reproductive medicine

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Potential Association between Marital Status and Maternal and Neonatal Complications and Placental Pathology in Singleton Pregnancy

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Abstract: Maternal marital status, educational levels, and income levels were associated with adverse pregnancy outcomes and placental inflammatory changes, preterm delivery, and stillbirth. We aimed to examine the association of marital status with maternal and neonatal complications and placental pathology in singleton pregnancy. A total of 3724 singleton placentas with maternal neonatal and placental pathology data were included in the study, and there were statistically significant associations between marital status and maternal age, race/ethnicity, maternal BMI at delivery, neonatal birth weight, preeclampsia, and preterm delivery. There were significant associations between marital status and maternal inflammatory response, maternal vascular malperfusion, and meconium stain of fetal membranes. These data demonstrated that marital status affects not only the maternal well-being during pregnancy, but also neonatal birth data and placental pathology.

Keywords: marital status; pregnancy complications; placental pathology; racial disparity

Citation: Zhang, P.; Shama, N.; Shama, A.; Lederman, S. Potential Association between Marital Status and Maternal and Neonatal Complications and Placental Pathology in Singleton Pregnancy. *Reprod. Med.* **2023**, *4*, 28–33. https://doi.org/10.3390/reprodmed4010004

Academic Editor: Stefano Palomba

Received: 5 December 2022
Revised: 17 January 2023
Accepted: 29 January 2023
Published: 2 February 2023

1. Introduction

Social environmental factors have long been associated with physical and mental health, and maternal psychosocial well-being can influence pregnancy and fetal/neonatal outcomes [1]. Marital status, maternal income, and maternal education levels were associated with adverse pregnancy outcomes, maternal placental inflammatory changes, preterm delivery, and stillbirth [2–4]. However, these social environmental factors and placental pathology are less studied. Here we aimed to study the relationship between the marital status of pregnant women and clinical pregnancy complications, neonatal birth data, and various categories of placental pathology.

2. Materials and Methods

This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline and included all singleton placentas in the third trimester submitted chronologically for pathology examination from March 2020 to November 2021 with the exception of twin or multiple births. Placental examination at our institution is criteria-based and performed according to the standard procedure [5–7]. Placental pathology data, neonatal birth data, maternal racial and ethnic data, and marital status were retrieved from medical records from the hospital medical record system (Cerner Corporation) based on standard national criteria. Marital status was listed as married, single, divorced, life partner, or others, including unknowns and declined to respond. Classification for race and ethnicity included Asian, Hispanic, non-Hispanic Black, and non-Hispanic White categories; responses outside of these categories (i.e., "unknown", "others", or "declined") were recorded together as one group. Laboratory tests of white blood cell count with differentials and blood pressure measurements were from pre-admission

tests for delivery only. Statistical analysis was performed by using various programs in the R-package, including the baseline characteristic table, multivariate tests, and logistic regression models. $p < 0.05$ was considered significant. An institutional review board review of the work was approved by the NewYork Presbyterian-Brooklyn Methodist Hospital [1592673-1] (approval date 13 April 2020).

3. Results

A total of 3724 cases with placental pathology information, maternal, and neonatal information were collected for the study, including 2149 patients who reported "married" (57.7%), 1227 "single" (32.9%), 312 "life partner" (8.4%), 20 "others/unknown/declined" (0.5%), and 16 "divorced" (0.4%). There were statistically significant differences in marital status among various racial/ethnic groups, with the non-Hispanic Black group being the highest group reporting to be single (Table 1, $p < 0.001$) [8].

Table 1. Marital status and pregnancy complications.

