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Association of Pre-Gestational Diabetes Mellitus (Type 1 & Type 2), Gestational Diabetes, and Pre-Eclampsia with Preterm Birth Among Omani Women

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Abstract: *Background*: To understand what results in preterm birth, the purpose of this quantitative cross-sectional study was to determine if and to what extent rates of pre-gestational diabetes mellitus, gestational diabetes mellitus, and pre-eclampsia differ between Omani women who deliver preterm infants and Omani women who deliver term infants. Shonkoff's bio-developmental framework provided the theoretical foundation for the study. *Methodology*: A quantitative method. Specifically, this is a retrospective cross-sectional study using secondary data Secondary. Data were gathered from a simple random sample of 400 women who delivered preterm or term infants between 2015 and 2017 at Ibri hospital in Oman. Controls group included 200 women with full-term and 200 cases women with pre-term (case to control ratio was 1:1). After data extraction and cleaning, descriptive analyses and Chi-square tests of independence were conducted. *Results*: A total of 400 randomly selected participants (mean age of the participants was 29.26 (SD±5.75) years) were included in the study (200 participants gave birth to preterm infants and 200 participants gave birth to full term infants). The demographics of the women, maternal clinical characteristics, neonatal clinical characteristics, maternal complications in previous pregnancy, and maternal complications in current pregnancy, were summarized. According to the results of chi-square tests of independence, there was no association between delivery term and complications in current pregnancy, in terms of pre-gestational diabetes mellitus, GDM, and pre-eclampsia. Nonetheless, numerous statistically significant association were found between risk of preterm birth and demographic as well as clinical factors. *Conclusion*: According to the results, there was no statistically significant association between delivery term and complications in current pregnancy, in terms of pre-gestational diabetes mellitus and pre-eclampsia. However, most of the indicators related to determine the connection between education, number of infants born prematurely, maternal family history of GDM, maternal family history of gestational hypertension, maternal family history of obesity, infants' birth weight, Apgar score at 1 minute and Apgar score at 5 minutes, and fetal demise the second research question were statistically significant with preterm birth. Finally, the researcher recommends addressing the current study's limitation of Omani specific results in broader studies covering a greater population and diverse population demographics. Also the researcher recommends the results of this study be applied to nursing practice and education by training nurses and nursing students to identify factors in patient family histories which might suggest high risk pregnancies.

Keywords: Preterm, Pre-eclampsia, Pre-gestational Diabetes Mellitus, Gestational Diabetes Mellitus

1. Introduction

Unfortunately, millions of infants worldwide are born preterm each year (less than 37 weeks' gestation) and complications from preterm birth are the second leading cause of death in children ages five or younger [1]. Globally, factors related to preterm birth include medical conditions of the mothers or fetus, environmental exposure, infertility treatment, genetic influences, and behavioral and socioeconomic factors [2]. Notably, preterm birth occurs at a rate of over 14% among Omani women. [3] Diabetes and pre-eclampsia rates have also increased among Omani adults,

which can pose a significant threat to pregnant women and their babies [4]. Chronic conditions as pre-gestational diabetes mellitus and gestational diabetes and pre-eclampsia can increase the risk of preterm birth [1]. The problem that this study sought to address is that it is not known whether gestational age (preterm or term infants) is impacted by the occurrence of pre-gestational diabetes mellitus, GDM, and pre-eclampsia among Omani women. This study also examined if and to what extent demographic variables and clinical variables are related to delivering preterm or term infants among Omani women. Ultimately, the results from this study can help inform education efforts to pregnant Omani women and policy formation to promote maternal and infant health. Shonkoff's (2010) bio-developmental framework guided the current study [5].

Results of studies on risk factors associated with preterm birth have varied in result. For example, it was found that maternal age was a risk factor for preterm birth [6-8]. However, another studies found contradicting results [9-11]. The difference in study outcomes could potentially result from differences in study design, suggesting an inconsistency in research on the effect of maternal age on preterm birth. One study performed a prospective study on 885 pregnant women residing in Sri Lanka. The focus of the study was the impact of stress on birth, so it is possible that the study participants were both younger and under more stress than the participants in other studies, which could impact preterm birth [6]. Unlike to this study, another study focused on older pregnant women, with ages greater than 35 [7]. This study also included a substantial number of patients (400) but included a control group.

Different study did not focus on patients under substantial stress but rather focused on a number of participants from the general population (8,586 participants) [9]. In this study, the research team used a cross-sectional population study, rather than focusing on a singular group of women. Among this wider population, the team found that the most significant risk factors for preterm birth were being a single mother or a teenage mother. The results were less significant for older participants, contradicting other study [7]. Previous studies were conducted in different countries, however, there is a lack of the available studies in the Middle East, the Gulf countries and Oman in particular showed a gap in literature.

