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THE ASSOCIATION BETWEEN FOETUS GROWTH AND PREGNANCY OUTCOME AND MATERNAL BMI AND NEONATAL BIRTH WEIGHT

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Abstract: The associations between Low Birth Weight and a greatly elevated risk of infant mortality Hence prevention of LBW is a major public health priority. This piece of research aims to understand the relationship between the maternal BMI, foetal growth, and the pregnancy outcome. A total of 455 ultrasound observations from 229 respondents were collected using a Prospective Observational Cohort Mixed Longitudinal study design in the second and last trimester of pregnancy from one private and two government hospitals in Pune, India to document AC, HC, BPD, FL and FW from 28th to 38th weeks of gestation during August 2018 to March 2020. The statistical analysis shows that the pregnancy outcome does not differ significantly according to the foetus growth. There is no relation between foetus growth and pregnancy outcome. But maternal BMI has shown association with neonatal weight. Increase in maternal BMI shows increase in the foetal weight.

***Index Terms*: Foetal parameters, Maternal BMI, Pregnancy outcome, Neonatal Birth weight**

Abbreviations:

BPD	=	Biparietal Diameter	FL	=	Femur Length
HC	=	Head Circumference	FW	=	Foetal Weight
AC	=	Abdominal Circumference	BMI	=	Body Mass Index
EDD	=	Estimated Date of delivery	NICU	=	Neonatal Intensive Care Unit

1. INTRODUCTION:

Pregnancy is one of the most critical and unique period in a woman's life cycle and also it is regarded as 'Welcome event' for successful womanhood in many societies. (Vijayalaxmi & Urooj, 2009) A review of epidemiological data which links maternal stress, physical stain and fasting and its association with preterm birth or low birth weight. (Hobel & Culhane, 2003). Maternal risk factors contribute substantially to neonatal, infant, and childhood mortality and morbidity (Park, 2017). Across the world, neonatal mortality is 20 times more likely for LBW babies compared to Normal Birth Weight (NBW) babies (>2.5 kg) (Badart-Smook, et al., 2008) Hence it is a well-recognized fact that birth weight is not only a critical determinant of child future health conditions like survival, growth, and development, but also is a valuable indicator of maternal health, nutrition, and quality of life (Moreira, et al., 2013)

2. NEED OF THE STUDY.

It is now a well-recognized fact that maternal health, nutrition, and quality of life is an indicator of birth weight of the neonate which is a critical determinant of child survival, growth, and development (Teo, Koon, Clara K. Chow, Mario Vaz, Sumathy Rangarajan, and Salim Yusuf. 2009). Low birth weight is weight less than 2,500g or (<5.5lbs) irrespective of gestational age with the measurement being taken preferably within the first hour of life, before significant postnatal weight loss has occurred. (*UNICEF-WHO Low Birthweight Estimates 2019 .Pdf*). WHO 1995 guidelines indicates LBW, prematurity and intrauterine growth retardation (IUGR) are the leading causes of perinatal morbidity, mortality, neurodevelopmental impairments and disabilities among newborn babies (*95docguidelines.Pdf*) (Rondó et al., 2003). Birth weight plays an important role in infant mortality and morbidity, development, and future health of the child (Durbin, 1975) (Kinsella & Monk, 2009). And also is associated with increased rate of risk of coronary heart dieses, and related disorders like stroke, hypertension and type 2 diabetes as well as other physical and neurologic impairments in future. (Brezina et al., 1975) (Whitaker, 1997) (Barker, 2008). Thus, prevention of LBW is a major public health priority. Hence this study was carried out to find whether there is any relationship between foetus growth and pregnancy outcome and is there any association between maternal BMI and the weight of the foetus,

3. RESEARCH METHODOLOGY

A study with Prospective Observational Cohort Mixed Longitudinal study design in the second and last trimester of pregnancy to document AC, HC, BPD, FL, FW and neonatal birth weight from 28^{th} to 38^{th} weeks of gestation and post-delivery during August 2018 to March 2020 was conducted.