Marital Status	Married	Single	Divorced	Life Partner	Others/Unknown	*p*-Value
	(*n* = 2149) (57.7%)	(*n* = 1227) (32.9%)	(*n* = 16) (0.4%)	(*n* = 312) (8.4%)	(*n* = 20) (0.5%)	
Neonatal sex						1.00
- Female	1064 (49.5%)	597 (48.7%)	9 (56.2%)	152 (48.7%)	10 (50.0%)	
- Male	1078 (50.2%)	624 (50.9%)	7 (43.8%)	159 (51.0%)	10 (50.0%)	
Neonatal birth weight (g)	3280.0 [2900.0; 3610.0]	3150.0 [2750.0; 3530.0]	3330.0 [3050.0; 3520.0]	3170.0 [2790.0; 3500.0]	3380.0 [3060.0;3 535.0]	**$p < 0.001$**
Neonatal birth length (cm)	50.0 [48.5; 52.0]	50.0 [48.0; 51.5]	50.0 [48.0; 51.0]	50.0 [48.0; 51.5]	50.8 [49.0; 52.0]	
Head circumference (cm)	34.0 [33.0; 35.0]	33.5 [32.5; 35.0]	34.0 [33.0; 34.5]	33.5 [32.5; 34.5]	33.8 [33.0; 35.0]	
Placental weight (g)	456.0 [392.0; 531.0]	451.0 [382.0; 528.0]	484.0 [459.5; 564.0]	448.5 [378.0; 524.5]	487.0 [405.5; 568.5]	0.06
Umbilical cord length (cm)	34.0 [27.0; 42.0]	35.0 [26.0; 42.0]	33.0 [26.5; 42.0]	35.0 [29.0; 42.0]	38.0 [33.0; 46.5]	0.42
Cord coiling per 10 cm	4.0 [3.0; 5.0]	4.0 [3.0; 5.0]	3.0 [3.0; 4.5]	3.0 [3.0; 5.0]	4.0 [3.0; 6.0]	**0.03**
Race/ethnicity						**$p < 0.001$**
- Asian	136 (6.3%)	15 (1.2%)	1 (6.2%)	3 (1.0%)	0 (0.0%)	
- Black	349 (16.2%)	759 (61.9%)	8 (50.0%)	174 (55.8%)	1 (5.0%)	
- Hispanic	118 (5.5%)	143 (11.7%)	1 (6.2%)	52 (16.7%)	1 (5.0%)	
- Others/Unknown	184 (8.6%)	94 (7.7%)	0 (0.0%)	14 (4.5%)	9 (45.0%)	
- White	1362 (63.4%)	216 (17.6%)	6 (37.5%)	69 (22.1%)	9 (45.0%)	
BMI at delivery	29.9 [26.7; 34.0]	32.2 [28.4; 37.1]	32.1 [29.2; 38.5]	32.9 [29.4; 38.6]	31.5 [28.2; 36.1]	**$p < 0.001$**
Maternal obesity (BMI > 30)	717 (49.2%)	523 (63.7%)	7 (58.3%)	158 (70.9%)	6 (50.0%)	**$p < 0.001$**
Obesity at delivery						**$p < 0.001$**
- Non-obese	740 (50.8%)	298 (36.3%)	5 (41.7%)	65 (29.1%)	6 (50.0%)	
- Class I obesity	416 (28.6%)	234 (28.5%)	3 (25.0%)	66 (29.6%)	1 (8.3%)	
- Class II obesity	184 (12.6%)	158 (19.2%)	1 (8.3%)	47 (21.1%)	4 (33.3%)	
- Class III obesity	117 (8.0%)	131 (16.0%)	3 (25.0%)	45 (20.2%)	1 (8.3%)	
GBS status	304 (29.6%)	183 (34.3%)	4 (40.0%)	56 (35.2%)	5 (41.7%)	0.25
SARS-CoV2 status	119 (5.5%)	61 (5.0%)	0 (0.0%)	18 (5.8%)	1 (5.0%)	0.82
Maternal age (year)	33.0 [29.0; 36.0]	30.0 [25.0; 34.0]	37.0 [33.5; 40.5]	32.0 [28.0; 36.0]	28.0 [24.5; 32.5]	**$p < 0.001$**
Gestational age (week)	39.0 [38.0; 40.0]	39.0 [38.0; 40.0]	39.0 [38.5; 40.5]	39.0 [38.0; 40.0]	40.0 [38.5; 41.0]	
Delivery mode						**0.01**

Table 1. *Cont.*

Marital Status	Married	Single	Divorced	Life Partner	Others/Unknown	*p*-Value
- Cesarean	708 (32.9%)	463 (37.7%)	6 (37.5%)	129 (41.3%)	7 (35.0%)	
- Vaginal	1441 (67.1%)	764 (62.3%)	10 (62.5%)	183 (58.7%)	13 (65.0%)	
Preeclampsia/PIH	295 (13.7%)	247 (20.1%)	2 (12.5%)	67 (21.5%)	3 (15.0%)	**$p < 0.001$**
Preterm delivery (<37 w)	203 (9.5%)	173 (14.1%)	1 (6.2%)	37 (11.9%)	2 (10.0%)	**$p < 0.001$**
GDM2	275 (12.8%)	136 (11.1%)	5 (31.2%)	36 (11.5%)	0 (0.0%)	**0.03**
Category 2 fetal tracing	403 (18.8%)	247 (20.1%)	2 (12.5%)	59 (18.9%)	2 (10.0%)	0.64
Placental abruption	33 (1.5%)	23 (1.9%)	0 (0.0%)	11 (3.5%)	0 (0.0%)	0.15
IUGR	103 (4.8%)	60 (4.9%)	1 (6.2%)	15 (4.8%)	1 (5.0%)	1.00
IUFD	25 (1.2%)	17 (1.4%)	0 (0.0%)	6 (1.9%)	0 (0.0%)	0.77
Macrosomia (>4000 g)	174 (8.1%)	87 (7.1%)	0 (0.0%)	15 (4.8%)	2 (10.0%)	0.19
Oligohydramnios	50 (2.3%)	28 (2.3%)	0 (0.0%)	9 (2.9%)	0 (0.0%)	0.86