Studies related to GDM, pre-eclampsia, and preterm birth used a variety of research designs and produced consistent results. One researcher used a retrospective cohort study design and found that the frequency and occurrence of GDM were increasing [12]. Another study used a systemic literature review to evaluate the relationship of BMI and pre-eclampsia [13]. The results of this study were consistent with above mentioned study, because rates of high BMI's are increasing among pregnant women [12]. Additionally, studies focusing on GDM, pre-eclampsia, and preterm birth included diverse populations and research approaches. One study examined perinatal outcomes among Southeast Asian women and found that their rates were of GDM were higher than Japanese women and non-Hispanic white women born in the United States [14]. However, a potential flaw in this study is that all of the non-Hispanic white women and Japanese women were born in the United States, which begs the question of whether the lower rates of GDM might be a function of healthcare in the United States verses Southeast Asia.

Studies on the prevention of preterm birth are largely unified and, while they may focus on different prevention techniques, typically do not contradict one another. However, a potential weakness in preterm birth prevention studies is a large focus on preventing preterm birth in women who are already exhibiting risk factors. For example, one researcher studied the efficacy of progesterone in reducing preterm birth and found it to be effective. However, this study focused on women who already had one preterm birth, as progesterone is only FDA approved for that group [15]. Similarly, another study indicate that aspirin might be helpful in treating women with pre-eclampsia, which put women at risk for preterm birth [16]. However, aspirin was not found to be helpful in women who were otherwise healthy. One study echoes the need for additional focus on preventing preterm birth in women who do not yet exhibit risk factors, which can include increased education, improved nutrition, and smoking cessation [17]. Most similar studies agree that early education and preconception care is important [4, 17, 18]. Studies suggesting the importance of early medical care and education tended to be cross-sectional with large population sizes.

2. Methodology

2.1. Study Area

The study was conducted in one hospital in Oman, Ibri Regional Hospital, a government health care institution that provides free primary and secondary health care services to patients. Ibri Hospital is the regional and referral hospital in the Al Dhahira Governate with 240 beds that receives patients from throughout the governate, including patients who are transferred from local health centers and extended health centers. In 2015, the total of full-term infants born in Ibri Hospital was 3,910 and the total of preterm infants was 372, whereas in 2016 there were 3,944 full-term infants and 394 preterm infants [19].

2.2. Study Design

The current study utilized quantitative methods. Specifically, this is a retrospective cross-sectional study using secondary data. The current study used previously reported data regarding women that delivered preterm and term infants and outcomes of pre-gestational diabetes mellitus, GDM, and pre-eclampsia, while also utilizing previously collected demographic and clinical data (e.g. maternal demographic data, complications in current pregnancy, and complications in previous pregnancy).

2.3. Sample Size Determination

A sample size was derived for logistic regression depends on the number of predictors and the estimated percentage of preterm subjects. Using three predictors (pre-gestational diabetes mellitus, gestational diabetes mellitus, pre-eclampsia) and 10% preterm subjects, the required sample size is 300 participants (150 preterm birth and 150 full term birth). Based on the data reported by Ibri Hospital, where the subjects of this study gave birth, 10% of births were preterm during the period between 2015 to 2017 (3,910 to 3,944 full term infants/ 372 to 394 preterm infants) [19].

According to Peduzzi, Concato, Kemper, Holford, and Feinstein [20] to calculate the sample needed to power the current study, when p is the smallest of the proportions of negative or positive cases in the population and k is the number of covariates (the number of independent variables), then the minimum number of cases to include is: $N = 10k/p$. In the current study there are three covariates and the proportion of positive cases in the population is 0.10 (10%). The minimum number of cases required is $N = 10 \times 3/0.10 = 300$. This sample size helped to ensure sufficient power to detect relationship among the predictors. To power the analyses, the researcher needed at least $N = 300$ and was able to randomly select $N = 400$ in equal groups. The power analysis to determine sample size for the Chi-squares was based on alpha=.05, power=.80, and a medium effect size. The actual sample size was larger than the minimums calculated in these analyses resulting in more power than required to detect medium effects.

2.4. Sampling Technique

In the current study, simple random sampling was followed to select the participants. During the random selection of the selected participants, the participants' code number list and commands were given to the computer software program to select 200 mothers who delivered preterm birth infants, born before 37 gestational weeks, out of a total of 800 mothers. The selection procedure was performed by opening the Research Randomizer program page; filling in the required fields; entering the number to be generated (1), the number in each set (200), the range of number (1-800); selecting the order of numbers as ascending; and finally clicking 'Randomize' to get the required 200 numbers for selecting participants. Then, the numbers were matched with the list of eligible patients. A similar procedure was applied to select a random sample of 200 mothers out of 5000 women who delivered full term infants, born at or after 37 gestational weeks. Within each group, the participants had an equal chance of being included in this study.