3.1.Population and Sample

A total of 455 ultrasound observations from 229 respondents were collected from one private and two government hospitals from Pune, Maharashtra, India.

A pilot study was conducted in the private hospital for sample size calculation. The pilot study was conducted among (n=42) respondents which was derived on the basis of total deliveries (N=1200) taken place in the hospital per year. Here two institutions are considered under study; hence the population size would be 2*1200 =2400. Final sample size was calculated using Bartlett, Kotrlik, and Higgins, 2001 table for continuous and categorical data where the margins of error used was .03 for continuous data and .05 for categorical data. The population size estimated is 2400 that is 4000 at most approximately (Bartlett, Kotrlik, and Higgins, 2001). The sample size described in the table for continuous data alpha = 0.05 & t = 1.96 is 119 and Cochran's sample size formula which came about minimum sample size for the study to be (N=226; CI:95%) (Bartlett et al., 2001). During entire period of data collection more than 500 women were approached for interviews. Amongst those 415 were considered for study, out of which 229 were the responses for maternal anthropometric measurements, interview and dietary data, but complete set of foetal biometry was obtained from 145 respondents. Hence the actual sample size for main study is 229. Each respondent was visited 3 times during the entire gestation period and the last visit used to be in the PNC ward to document the pregnancy outcome, neonatal anthropometry and other complications/ morbidities if occur during delivery. Hence the number of responses from each respondent were 455

Ethical consideration and Consent:

The study protocol was approved by the Institutional Ethical Committee of Deenanath Mangeshkar Hospital & Research Center *(IHR_2018_ruL_AK_271)*, Savitribai Phule Pune University (SPPU), Pune *(SPPU/IEC/2019/45)* and Pune Municipal Corporation *(HO/1166)*. As per the guidelines and suggestions given by Institutional Ethical Committee of Savitribai Phule Pune University, Deenanath Mangeshkar Hospital and Research Center and Pune Municipal Corporation, the theme of the research topic is well conveyed to all the subjects in all the three hospitals prior to data collection in details. Anthropometric measurements especially of neonates and that to the new born in NICU are taken in presence of hospital authorities. All the data is collected with written consent and by sharing information sheet to the respondents or the relative of the respondents. When the respondent or her relative were convinced, then only actual procedure of data collection used to begin.

3.2.Data and Sources of Data

The methodology employed to document the measurements of the several parts of foetal anatomy and their growth is called as Foetal Biometry. Ultrasound scanning is the technique which is most reliable and important

to understand the growth and wellbeing of the foetus is used in it as a secondary tool. Apart from this the anthropometry of the mother was documented thrice i.e. the initial reading documented on the ANC card at first visit, during the 24th to 30th week of gestation and during 34th to 38th week of gestation. Anthropometry is a traditional tool of the anthropologists to assess the nutritional status. BMI is the best indicator to assess the nutritional status of the population achieved in specific ecological conditions by extracting food resources around. Height is taken with an anthropometric rod and weight by digital weighing machine to calculate BMI. BMI is the ratio of weight in Kg. to height in meter square. The participants were drawn from middle to affluent socio-economic background from private hospital and below poverty level background from government hospitals. Socio-economic status (SES) is a measure of an individual's of family's social position relative to others (Nick Townsend & Angela Scriven, 2014) which was derived using modified Kuppuswamy's Classification.("MODIFIED KUPPUSWAMY SCALE" retrieved on 2022)

3.3.Theoretical framework

The data were collected within 4 visits from the same respondent. The first interaction was at the time of anomaly scan to confirm singleton pregnancy without anomaly in the 20th week of gestation. The second visit during 28th to 32nd week of gestation and third visit during the third trimester (34th to 38th weeks of gestation) for documentation of fetal biometry through sonography reports. The sex of the fetus was not disclosed during entire period of gestation for legal purpose. Inclusion criteria: All singleton pregnant women with at least one Sonography (19 to 20 weeks) report, irrespective of Socio-economic background, within 18 to 40 years age group, enrolled for institutional delivery in the hospital and, those willing to participate in the study were enrolled as a part of study. Following were the limitations of the study; (i) Genetical factors were not considered; (ii) Biochemical tests were not conducted due to shortage of funds; (iii) chances of drop outs due to migration which were considered as an error.

