had increased odds because there are enough equipment and health care personnel to examine these women unlike when it comes to HCIVs which provide a limited number of services, are not well equipped with adequate health-care staff and the necessary equipment as well. Women with Diabetes mellitus were likely to develop depressive symptoms in the postpartum period, but the reverse has been minimally documented. Distress is likely to cause a spike in the blood glucose over time and these mothers are likely to become chronically diabetic (Halligan et al., 2004).

Strength and limitations

The main strength of the study is the use of Mini-International Neuropsychiatric Interview (MINI 7.0.2) for the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) and Hemoglobin A1c (HbA1c) which scientifically recognized and validated methods of diagnosing PPD and diabetes mellitus, respectively. Additionally,

covering a wider postpartum period of between 6 weeks and 6 months was also important in ensuring the problem is not under-reported. The major weakness of the study is that the participants were selected from only two health facilities within the radius of less than 30 Km of each other which may be a limitation to the generalization of the study findings. While covering a wider postpartum period was important, the study did not capture disaggregated data on prevalence of PPD and diabetes mellitus in different postpartum periods. This makes it difficult to determine the postpartum periods with high risk of PPD and diabetes mellitus to inform targeted response. In addition, establishing the temporal relationship between the exposure and outcome variables, maybe difficult to determine the bidirectional interaction between PPD and DM in relation to the design utilized in this study.

Conclusion

This study disclosed a high prevalence of PPD among mothers between 6 weeks and 6 months postpartum and it is strongly associated with diabetes mellitus. With a prevalence of 28%, mothers diagnosed with postpartum depression are at a higher risk of developing diabetes mellitus which has negative effects on the maternal health outcomes of both the mothers and their infants. The study highlights the need for integration of diabetes mellitus prevention and management interventions in postnatal care. Also, there is need to explore the prevalence of PPD and diabetes mellitus; and their associations in a longitudinal way with a larger sample size and controlling for other metabolic factors. In addition, postpartum mothers should be screened and measures put in place to prevent PPD and if these mothers are suffering from PPD, then the clinicians should consider screening them for Diabetes mellitus.

Implications

The findings of this study are very useful in improving the maternal health outcomes and attaining the Sustainable Development Goal 3 by 2040. The study provides evidence of high prevalence of PPD and diabetes mellitus among postpartum mothers and the co-existence of the two conditions can be fatal to the health of mothers and their infants. There is therefore need for interventions that will increase public awareness, screening, prevention and management of both PPD and diabetes mellitus among postpartum mothers. Health professionals such as midwives need to be trained in the management of mothers with comorbidity of PPD and diabetes mellitus. The increased capacity of health workers to detect and manage will ensure that such conditions are detected early for better case management.

Future research

Further studies are needed looking at varying study contexts such as rural and urban, private and public health facilities and other regions of Uganda so as to have conclusive evidence on prevalence of postpartum depression and its association with Diabetes

mellitus among mothers in Uganda as a whole. Without a national view, the problem of PPD and diabetes mellitus among postpartum mothers will not get the attention it deserves as it may be treated as an isolated case. Future studies may also provide disaggregated data on the association of postpartum depression and Diabetes mellitus among mothers per categorized postpartum period to help in understanding the most risk postpartum period. Such findings would be critical in ensuring targeted interventions in the context of resource constrained countries like Uganda where targeting all postpartum women may not be financially feasible. Last but not least, future studies could consider a prospective analytical study design in order to note the bidirectional interaction between PPD and Diabetes mellitus. Future research could also determine the efficacy of targeted PPD screening, prevention interventions and management. In case, mothers are diagnosed with PPD then the clinicians should consider early screening for Diabetes mellitus.

Ethical approval and consent to participate

Ethical approval to conduct the study was obtained from the Mbarara University of Science and Technology Research and Ethics Committee (REF# MUREC 1/7) and the Uganda National Council for Science and Technology (HS 2673). Written informed consent to participate in the study was obtained from all participants prior to enrolment in the study, and unique identifiers were used for participant identification. All methods were carried out in accordance with relevant guidelines and regulations.

List of abbreviations

PPD	Postpartum Depression
MINI	Mini-International Neuropsychiatric Interview
HbA1c	Hemoglobin A1c
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, 5th Edition
AOR	Adjusted Odd Ratio
APA	The American Psychiatric Association
UAE	United Arab Emirates
LIC	Low Income Countries
HIC	High Income Countries
WHO	World Health Organisation
NCDs	Non-Communicable Diseases
MRRH	Mbarara Regional Referral Hospital
BHCIV	Bwizibwera health center IV
MCH	Maternal and Child Health Unit
IFCC	International Federation of Clinical Chemistry and Laboratory Medicine
PI	Principle Investigator
HIV	Human Immune Virus
CI	Confidence Interval
OR	Odds Ratio

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ORCID

Catherine Atuhaire http://orcid.org/0000-0002-6028-7491
Daniel Atwine http://orcid.org/0000-0002-3373-1999
Godfrey Zari Rukundo http://orcid.org/0000-0002-3739-1426

Authors' contributions

All authors made substantial contributions to conception, design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content and approved the final draft. Lynn T Mathews and Godfrey Zari Rukundo are both senior authors.

Data availabilty statement

All relevant data are included in the manuscript.

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