2.5. Ethical Approval

Approval from the Institutional Review Boards (IRB) from the Ministry of Health in Oman and Villanova University was obtained. The data were de-identified, though they were extracted from identified patient health records. There were minimal potential risks to the patient participating in this study. The use of secondary data did not involve meeting with patients or informed consent. The researcher does not have any conflicts of interest and does not predict any ethical violations.

2.6. Data Collection Instruments

The researcher familiarized herself with the available data in the electronic health records to make sure that the data of interest existed. The common risk factors for preterm birth were selected according to the research questions. The form was developed with guidance of expertise in nursing care of childbearing women and families. The form was refined by expertise in preterm birth. Additionally, the form was reviewed and refined by a senior nurse in Oman who has experience in maternal and child health nursing. All the experts helped in refining the form and have a specific content. Pilot testing a data extraction tool early in the study phase helps researchers gauge the ease of use and efficiency of the data collection. The form was reviewed by a senior nurse in Ibri Hospital in Oman to confirm the feasibility of the form and to allow for more refinement. The principal investigator of the study is the only person who collected the needed data from the medical records.

2.7. Methods of Data Collection

The electronic health record that is used in Ibri Hospital is Al Shifa 3 Plus. It is a comprehensive healthcare information management system. It is a fully integrated and easily accessible electronic medical record that provides a view of the patient's care. It captures all aspects of patient's information that have clinical significance, from the patient's referral or walk into the healthcare facility to the discharge from the facility after the needed care is delivered. The mother and child module is one of the modules that can be found in this health record. It records the birth history and prenatal care. Once the infant is born, a record is created in the system and the care will be extended to the child under the IMCI (Integrated Management Childhood Illnesses system). The current study aimed to determine the relationship between pre-gestational diabetes mellitus, GDM, and pre-eclampsia with preterm birth. Research Randomizer was used to select the participants in the study to avoid selection bias. The data were extracted from the medical records using a data extraction tool, which was developed to answer the research questions.

2.8. Data Analysis

All data were analyzed using the Statistical Package for the Social Sciences (SPSS) software version 20 for Windows (IBM Corp., Armonk, NY). Continuous variables, such as gestation, gravidity, parity, spontaneous abortion, medically induced abortion, and number of infants born prematurely, were converted into categorical variables. Descriptive analyses were conducted first, and frequency tables were used to summarize the patients' data, including demographics of the mothers, clinical characteristics for mothers, clinical

characteristics for infants, complications in previous pregnancy for mothers, and complications in current pregnancy for mothers.

Then, chi-square tests of independence were performed to answer all the research questions. Chi-square test was used because the data were either nominal or ordinal (subjects fall into categories) and included frequency counts of subjects falling into each category; each subject could fall into only one category; and the groups (preterm/full term) were independent. As multiple tests were performed, the type 1 error rate was inflated, and therefore, for any test, a *p*-value less than 0.01, rather than 0.05, was considered significant in this study. All *p*-values were two-sided. When significance was found and an independent variable included more than two categories, post hoc testing was performed.

3. Results

This study was conducted from 2015 to 2017. A total of 400 women, regardless of their age were included in the study (200 participants gave birth to preterm infants and 200 participants gave birth to full term infants). Demographic characteristics of the participants are presented in Table 1. Over 60% (60.7%) of the women were 25 to 35 years old. The mean age of the participants was 29.26 (SD=5.75) years. Over two-thirds of the women (68.7%) were housewives. Almost half of the women (49.3%) had secondary education.

Table 1. Demographics of the Mothers.

Variable		N	%
Age	<25 years	82	20.5
	25-35 years	243	60.7
	≥35 years	75	18.8
Marital status	Married	400	100
Occupation	Housewife	250	68.7
	Education sector	30	8.2
	Health sector	44	12.1
	Other	40	11
Level of education	No education	11	3
	Primary	27	7.4
	Middle	42	11.6
	Secondary	179	49.3
	Higher	104	28.7

Note. N=400. There were 36 missing values for occupation and level of education.

Table 2 shows the clinical characteristics of mothers, half of the women (50.0%) had gestation ≥ 37 weeks. A majority of the women had gravidity 1 to 4 (74.2%), parity of 0 to 4 (82.1%), no spontaneous abortion (72.8%), no medically induced abortion (98.0%), no multifetal pregnancies (97.5%), no history of fetal demise (96.8%), no treatment of infertility (97.7%), no history of high blood pressure (98.0%), no history of pre-gestational diabetes mellitus (96.2%), no history of elevated HbA1C

(99.2%), and no maternal family history of obesity (80.3%). Over 60% of the women had no maternal family history of GDM (62.8%) or gestational hypertension (62.8%). Slightly less than half of the women (48.0%) had no infants born prematurely.