The demographic background of mothers including information on religion, maternal age, family background, educational status (both mother and father), family income, occupation, pregnancy related information was recorded. In addition to that, gestational weight gain, parity, self-reported pre-pregnancy weight and height were also documented to calculate BMI (weight in kg/ height in meter square). The foetal parameters were documented from sonography reports as a secondary tool (19-20 weeks, 28-32 weeks, 35-38 weeks). The specific objective set for achieving research questions was; to observe the growth parameters of the foetus and the neonatal weight, by compilation of antenatal card to find out Gestational age (EDD) and important notice regarding foetal location in uterus to study the growth of foetus by foetal biometric parameters like: BPD from 2nd trimester, HC in 3rd trimester, AC in 3rd trimester, FL in 2nd and 3rd trimester; to know the important notice regarding foetal location in uterus, foetal growth pattern, clinical condition of pregnant mother during pregnancy, anthropometry of the neonate (length and Weight, Chest Circumference) and to observe the clinical condition of the neonate by documenting deformities, NICU admission etc.

3.4. Statistical tools

Descriptive and Inference Statistical analysis comparison were carried out.

3.4.1. Descriptive Statistics

Descriptive analysis was accomplished to express mean, standard deviation, standard error of mean and minimum, maximum of continuous variables that consisted of; maternal age, , maternal anthropometric measurements, foetal growth parameters, birth measurements of the neonate.

3.4.2. Statistical Analysis

standard numerical techniques are included to compute descriptive statistics such as mean ± SD, minimum, median and maximum to assess the symmetry of data distribution and the validity of the assumption of normality. This analysis was applied to the type of data means, **ANOVA** for quantitative. The information was compiled using Microsoft Excel Version 10 and IBM SPSS Statistics Data Editor Version 29.0.0.0(241)

4. RESULTS AND DISCUSSION

4.1.Results for socio demographic variables

The socio-demographic profile of the respondent reveals; the educational background of the respondents and their husbands shows: 0.9% respondents were able to read and write also the same percentage was seen in the category

of respondents who have studies above post-graduation, 23.5% were 12th passed from both genders. The respondents who performed arrange marriage were 45.3%, 56.5% respondents were staying in joint families. 28.9% families were dependent on single bread winner, 80.4% respondent were having regular menstrual cycle, the problem of addictions was found in 30.7% families, followed by the incidences of possession 23.9%, among one or more family members. The pregnancy related information reveals; 37.5% respondents were primipara, 96.5% respondents reported no cases of still birth or death of neonate during previous deliveries. 83% respondents have history of vaginal delivery, 62.5% respondents delivered their children in civil hospitals. 53.6% respondents reported to have no co-morbidities during pregnancy and 31.7% respondents reported to show symptoms like fatigue over last 6 months. The information about pregnancy outcome shows 75% deliveries were FTND, 83% babies were born within the range of normal weight. the occurrences of Meconium Liquor Stained during the process of delivery was 8.4%, 61.3% neonates were fed with maternal milk immediately after the delivery, 96.9% neonates cried immediately after birth and 8.1% neonates were kept in NICU (Neonatal Intensive Care Unit) for some of the complications during the delivery, because of their weight or respiratory problems.