Abbreviation: GBS—group B streptococcus; PIH—pregnancy-induced hypertension; GDM2—gestational diabetes mellitus; IUGR—intrauterine growth restriction; IUFD—intrauterine fetal demise. Values shown were mean with the percentage of the total or 95% confidence intervals. $p < 0.05$ is considered significant and bolded.

There was a statistically significant difference in body mass index (BMI) at the time of delivery, with the highest BMI in the group of "singles" (Table 1) ($p < 0.001$). Class II and class III maternal obesity based on BMI at delivery were also highest in the group of singles ($p < 0.001$). There was significantly higher Cesarean section delivery in the groups of singles and life partners in comparison to the group of "married". The maternal age of those reported single was statistically younger ($p < 0.001$). Preeclampsia and preterm delivery (<37 weeks) were significantly more prevalent in those reported single and life partners ($p < 0.001$). Mixed-type decidual vasculopathy was found statistically more prevalent in singles and life partners than in other groups (Table 2, $p = 0.01$).

Table 2. Marital status and placental pathology.

Marital Status	Married	Single	Divorced	Life Partner	Others/Unknown	*p*-Value
	(n = 2149) (57.7%)	(n = 1227) (32.9%)	(n = 16) (0.4%)	(n = 312) (8.4%)	(n = 20) (0.5%)	
Placental weight (g)	456.0 [392.0; 531.0]	451.0 [382.0; 528.0]	484.0 [459.5; 564.0]	448.5 [378.0; 524.5]	487.0 [405.5; 568.5]	0.06
Gestational age (week)	39.0 [38.0; 40.0]	39.0 [38.0; 40.0]	39.0 [38.5; 40.5]	39.0 [38.0; 40.0]	40.0 [38.5; 41.0]	
Fetal placental ratio (FPR)	7.1 [6.3; 7.8]	6.8 [6.1; 7.6]	6.8 [6.0; 7.2]	6.9 [6.1; 7.7]	7.0 [5.8; 7.5]	**$p < 0.001$**
Maternal vascular malperfusion						
Decidual vasculopathy						
- Classic type	567 (26.4%)	315 (25.7%)	3 (18.8%)	84 (26.9%)	6 (30.0%)	0.92
- Mixed type	99 (4.6%)	89 (7.3%)	0 (0.0%)	24 (7.7%)	1 (5.0%)	**0.01**
- Mural hypertrophy	161 (7.5%)	96 (7.8%)	3 (18.8%)	25 (8.0%)	3 (15.0%)	0.35
- No vasculopathy	1322 (61.5%)	727 (59.3%)	10 (62.5%)	179 (57.4%)	10 (50.0%)	0.42
Infarctions	151 (7.0%)	93 (7.6%)	0 (0.0%)	25 (8.0%)	3 (15.0%)	0.46
Thrombosis	440 (20.5%)	256 (20.9%)	1 (6.2%)	64 (20.5%)	2 (10.0%)	0.49
Placental abruption	33 (1.5%)	23 (1.9%)	0 (0.0%)	11 (3.5%)	0 (0.0%)	0.15
Fetal vascular malperfusion						
FVM (Avascular villi)	250 (11.6%)	143 (11.7%)	3 (18.8%)	40 (12.8%)	2 (10.0%)	0.88