Table 2. Clinical Characteristics for Mothers.

		N	%
Gestation	<28 weeks	32	8.0
	28-31 weeks	29	7.0
	32-36 weeks	140	35.0
	≥37 weeks	129	50.0
Gravidity	1-4	297	74.2
	5-7	80	20.0
	>7	23	5.8
Parity	0-4	326	82.1
	5-7	57	14.4
	>7	14	3.5
Spontaneous abortion	0	291	72.8
	1	77	19.2
	2-6	32	8.0
Medically induced abortion	0	392	98.0
	1-3	8	2.0
Number of infants born prematurely	0	192	48.0
	1	168	42.0
	2-5	40	10.0
Multiple pregnancies	No	390	97.5
	Yes	10	2.5
History of fetal demise	No	387	96.8
	Yes	13	3.2
Treatment of infertility	No	388	97.7
	Yes	9	2.3
Mother's history of high blood pressure	No	390	98.0
	Yes	8	2.0
Mother's history of pre-gestational diabetes mellitus	No	383	96.2
	Yes	15	3.8
Mother's history of elevated HbA1c	No	395	99.2
	Yes	3	0.8
Maternal family history of GDM	No	248	62.8
	Yes	105	37.2
Maternal family history of gestational hypertension	No	230	62.8
	Yes	136	37.2
Maternal family history of obesity	No	293	80.3
	Yes	72	19.7
Pregnancy outcome	Preterm	200	50.0
	Full	200	50.0

Note. N=400. There were 3 missing values for parity, treatment of infertility, 2 missing values for mother's history of high blood pressure, pre-gestational diabetes mellitus, and elevated HbA1C, 47 missing values for maternal family history of GDM, 34 missing values for maternal family history of gestational hypertension, and 35 missing values for maternal family history of obesity.

Neonatal clinical characteristics are presented in Table 3. Almost all infants were delivered via spontaneous vaginal delivery (97.0%). Slightly over half of the infants (56.0%) were ≥ 2500 grams at birth. A majority of the infants had Apgar scores of 7 to 10 at 1 minute (85.5%) and Apgar scores of 7 to 10 at 5 minutes (93.4%).

Table 3. *Clinical Characteristics for Infants.*

		N	%
Type of delivery	Spontaneous Vaginal Delivery	387	97.0
	Cesarean section	11	2.7
	Forceps Assisted Vaginal Delivery	0	0
	Vacuum Assisted Vaginal Delivery	1	0.3
Infant's birth weight	<2500 gram	176	44.0
	≥2500 gram	224	56.0
Apgar score at 1 minute	0-3	32	8.0
	4-6	26	6.5
	7-10	342	85.5
Apgar score at 5 minutes	0-3	15	3.8
	4-6	15	3.8
	7-10	370	93.4

Note. N=400.

Table 4. *Complications in a Previous Pregnancy.*

		N	%
Anemia	No	262	65.4
	Yes	43	10.8
	Not applicable	95	23.8
Pre-eclampsia	No	300	75
	Yes	6	1.5
	Not applicable	94	23.5
Gestational hypertension	No	303	75.7
	Yes	1	0.3
	Not applicable	96	24
Gestational diabetes mellitus	No	281	70.2
	Yes	24	6
	Not applicable	95	23.8
Urinary tract infections	No	303	75.7
	Yes	1	0.3
	Not applicable	96	24
Cervical incompetence	No	288	72
	Yes	17	4.3
	Not applicable	95	23.7
Placenta previa	No	299	74.7
	Yes	6	1.5
	Not applicable	95	23.8
Placental abruption	No	304	76
	Yes	1	0.3
	Not applicable	95	23.7
Pre-existing hypertension/Renal disease	No	305	76.2
	Yes	1	0.3
	Not applicable	94	23.5
Fetal macrosomia	No	304	76
	Yes	2	0.5
	Not applicable	94	23.5
Fetal demise	No	299	74.7
	Yes	6	1.5
	Not applicable	95	23.8

Note. N=400. Not applicable due to first pregnancy.

Maternal complications in a previous pregnancy were recorded and they are summarized in Table 4. Around 10% of the women (10.8%) had anemia in previous pregnancy. Very few women had pre-eclampsia (1.5%), gestational hypertension (0.3%), urinary tract infections (0.3%), placenta previa (1.5%), placental abruption (0.3%), pre-existing hypertension/Renal disease (0.3%), fetal macrosomia (0.5%), or fetal demise (1.5%) in previous pregnancy. Under 10% of the women had GDM (6.0%) and cervical incompetence (4.3%) in a previous pregnancy.