4.2. Results of Descriptive Statistics of Study Variables in Foetal Growth Parameters and Pregnancy Outcome

Table 4.1 Descriptive Statistics

Vaiable		Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
BPD(II)	FTND	71.45	9.56	.95	69.55	73.35	47.00	92.00
	LSCS	71.97	8.56	2.01	67.71	76.23	51.90	87.00
	LBW	71.24	7.17	1.52	68.06	74.42	54.80	80.60
	SGA	68.66	9.08	2.73	62.55	74.76	50.80	82.00
	LGA	75.83	4.00	1.11	73.41	78.26	67.00	80.80
	IUGR	65.85	1.20	.850	55.04	76.65	65.00	66.70
	Total	71.57	8.81	.68	70.22	72.92	47.00	92.00
HC(II)	FTND	262.3	33.51	3.35	255.70	269.0	175.0	329.0
	LSCS	266.4	29.35	6.91	251.81	281.01	207.0	320.0
	LBW	260.2	25.78	5.49	248.85	271.72	197.3	295.0
	SGA	253.8	31.79	9.58	232.50	275.22	192.0	297.0
	LGA	276.0	13.56	3.76	267.80	284.20	251.0	294.9
	IUGR	247.9	8.34	5.90	172.93	322.86	242.0	253.8
	Total	262.8	30.76	2.38	258.13	267.57	175.0	329.0
AC(II)	FTND	239.4	38.01	3.80	231.92	247.01	152.0	322.0
	LSCS	233.5	44.81	10.56	211.21	255.79	104.4	304.0
	LBW	236.5	27.87	5.94	224.20	248.92	173.1	271.0
	SGA	224.8	37.70	11.36	199.52	250.18	163.0	270.0
	LGA	255.9	24.95	6.92	240.88	271.03	213.0	296.0
	IUGR	211.30	11.73	8.30	105.83	316.76	203.0	219.6
	Total	238.42	36.80	2.85	232.78	244.06	104.4	322.0
FL(II)	FTND	53.78	8.44	.84	52.09	55.46	34.00	71.00
	LSCS	53.98	7.73	1.82	50.13	57.82	38.20	69.00
	LBW	52.67	7.00	1.49	49.57	55.78	37.70	60.00
	SGA	51.75	7.86	2.36	46.47	57.03	37.00	61.00
	LGA	56.00	4.84	1.34	53.07	58.93	45.00	62.30
	IUGR	44.30	7.49	5.30	-23.04	111.64	39.00	49.60
	Total	53.58	7.92	.617	52.36	54.80	34.00	71.00
FW(II)	FTND	1333.60	507.96	51.84	1230.68	1436.53	440	2966
	LSCS	1317.16	489.55	112.3	1081.20	1553.12	482	2566
	LBW	1235.36	396.61	84.55	1059.51	1411.21	481	1752
	SGA	1142.11	520.67	173.55	741.89	1542.34	433	1890
	LGA	1487.38	341.29	94.65	1281.14	1693.63	855	1930
	IUGR	867.50	139.30	98.50	-384.06	2119.06	769	966
	Total	1314.16	480.5	37.87	1239.37	1388.95	433	2966
BPD(III)	FTND	87.81	3.78	.403	87.01	88.61	77.00	95.00
	LSCS	89.037	5.05	1.26	86.34	91.73	72.70	95.00