Table 2. *Cont.*

Marital Status	Married	Single	Divorced	Life Partner	Others/Unknown	*p*-Value
Inflammatory/Infectious						
- MIR						
Acute chorioamnionitis	728 (33.9%)	415 (33.8%)	4 (25.0%)	111 (35.6%)	7 (35.0%)	0.92
Chronic deciduitis (>50/HPF lymphocytes)	538 (25.0%)	289 (23.6%)	4 (25.0%)	79 (25.3%)	6 (30.0%)	0.85
Chronic villitis	459 (21.4%)	211 (17.2%)	4 (25.0%)	49 (15.7%)	4 (20.0%)	**0.02**
- FIR						
Acute funisitis/fetal vasculitis	272 (12.7%)	179 (14.6%)	1 (6.2%)	46 (14.7%)	3 (15.0%)	0.44
Meconium stain	664 (30.9%)	311 (25.3%)	6 (37.5%)	75 (24.0%)	8 (40.0%)	**$p < 0.001$**
Subchorionic hematoma (>1.0 cm)	147 (6.8%)	122 (9.9%)	2 (12.5%)	29 (9.3%)	0 (0.0%)	**0.01**
MPFD/MFI	65 (3.0%)	35 (2.9%)	1 (6.2%)	11 (3.5%)	1 (5.0%)	0.88
Umbilical cord abnormalities	170 (7.9%)	96 (7.8%)	0 (0.0%)	21 (6.7%)	1 (5.0%)	0.72
Lab and other tests						
WBC (×1000/microliter)	10.0 [8.4; 12.1]	9.6 [7.9; 11.6]	11.7 [9.6; 12.3]	9.5 [8.0; 11.5]	11.2 [9.3; 12.6]	**$p < 0.001$**
Neutrophil differential (%)	72.9 [68.3; 77.8]	71.9 [66.4; 76.6]	73.4 [72.4; 76.4]	72.2 [67.5; 77.5]	71.5 [69.7; 79.2]	**$p < 0.001$**
Lymphocytes (%)	17.7 [14.0; 21.9]	18.5 [14.5; 23.1]	16.5 [14.5; 18.6]	17.8 [13.8; 22.4]	17.8 [12.4; 19.4]	**0.01**
Body temperature (°C)	36.7 [36.5; 37.0]	36.7 [36.5; 37.0]	36.8 [36.5; 37.0]	36.7 [36.4; 37.0]	36.7 [36.4; 36.8]	0.65
BMI at delivery	29.9 [26.7; 34.0]	32.2 [28.4; 37.1]	32.1 [29.2; 38.5]	32.9 [29.4; 38.6]	31.5 [28.2; 36.1]	**$p < 0.001$**
Maternal obesity (BMI > 30)	717 (49.2%)	523 (63.7%)	7 (58.3%)	158 (70.9%)	6 (50.0%)	**$p < 0.001$**
Blood pressure (Systolic)	125.0 [117.0; 134.0]	128.5 [118.0; 139.0]	131.0 [120.5; 135.5]	127.0 [120.0; 138.0]	125.5 [120.0; 133.5]	**$p < 0.001$**
Blood pressure (Diastolic)	77.0 [70.0; 84.0]	78.0 [71.0; 85.0]	80.0 [73.5; 84.0]	77.0 [72.0; 86.0]	76.0 [70.5; 86.0]	0.05

Abbreviation: BMI—body mass index; MIR—maternal inflammatory response; FIR—fetal inflammatory response; MPFD/MFI—massive perivillous fibrinoid deposit/maternal floor infarction. Data shown were mean with percentage of total or 95% confidence intervals. $p < 0.05$ is considered significant and bolded.

Subchorionic hematoma was the highest in single and divorced groups ($p < 0.001$), and maternal inflammatory response (MIR, chronic villitis) and meconium stain of fetal membranes were statistically highest in the married and divorced groups ($p = 0.02$). Logistic regression models of the married group and the single group to exclude the confounding factors revealed the persistence of statistically significant differences in various placental pathologies in ethnic Black and Hispanic groups. Subchorionic hematoma, class II and class III maternal obesity, and fetal inflammatory response (FIR) were statistically associated with the single group (Figure 1), and maternal inflammatory response (chronic villitis) with the married group.