Maternal complications in the current pregnancy were

recorded and they are summarized in Table 5. Over one-third of the women (33.3%) had anemia in the current pregnancy. Very few women had pre-eclampsia (4.0%), pre-gestational diabetes mellitus (1.3%), urinary tract infections (3.0%), placenta previa (1.3%), pre-existing hypertension/Renal disease (0.3%), or fetal demise (0.3%) in current pregnancy. More than 20% of the women (22.5%) had GDM and five percent of the women had cervical incompetence in the current pregnancy. No women (0%) had fetal macrosomia and placental abruption in current pregnancy.

Table 5. *Complications in Current Pregnancy.*

		N	%
Anemia	No	267	66.7
	Yes	133	33.3
Pre-eclampsia	No	384	96.0
	Yes	16	4.0
Pre-gestational diabetes mellitus	No	395	98.7
	Yes	5	1.3
Gestational diabetes mellitus	No	310	77.5
	Yes	90	22.5
Urinary tract infections	No	388	97.0
	Yes	12	3.0
Cervical incompetence	No	379	95
	Yes	20	5.0
Placenta previa	No	394	98.7
	Yes	5	1.3
Placental abruption	No	400	100
	Yes	0	0
Pre-existing hypertension/ Renal disease	No	397	99.3
	Yes	3	0.7
Fetal macrosomia	No	400	100
	Yes	0	0
Fetal demise	No	399	99.1
	Yes	1	0.3

Note. N=400. There was a missing value for cervical incompetence and placenta previa.

According to the results of chi-square test of independence, there were no statistically significant between delivery term and complications in current pregnancy, in terms of pre-eclampsia ($\chi^2(1, N=400)=6.510, p=0.011$), pre-gestational diabetes mellitus ($\chi^2(1, N=400)=5.063, p=0.024$), and GDM ($\chi^2(1, N=400)=3.670, p=0.055$). Table 6.

Table 6. *Association Between Delivery Term and Complications in Current Pregnancy (Pre-eclampsia, Pre-Gestational Diabetes Mellitus, and GDM).*

		Preterm	Full-term	Chi-square test	p
Pre-eclampsia	No	187 (93.5)	197 (98.5)	$\chi^2(1, N=400)$ =6.510	0.011
	Yes	13 (6.5)	3 (1.5)		
Pre-Gestational diabetes mellitus	No	195 (97.5)	200 (100)	$\chi^2(1, N=400)$ =5.063	0.024
	Yes	5 (2.5)	0		
GDM	No	147 (73.5)	163 (81.5)	$\chi^2(1, N=400)$ =3.670	0.055
	Yes	53 (26.5)	37 (18.5)		

Note. $p<0.01$ indicates significance.

Regarding the association between term versus preterm delivery term in relation to maternal demographic

characteristics, it was found that there were statistically significant associations between delivery term and occupation (χ^2(3, N=364)=116.471, p<0.001) and education level (χ^2(4, N=363)=144.844, p<0.001) (Table 7).

***Table 7.** Association Between Delivery Term and Demographics.*

Variable		Preterm	Full-term	Chi-square test	p
Age	<25 years	51 (25.5)	31 (15.5)	χ^2(2, N=400)=6.706	0.035
	25-35 years	111 (55.5)	132 (66.0)		
	≥ 35 years	38 (19.0)	37 (18.5)		
Marital status	Married	200 (100)	200 (100)	NA	
Occupation	Housewife	182 (92.9)	68 (40.5)	χ^2(3, N=364)=116.471	<0.001*
	Education sector	2 (1.0)	28 (16.7)		
	Health sector	8 (4.1)	36 (21.4)		
	Other	4 (2.0)	36 (21.4)		
Level of education	No education	11 (5.6)	0	χ^2(4, N=363)=144.844	<0.001*
	Primary	27 (13.8)	0		
	Middle	42 (21.4)	0		
	Secondary	104(53.1)	75 (44.9)		
	Higher	12 (6.1)	92 (55.1)		

*Note. p<0.01 indicates significance. NA=not applicable. *indicates significant at the 0.01 level. Post hoc analysis for pairwise comparisons was performed for variables with more than two levels.*

Regarding the association between preterm versus term delivery and maternal clinical characteristics, it was found that there were statistically significant associations between delivery term and medically induced abortion (χ^2(1, N=399)=8.205, p=0.004), number of infants born prematurely (χ^2(2, N=400)=354.464, p<0.001), multiple pregnancies (χ^2(1, N=400)=7.572, p=0.006), maternal family history of GDM (χ^2(1, N=353)=112.649, p<0.001), maternal family history of gestational hypertension (χ^2(1, N=366)=136.311, p<0.001), and maternal family history of obesity (χ^2(1, N=365)=78.857, p<0.001) (Table 8).