	LBW	86.31	5.42	1.21	83.77	88.85	74.00	96.00
	SGA	86.35	3.68	1.11	83.87	88.83	80.00	92.00
	LGA	89.14	3.75	1.25	86.25	92.03	84.00	95.20
	IUGR	77.00	.	.	.	.	77.00	77.00
	Total	87.6	4.29	.35	86.93	88.34	72.70	96.00
HC(III)	FTND	318.04	10.957	1.16	315.7	320.32	281.00	337.00
	LSCS	319.05	17.12	4.28	309.92	328.13	266.00	344.00
	LBW	313.97	17.67	3.95	305.69	322.24	273.00	345.00
	SGA	312.85	11.35	3.42	305.22	320.48	296.00	334.10
	LGA	321.81	9.81	3.27	314.26	329.35	303.00	334.00
	IUGR	286.00	.	.	.	.	286.00	286.00
	Total	317.21	13.05	1.089	315.06	319.35	266.00	345.00
AC(III)	FTND	311.89	14.52	1.54	308.81	314.96	251.00	341.00
	LSCS	317.95	23.19	5.79	305.59	330.31	249.00	354.00
	LBW	302.49	21.42	4.79	292.46	312.52	257.00	334.00
	SGA	292.15	19.04	5.74	279.36	304.94	246.00	318.00
	LGA	317.43	9.63	3.21	310.02	324.83	302.00	336.00
	IUGR	246.00	.	.	.	.	246.00	246.00
	Total	309.65	18.64	1.54	306.59	312.71	246.00	354.00
FL(III)	FTND	69.10	3.72	.39	68.31	69.89	57.40	77.00
	LSCS	69.54	4.71	1.17	67.03	72.05	55.60	76.00
	LBW	67.96	5.69	1.27	65.29	70.62	57.40	76.00
	SGA	67.50	3.67	1.10	65.03	69.96	61.20	72.10
	LGA	69.27	4.64	1.54	65.70	72.84	62.50	78.00
	IUGR	59.00	.	.	.	.	59.00	59.00
	Total	68.81	4.25	.35	68.11	69.51	55.60	78.00
FW(III)	FTND	2687.55	326.05	34.56	2618.87	2756.23	1528	3417
	LSCS	2778.33	494.82	127.76	2504.31	3052.36	1361	3566
	LBW	2495.10	492.75	110.18	2264.48	2725.72	1541	3383
	SGA	2278.36	344.58	103.89	2046.87	2509.86	1601	2749
	LGA	2876.22	301.21	100.40	2644.69	3107.76	2440	3403
	IUGR	1480.00	.	.	.	.	1480	1480
	Total	2642.74	404.00	33.55	2576.42	2709.05	1361	3566

Table 4.1displays group statistics (at 5% level of confidence) for foetal parameters like BPD, HC, AC, FL, FW documented from second and third trimester with pregnancy outcome such as FTND, LSCS, LBW, SGA, AGA, LGA, IUGR (Intra Uterine Growth Retardation). The figures in bracket near foetal parameters indicate the gestational trimester. II denotes second trimester and III denotes the third trimester. The descriptive statistics from above table shows the values were normally distributed about their mean and variances.

Table 4.2 ANOVA Independent Samples Test to find out association between foetus growth and pregnancy outcome

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
BPD(II)	Between Groups	402.00	5	80.400	1.036	.398
	Within Groups	12413.64	160	77.585		
	Total	12815.64	165			
HC(II)	Between Groups	3983.90	5	796.780	.837	.525
	Within Groups	152231.35	160	951.446		
	Total	156215.25	165			
AC(II)	Between Groups	8115.19	5	1623.039	1.206	.309
	Within Groups	215391.85	160	1346.199		
	Total	223507.05	165			
FL(II)	Between Groups	310.28	5	62.058	.987	.427
	Within Groups	9993.62	159	62.853		
	Total	10303.91	164			
FW(II)	Between Groups	1228566.76	5	245713.352	1.066	.381
	Within Groups	35715869.04	155	230424.962		
	Total	36944435.80	160			
BPD(III)	Between Groups	220.95	5	44.191	2.517	.032
	Within Groups	2440.30	139	17.556		
	Total	2661.25	144			

HC(III)	Between Groups	1698.54	5	339.709	2.068	.073
	Within Groups	22833.44	139	164.269		
	Total	24531.98	144			
AC(III)	Between Groups	10534.40	5	2106.880	7.411	<.001
	Within Groups	39517.43	139	284.298		
	Total	50051.83	144			
FL(III)	Between Groups	147.61	5	29.523	1.665	.147
	Within Groups	2463.98	139	17.727		
	Total	2611.60	144			
FW(III)	Between Groups	4193506.78	5	838701.357	6.037	<.001
	Within Groups	19309821.25	139	138919.577		
	Total	23503328.04	144			

Table 4.2 shows One-way ANOVA test to find out the association between foetus growth and pregnancy outcome. The figures in bracket indicate the trimester of growth parameters documented. P<0.05 indicates the level of significance. Each of the foetal parameter was tested with pregnancy outcome to find out the association. The result shows that the pregnancy outcome does not differ significantly according to the Foetus Growth. The analysis shows all values more than 0.05 indicating no association between foetal parameters and the pregnancy outcome.

