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Original Article

Paternal factors to the offspring birth weight: the 829 birth cohort study

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Abstract: Objective: To investigate the contributions of parental, especially paternal factors to the offspring birth weight. Methods: Eligible 829 live-born, singleton children living in Hubei, China were recruited. Birth weight were measured immediately after birth and information about the parents were collected by face-to-face interview using questionnaire. Association between parental factors and birth weight was evaluated using univariate linear regression and multinomial logistic regression models. Results: Fathers living in the rural area had offspring with higher risk of low birth weight when compared with fathers who live in the capital city. Maternal lower education, lower gestational weight gain, being primipara and shorter gestational age were risk factors for low birth weight. In addition, Mothers with the history of chronic disease had higher risk to deliver a low birth weight baby. On the contrary, women who increased non-staple food consumption during pregnancy had higher risk to have a macrosomic pregnancy. However, lifestyle factors including diet, exercise, screen time, drinking and smoking from both maternal and paternal exhibited little influence on fetal birth weight. Conclusion: Paternal as well as maternal factors exert influence on the fetal birth weight, although maternal factors make bigger contributions. Compared with socioeconomic and obstetric factors, lifestyle before and during pregnancy has less influence on fetal birth weight, suggested that special attention should be paid to antenatal care for the pregnant women with lower socioeconomic status in rural area.

Keywords: Birth weight, paternal factor, maternal factor, socioeconomic, diet, lifestyle

Introduction

Low Birth Weight (LBW), defined as a birth weight of an infant less than 2500 g, represents 15.5% of all birth infants worldwide [1], of which 96.5% occurred in developing countries [2]. Globally, LBW is a leading cause of infant morbidity and mortality, results in 60-80% of neonatal death [3-5]. Moreover, LBW could be complicated by dyspnea, aspiration pneumonia, hyperbilirubinemia, hypoxic ischemic encephalopathy, hyaline membrane disease, intracranial hemorrhage, etc., posing an adverse impact on the quality of life and the grow of newborns [6]. In addition, LBW also contributes to angiocardiopathy, diabetes and intelligence quotient (IQ) in their adulthood life [7, 8]. To lower the incidence of LBW, numerous studies have been carried out to identify the influence factors: Previous study suggested that unintended pregnancies and smoking are mainly causes of LBW [9]; Siza JE found that HIV infection, low educational level, hypertension, pre-eclampsia and eclampsia complex, gestational age, malnutrition (BMI <18) and maternal antenatal care may all make contributions to LBW [10]; Claire C. Murphy revealed that women who reported abuse during pregnancy were more likely to give birth to a baby with LBW [11].

On the other end of birth weight spectrum, macrosomia is generally defined as the birth weight exceeding 4000 g [12]. In recent decades, the prevalence of macrosomia is raising gradually with increased incidence of obese women. In the United States, approximately 10% of infants have a birth weight of 4000 g or more [13]. A recent survey showed that the incidence rate of macrosomia is 6.5% in rural China [14]. Fetal macrosomia can increase the rates of induction of labor, instrumental childbirth, obstructed labor, fetal asphyxia, shoulder dystocia and birth injury [15, 16]. Moreover, the macrosomia may have an increased susceptibility to obesity, diabetes and cardiovascular disease in later life [6, 17]. Studies showed that related factors for macrosomia are heredity, infant sex [18], glycometabolic disturbance [19], pregnancy weight gain [20], maternal reference nutrient intake [21], maternal age and parity [22].

Due to its critical role in child early growth and later disease development, numerous studies have been carried out to identify the contributions of parental socioeconomic status, medical risk factors or lifestyles to fetal birth weight [23-26]. While the impact of maternal factors on birth weight is well established [27, 28], the contribution of paternal factor on birth weight are still controversial [29, 30]. In addition, the influence of regional economic development, family location, and medical services, etc. on fetal birth weight also remains illustrated. Therefore, the present study is to investigate the impacts of both maternal and paternal factors, especially socioeconomic status, on their fetal birth weight.

Subjects and methods

Parents of the eligible fetuses in Wuhan Renming and Wuhan Zhongnan hospitals, Hubei province from June 2012 to August 2013 were invited to participate in this survey. After obtaining the consent, we collected information from the parents by face-to-face interview using questionnaire which consist of basic information, socioeconomic status, anthropometry index, medical history, and lifestyle.