***Table 8.** Association Between Delivery Term and Clinical Characteristics for Mothers.*

Variable		Preterm	Full-term	Chi-square test	P
Gravidity	1-4	150 (75.0)	147 (73.5)	χ^2(2, N=400)=0.274	0.872
	5-7	38 (19.0)	42 (21.0)		
	>7	12 (6.0)	11 (5.5)		
Parity	0-4	164 (83.2)	162 (81.0)	χ^2(2, N=397)=0.433	0.805
	5-7	27 (13.8)	30 (15.0)		
	>7	6 (3.0)	8 (4.0)		
Spontaneous abortion	0	144 (72.4)	146(73.0)	χ^2(2, N=399)=1.461	0.482
	1	36 (18.1)	41 (20.5)		
	2-6	19 (9.5)	13 (6.5)		
Medically induced abortion	0	191 (96.0)	200 (100)	χ^2(1, N=399)=8.205	0.004*
	1-3	8 (4.0)	0		
Number of infants born prematurely	0	2 (92.9)	190 (40.5)	χ^2(2, N=400)=354.464	<0.001*
	1	158 (1.0)	10 (16.7)		
	2-5	40 (4.1)	0 (21.4)		
Multiple pregnancies	No	190 (95.0)	199 (99.5)	χ^2(1, N=400)=7.572	0.006*
	Yes	10 (5.0)	1 (0.5)		
History of fetal demise	No	189 (94.5)	198 (99.0)	χ^2(1, N=400)=6.440	0.011
	Yes	11(5.5)	2 (1.0)		
Treatment of infertility	No	191 (96.0)	197 (99.5)	χ^2(1, N=397)=5.535	0.019
	Yes	8 (4.0)	1 (0.5)		
Mother's history of high blood pressure	No	191 (96.5)	199 (99.5)	χ^2(1, N=398)=4.654	0.031
	Yes	7 (3.5)	1 (0.5)		
Mother's history of pre-gestational diabetes mellitus	No	192 (97.0)	191 (95.5)	χ^2(1, N=398)=0.593	0.441
	Yes	6 (3.0)	9 (4.5)		
Mother's history of elevated HbA1C	No	197 (99.5)	198 (99.0)	χ^2(1, N=398)=0.326	0.568
	Yes	1 (0.5)	2 (1.0)		
Maternal family history of GDM	No	183 (93.4)	65 (41.4)	χ^2(1, N=353)=112.649	<0.001*
	Yes	13 (6.6)	92 (56.6)		
Maternal family history of gestational hypertension	No	177 (90.3)	53 (31.2)	χ^2(1, N=366)=136.311	<0.001*
	Yes	19 (9.7)	117 (68.8)		
Maternal family history of obesity	No	191 (97.4)	102 (60.4)	χ^2(1, N=365)=78.857	<0.001*
	Yes	5 (2.6)	67 (39.6)		

*Note. p<0.01 indicates significance. * indicates significant at the 0.01 level. Post hoc analysis for pairwise comparisons was performed for variables with more than two levels.*

Regarding the association between preterm versus term delivery and neonatal clinical characteristics, it was found that there were statistically significant associations between delivery term and type of delivery (χ^2(2, N=399)=12.310, p=0.002), infants' birth weight (χ^2(1, N=400)=182.183, p<0.001), Apgar score at 1 minute (χ^2(2, N=400)=50.425, p<0.001), and Apgar score at 5 minute (χ^2(2, N=400)=28.386, p<0.001) (Table 9).

Table 9. *Association Between Delivery Term and Clinical Characteristics for Infants.*

Variable		Preterm	Full-term	Chi-square test	p
Type of delivery	Spontaneous Vaginal Delivery	188 (94.5)	199 (99.5)	χ^2(2, N=399)=12.310	0.002*
	Cesarean section	11 (5.5)	0		
	Forceps Assisted Vaginal Delivery	0	0		
	Vacuum Assisted Vaginal Delivery	0	1 (0.5)		
Infant's birth weight	<2500 gram	155 (77.5)	21 (10.5)	χ^2(1, N=400)=182.183	<0.001*
	≥ 2500 gram	45 (22.5)	179 (89.5)		
Apgar score at 1 minute	1-3	30 (15.0)	2 (1.0)	χ^2(2, N=400)=50.425	<0.001*
	4-6	24 (12.0)	2 (1.0)		
	7-10	146 (73.0)	196 (98.0)		
Apgar score at 5 minutes	1-3	14 (7.0)	1 (0.5)	χ^2(2, N=400)=28.386	<0.001*
	4-6	15 (7.5)	0		
	7-10	171 (85.5)	199 (99.5)		

*Note. p<0.01 indicates significance. * indicates significant at the 0.01 level. Post hoc analysis for pairwise comparisons was performed for variables with more than two levels.*

Regarding the association between preterm versus term delivery and complications in previous pregnancy, it was found that there were statistically significant associations between delivery term and cervical incompetence (χ^2(1, N=305)=14.111, p<0.001), placenta previa (χ^2(1, N=305)=7.707, p=0.006), and fetal demise (χ^2(1, N=305)=7.707, p=0.006) in previous pregnancy (Table 10).