4.3.Results of Descriptive Statistics of Study Variables in Maternal BMI and Neonatal Birth Weight

The association between the BMI of Mother & the Weight of neonate is measured by Pearson's Correlation Coefficient (Table 4) & its significance was tested by t test. P value < 0.05 shows the level of significance. For significant correlation coefficient, if the value is positive then one variable increases with the other & the value is negative then one variable decreases with the increase in other.

Table 4.3 Correlations between BMI of mother and weight of the foetus

Correlations			
		W @ B	BMI
W @ B	Pearson Correlation	1	.465**
	P value (2-tailed)		.000
	N	103	65
BMI	Pearson Correlation	.465**	1
	P value (2-tailed)	**.000**	
	N	65	134
**. Correlation is significant at the 0.01 level (2-tailed).			

Above table 4.3 shows the correlation between BMI of mother with neonatal birth weight. The correlation coefficient between the BMI of Mother & the Weight of Foetus is significant (ρ=0.465, p=0.000). The positive correlation coefficient between the BMI of Mother & the Weight of Foetus suggest that one increases with the other. In other words, the increase in the BMI of mother increases the weight of the foetus.

Discussion

Bukowski R. states about "Fetal Growth Potential and Pregnancy Outcome" in Perinatology seminar that; when compared with traditional population-based norms, fetal growth potential is a better predictor of several important adverse outcomes of pregnancy which include: stillbirth, neonatal mortality and morbidity, and long-term adverse neonatal outcomes like neonatal encephalopathy, cerebral palsy and cognitive abilities. He further adds that the impairment of individual growth potential is also strongly associated with spontaneous preterm delivery. He further recommends definitive interventional trials to be conducted to validate the clinical value of fetal growth potential, but yet many observational studies, conducted in various populations, indicate its significant promise in this respect. (Bukowski, 2004) A study conducted among 290 young, primarily minority gravidas found infants delivered preterm had asymmetric growth patterns suggesting growth failure late in pregnancy. (Hediger et al., 1995) A study conducted among obese women to understand the risk of adverse pregnancy outcome among overweight or obese women shows the increased risk of caesarean section or induced delivery compared to women with normal BMI. Also babies of such women are more likely to be large for gestational age (LGA). (Athukorala et al., 2010) Women with short stature (<145cm), low body weight (<45kg), and/or MUAC<22cm are considered to be at risk of adverse pregnancy outcomes.(Kruger, 2005) Another study shows maternal dietary intake and nutritional status during pregnancy have impact on fetal body composition. (Shaikh et al., 2009) A systematic review incorporates the study by Doherty et al. 2006 trying to understand the relationship between pre-pregnancy body mass index and pregnancy outcome shows positive correlation with foetal growth restriction. (Gaudet et al., 2014) (Doherty et al., 2006) The same study concludes that the maternal obesity plays a significant

role in the development of the fetal overgrowth. (Gaudet et al., 2014) A study was carried out to determine whether the qualities of diet during pregnancy and maternal pre-gestational body mass index (BMI) are associated with increased oxidative stress markers in mothers and newborns which shows Malondialdehyde (MDA) and Nitric Oxide (NO) levels in mother–newborn pairs with maternal pregestational overweight or obesity were higher than in mother–newborn pairs with pregestational normal weight. (Lopez-Yañez Blanco et al., 2022) Maternal MUAC can be an easy and cost-effective tool to identify mother at risk of delivering Low birth weight Babies as the study have shown association between maternal MUAC (19-23 cm) with 81% of LBW babies. (Shrivastava et al., 2016) studies in maternal obesity indicates significant risk for the mother and the fetus (Sebire et al., 2001).

CONCLUSION

The statistical analysis shows that the pregnancy outcome does not differ significantly according to the foetus growth. There is no relation between foetus growth and pregnancy outcome. But maternal BMI has shown association with neonatal weight. Increase in maternal BMI shows increase in the foetal weight.

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Conflict of Interest

The authors declare no conflict of interest.

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