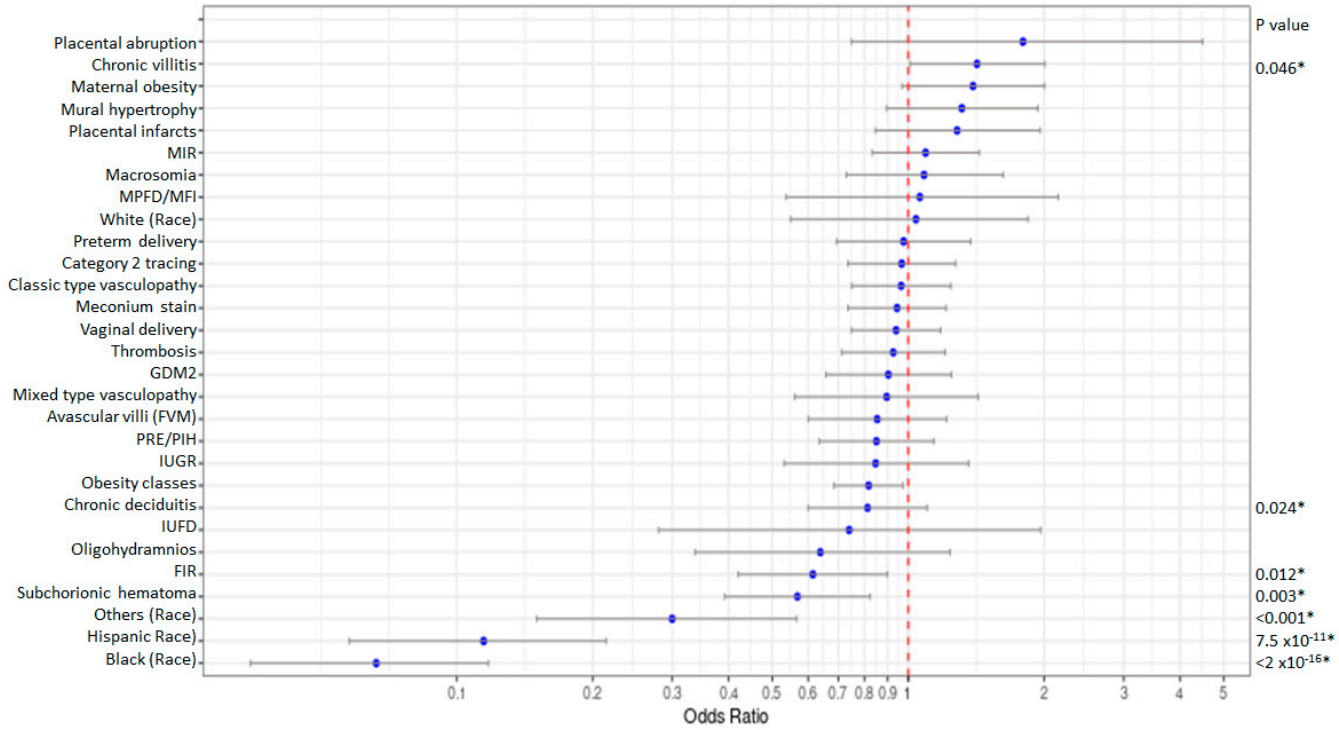

Figure 1. The odds ratio of the married and the single groups in association with various pregnancy complications and placental pathology by the logistic regression model. $p < 0.05$ * is considered significant. The values expressed were mean with 95% confidence intervals (95% CI).

4. Discussion

Our current data showed a statistically significant increase in certain pregnancy complications and placental pathology categories in groups of various marital statuses during pregnancy. The etiology of this increased prevalence of pregnancy complications and placental pathology in groups of certain marital statuses remains unclear and multifactorial. The patient population in our study was from an urban community hospital in New York City with similar demographics and similar or equal access to the patients' healthcare. Marital status and relationship types of pregnant women have changed significantly since the 1980s and marriage is one of the many maternal prenatal stress factors during pregnancy that mainly manifested as psychosocial well-being of the mothers [1,9]. The psychological, emotional, and nutritional health of pregnant women appears to influence not only the maternal physical health during pregnancy, but also the fetal and placental health through complex cellular and metabolic activities, although the molecular mechanism of mental and social impacts on physical health is largely unknown. Attention to the psychosocial health of pregnant women will lead to not only better maternal health but also better fetal/neonatal outcomes.

The limitation of the study is the small number of divorced pregnant cases in the study population. Divorced pregnant women represent an important group of patients with a different type of relationship during pregnancy which may exert a different level of prenatal stress on the fetus and the mother, and the impacts of divorce during pregnancy warrant further investigation.

5. Conclusions

There were statistically significant differences in pregnancy complications and placental pathology among various groups of pregnant mothers with different marital statuses, and these differences persisted after the confounding factors were analyzed by using logistic regression models. The underlying etiology of these differences is difficult to determine.

Marital status as a proxy of psychosocial well-being should be taken into consideration in pregnancy counseling.

Author Contributions: Conceptualization, P.Z. and S.L.; methodology, P.Z., N.S. and A.S.; formal analysis, P.Z.; writing—original draft preparation, P.Z.; writing—review and editing, P.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was approved by the institutional review board of NewYork Presbyterian-Brooklyn Methodist Hospital [1592673-1] (approval date 13 April 2020).

Informed Consent Statement: Patient consent was waived and the patients information was deidentified.

Data Availability Statement: All data were contained in the manuscript. No additional data was available.

Conflicts of Interest: The authors declare no conflict of interest.

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