Table 10. *Association Between Delivery Term and Complications in Previous Pregnancy.*

Variable		Preterm	Full-term	Chi-square test	p
Anemia	No	117 (87.3)	145 (84.8)	χ^2(1, N=305)=0.393	0.531
	Yes	17 (12.7)	26 (15.2)		
Pre-eclampsia	No	130 (96.3)	170 (99.4)	χ^2(1, N=306)=3.818	0.051
	Yes	5 (3.7)	1 (0.6)		
Gestational hypertension	No	134 (100)	169 (99.4)	χ^2(1, N=304)=0.791	0.374
	Yes	0	1 (0.6)		
GDM	No	120 (88.9)	161 (94.7)	χ^2(1, N=305)=3.512	0.061
	Yes	15 (11.1)	9 (5.3)		
Urinary tract infections	No	133 (99.3)	170 (100)	χ^2(1, N=304)=1.273	0.259
	Yes	1 (0.7)	0		
Cervical incompetence	No	120 (88.9)	168 (98.8)	χ^2(1, N=305)=14.111	<0.001*
	Yes	15 (11.1)	2 (1.2)		
Placenta previa	No	129 (95.6)	170 (100)	χ^2(1, N=305)=7.707	0.006*
	Yes	6 (4.4)	0		
Placental abruption	No	133 (93.3)	171 (100)	χ^2(1, N=305)=1.280	0.258
	Yes	1 (0.7)	0		
Pre-existing hypertension/Renal disease	No	134 (99.3)	171 (100)	χ^2(1, N=306)=1.271	0.260
	Yes	1 (0.7)	0		
Fetal macrosomia	No	135 (100)	169 (98.8)	χ^2(1, N=306)=1.589	0.207
	Yes	0	2 (1.2)		
Fetal demise	No	129 (95.6)	170 (100)	χ^2(1, N=305)=7.707	0.006*
	Yes	6 (4.4)	0		

*Note. p<0.01 indicates significance. * indicates significant at the 0.01 level.*

Regarding the association between preterm versus term delivery and complications in the current pregnancy, it was found that there was a statistically significant association between delivery term and cervical incompetence (χ^2(1, N=399)=13.560, p<0.001) in current pregnancy (Table 11).

Table 11. *Association Between Delivery Term and Complications in Current Pregnancy.*

		Preterm	Full-term	Chi-square test	p
Anemia	No	134 (67.0)	133 (66.5)	χ^2(1, N=400)=0.011	0.915
	Yes	66 (33.0)	67 (33.5)		

		Preterm	Full-term	Chi-square test	*p*
Urinary tract infections	No	191 (95.5)	197 (98.5)	χ^2(1, *N*=400)=3.093	0.079
	Yes	9 (4.5)	3 (1.5)		
Cervical incompetence	No	181 (91.0)	198 (99.0)	χ^2(1, *N*=399)=13.560	<0.001*
	Yes	18 (9.0)	2 (1.0)		
Placenta previa	No	194 (97.5)	200 (100)	χ^2(1, *N*=399)=5.089	0.024
	Yes	5 (2.5)	0		
Placental abruption	No	199 (100)	200 (100)	NA	NA
	Yes	0	0		
Pre-existing hypertension/Renal disease	No	197 (98.5)	200 (100)	χ^2(1, *N*=400)=3.023	0.082
	Yes	3 (1.5)	0		
Fetal macrosomia	No	200 (100)	200 (100)	NA	NA
	Yes	0	0		
Fetal demise	No	199 (99.5)	200 (100)	χ^2(1, *N*=400)=1.003	0.317
	Yes	1 (0.5)	0		

*Note. p<0.01 indicates significance. NA=not applicable. * indicates significance at the 0.05 level.*