Pre-pregnancy body mass index (BMI) was self-reported and weight gain during pregnancy was recorded in kg with one decimal place. According to BMI cutoffs for overweight and obesity in Chinese, maternal prepregnancy weight and paternal weight was classified into underweight (BMI<18.5), normal weight (18.5≤ BMI<24), overweight (24≤BMI<28) and obesity (BMI≥28). Chronic diseases are defined as having one or more of the following characteristics: diabetes, hypertension, hypercholesterolemia or nephritis diagnosed by a medical doctor in the past or before pregnancy. Dietary supplement means ingesting at least one of calcium, vitamin, microelement and folic acid.

Birth weight was measured at birth with an electronic scale with a digital readout which recorded to the nearest 0.01 kg. LBW is defined by the World Health Organization as <2500 g, and macrosomia is defined as >4000 g. Birth weight between 2500 g and 4000 g was classified as normal in the study. Gestational age less than 32 weeks was defined as very preterm, between 32-37 weeks as preterm, and between 37-41 weeks as term pregnancy. Maternal clinical data and pregnancy outcome were obtained from hospital records.

Statistical analysis

To exclude the potentially confounding factors, we select the independent variables for further analysis by using univariate linear regression. Since both a low and high birth weight increase the risk of offspring adiposity [1], we performed multinomial logistic regression to identify the contributions of parental factors to the abnormal birth weight by categorizing birth weight into three groups and setting the normal birth weight (2500-4000 g) as reference. Separate analyses were done for mothers and fathers. All statistical analyses were performed using SPSS version 20.0 (SPSS, Chicago, IL, USA), and. $p<0.05$ were considered significant.

Results

A total of 1017 pairs of parents with eligible fetuses were recruited. Participants (122) with either parent failed to complete the questionnaires were excluded. Multiple births (63 twins) and stillbirths (3) were also excluded from the present analyses. Finally, our data included 829 singleton children with 9.6% were low birth weight, and 5.5% were macrosomia. Coding for all the dependent variable was listed in Supplement Table 1.

Results of univariate linear regression analysis for maternal factors were summarized in the left part of **Table 1**. Family location, education, monthly income, gestational age (GA, weeks), dietary supplement and exercise time prior to pregnancy, gestational weight gain (GWG), increased non-staple food consumption and screening time during pregnancy have positively association with birth weight. Maternal parity, history of chronic disease and milk intake during pregnancy have negative association with birth weight.

Table 1. Multinomial Logistic regression to identify the contributions of Maternal factors to newborn body weight

Maternal factor		Univariate regression		Multinomial Logistic Regression						
				Low Birth Weight			Normal	High Birth Weight		
		B	P	β	OR	95% CI	Reference	β	OR	95% CI
Basic	Age (year)	0.02	0.381							
	Height (cm)	0.044	0.002							
	>164				1.000				1.000	
	160-163			1.517	4.559	1.426-14.571	1.000	0.624	1.867	0.851-4.096
	<159			0.998	2.705	0.875-8.326	1.000	0.517	1.687	0.677-4.221
Socioeconomic	Family Location	0.121	0.000							
	Capital city				1.000					
	Medium size city			-0.148	0.862	0.258-2.884	1.000	0.159	1.173	0.439-3.132
	Small size city			-0.249	0.78	0.242-2.517	1.000	0.16	1.174	0.369-3.740
	Town			0.344	1.411	0.459-4.338	1.000	-0.352	0.703	0.168-2.948
	Rural			0.68	1.974	0.758-5.140	1.000	-1.073	0.342	0.079-1.476
	Education (year)	0.074	0.000							
	≥16				1.000				1	
	14~15			-0.29	0.748	0.229-2.440	1.000	0.383	1.467	0.742-2.901
	10~12			1.326	3.766	1.334-10.633	1.000	0.222	1.249	0.506-3.082
	7~9			0.586	1.796	0.557-5.792	1.000	0.131	1.14	0.360-3.605
	≤6			1.089	2.971	0.685-12.892	1.000	0.142	0.868	0.088-8.533
	Household income (RMB/mon)	0.115	0.000							
	≥10000				1.000				1.000	
	3000~10000			-0.744	0.461	0.116-1.827	1.000	0.835	2.305	0.518-10.261
	≤3000			0.156	1.169	0.287-4.753	1.000	0.182	1.2	0.243-5.931
	Parity	-0.131	0.000							
	1				1.000				1.000	
	2			-0.619	0.54	0.258-1.130	1.000	0.675	1.965	0.888-4.347
	≥3			-1.299	0.273	0.078-0.594	1.000	-1.373	0.253	0.032-2.018
Pre-pregnancy	Chronic disease	-0.319	0.000							
	No				1.000				1.000	
	Yes			-1.97	0.139	0.057-0.339	1.000	-0.379	0.685	0.197-2.375
	Dietary supplement	0.072	0.039							
	No				1.000					
	Yes			0.181	1.198	0.641-2.239	1.000	-0.159	0.853	0.466-1.562