4. Discussion

Related to the research question: Do women in Oman who delivered preterm infants have significantly higher rates of pre-gestational diabetes mellitus (type 1 and type 2), gestational diabetes mellitus (GDM), and pre-eclampsia than women who deliver term infants? The results indicated that among women who had full term infants, 1.5% had pre-eclampsia, none had pre-gestational diabetes mellitus, and 18.5% had GDM. Among women who had preterm infants, 6.5% had pre-eclampsia, 2.5% had pre-gestational diabetes mellitus, and 26.5% had GDM. According to the results of chi-square test of independence, there was no association between pregnancy duration and complications in current pregnancy, including pre-eclampsia (χ^2(1, *N*=400)=6.510, *p*=0.011), pre-gestational diabetes mellitus (χ^2(1, *N*=400)=5.063, *p*=0.024), and GDM (χ^2(1, *N*=400)=3.670, *p*=0.055). These findings are inconsistent with current literature on preterm birth and pre-gestational diabetes mellitus, GDM, and pre-eclampsia. The study results indicated that while a larger percentage of Omani women who delivered preterm infants had pre-eclampsia than women who delivered full-term infants, the results were not statistically significant (χ^2(1, *N*=400)=6.510, *p*=0.011). These results contradict literature was done by different researchers who found that women with pre-eclampsia were more likely to deliver preterm babies [13, 21].

Related to the research question: What are the relationships between selected demographic or clinical factors and preterm birth among women in Oman? The findings of this study indicated that there was a statistically significant association between pregnancy duration and occupation (χ^2(3, *N*=364)=116.471, *p*<0.001) and education level (χ^2(4, *N*=363)=144.844, *p*<0.001) (Table 5). Additionally, mothers with preterm infants were statistically significantly more likely to have: medically induced abortion, previous preterm infants, multiple pregnancies, family histories of GDM, family history of gestational hypertension, and family histories of obesity. Finally, mothers with preterm infants were more likely to have cervical incompetence, placenta previa and fetal demise. In the current pregnancy, women with full-term infants were less likely to have cervical incompetence than mothers with preterm infants. These findings largely confirm current literature on maternal demographics. The study findings indicated that a maternal history of preterm births indicates an increased likelihood that the current pregnancy would be preterm, which confirms the findings of numerous researchers [9, 10]. The study findings confirm that women with family histories of obesity were more likely to have preterm infants, which was largely expected due to substantial literature suggesting that maternal obesity contributes to the likelihood that a woman will develop pre-eclampsia [12, 13]. As indicated by the study results and current literature, women who develop pre-eclampsia are more likely to deliver preterm [22].

Additionally, the study results indicate that women with higher degrees of education are more likely to deliver full term infants, which supports the findings of different literatures [6, 10]. The study findings and most of the literature review contradicts other finding of different study which argued that the mother's level of education was not associated with preterm birth [9].

Similar to the literature that was reviewed, the study establishes a connection between previous preterm births and previous abortions with preterm births in the current pregnancy. Like the current study, on literature studied the impact of numerous maternal characteristics on current pregnancies and found that women who had previous medically induced abortions or previously delivered preterm infants were more likely to deliver preterm in their current pregnancies [23].

Finally, the current study findings confirm literature on infant characteristics. The current study found that, not surprisingly, preterm infants were more likely to weigh less than 2500 grams at birth, which confirms previous literature findings that found infants born at a decreased gestational age were more likely to be underweight [23]. The current study confirms the facts that preterm birth increased the likelihood of infant demise according to WHO [1]. Though not directly studying the impact of preterm birth and infant Apgar score, previous study found that women with type 1 diabetes were more likely to have infants with abnormal Apgar scores [24].

5. Conclusion

This study intended to determine if there were any relationships between selected demographic or clinical factors and preterm birth. Shonkoff's bio-developmental. framework provided the theoretical foundation for this study. According to the results of chi-square tests of independence, there was no statistically significant association between delivery term and complications in current pregnancy, in terms of pre-gestational diabetes mellitus and pre-eclampsia. The lack of significant connection between pre-gestational diabetes mellitus, GDM, and pre-eclampsia, in the current study was surprising, and could potential result from the specificity of Omani patients, or these unexpected findings reflect the general health of Omani women. However, most of the indicators related to determine connection between education, number of infants born prematurely, maternal family history of GDM, maternal family history of gestational hypertension, maternal family history of obesity, infants' birth weight, Apgar score at 1 minute and Apgar score at 5 minutes, and fetal demise the second research question were statistically significant with preterm birth.

The researcher recommends addressing the current study's limitation of Omani specific results in broader studies covering a greater population and diverse population demographics. Also the researcher recommends the results of this study be applied to nursing practice and education by training nurses and nursing students to identify factors in patient family histories which might suggest high risk pregnancies. Additionally, it is important for nurses and doctors in a clinical setting to advise women about the risks associated with obesity, pre-eclampsia, and preterm delivery. Women who face a higher than average risk of preterm delivery due to demographic information or family history should receive increased education and care surrounding their pregnancy.

Acknowledgements

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