	Exercise time (minutes)	0.044	0.025							
	≥120				1.000				1	
	30~120			0.45	1.569	0.571-4.309	1.000	-0.428	0.652	0.310-1.373
	≤ 30			0.509	1.664	0.616-4.495	1.000	0.099	1.104	0.522-2.336
During pregnancy	Gestational weight gain (Kg)	0.122	0.000							
	≥20				1.000				1	
	10~20			0.767	2.154	0.861-5.387		-0.912	0.402	0.220-0.732
	≤10			1.071	2.917	1.091-7.804	1.000	-0.947	0.388	0.153-0.980
	Increase non-staple food	0.076	0.046							
	No				1.000				1	
	Yes			0.501	1.651	0.661-4.122	1.000	-0.759	0.468	0.243-0.902
	Scree time (hours per day)	0.055	0.010							
	≥5				1.000				1	
	1~5			-0.018	0.982	0.374-2.579		-0.274	0.761	0.388-1.489
	≤1			0.057	1.059	0.362-3.095		-0.546	0.579	0.251-1.335
	Pregnancy Age (week)	0.406	0.000							
	≥37				1.000					
	32~37			1.959	7.094	3.412-14.750	1.000	-0.355	0.701	0.334-1.472
	≤32			2.35	10.49	4.017-27.393	1.000	0.307	1.36	0.400-4.623

Footnote: Univariate linear regression was first performed to identify the independent variables for further analysis. We next set normal birth weight babies as reference group, to calculate the risk of being low or high birth weight by multinomial logistic regression analysis.

Then we performed multinomial logistic regression to identify the maternal factors' contributions (right part of **Table 1**). We found that compared with pregnant women with bachelor degree, women with lower education showed 2.77 (OR=3.77, 95% CI 1.33~10.63) higher risk to deliver a LBW baby. Compared to women with GWG≥20 Kg, women in GWG<10 Kg group had 1.92 (OR=2.92, 95% CI 1.10~7.80) times higher risk to have a LBW baby. Pregnancy length play a vital role in LBW, very preterm (GA ≤32 weeks) and preterm (GA=32~37 weeks) exhibited 9.49 (OR=10.49, 95% CI 4.02 ~27.39) and 6.09 (OR=7.09, 95% CI 3.41~14.75) times higher risk to have a LBW baby when compared with full term pregnancy (GA=37-41 weeks), respectively. On the contrary, pregnant women without a history of chronic disease had 86% (OR=0.14, 95% CI 0.06~0.34) lower risk to have a LBW baby. Comparing to primiparous women, multiparous had 73% (OR=0.27, 95% CI 0.08~0.95) lower risk to have a LBW baby (**Table 1**). Genetic factors are also involved in the regulation of fetus birth weight, and women with height of 160~163cm had 3.56 (OR=4.56, 95% CI 1.43~14.57) times higher risk to deliver a LBW baby compared with the women who are over 164cm.

For macrosomia, pregnant women with GWG <10 Kg and GWG 10~20 kg had 61% (OR=0.39, 95% CI 0.15~0.98) and 60% (OR=0.40, 95% CI 0.22~073) lower risk to have a macrosomia than women with GWG≥20 kg, respectively. Compared to women who increased their non-staple food consumption during pregnancy, women who kept such consumption stable throughout pregnancy had 53% (OR=0.47, 95% CI 0.24~0.90) less risk to deliver a macrosomia (**Table 1**).

Univariate regression showed that the paternal factors of family location, education, paternal height and screening time were positively associated with birth weight (left part of **Table 2**). Surprisingly, multinomial logistic regression revealed that fathers living in rural areas had 3.51 (OR=4.51, 95% CI 2.08~9.77) times higher risk to have a LBW baby compared to fathers living in capital city. For macrosomia, none of the paternal factors exerted significant influence (**Table 2**).

Discussion

Our study demonstrated that both maternal and paternal factors are associated with the neonates' birth weight. However, parental lifestyle, such as diet, exercise and screen time, has no influence on birth weight. Among the paternal factors, family location is the only one which related to the birth weight. Multivariate analysis found living in rural areas still has 3.5 times higher odds of low birth weight compared to living in the large city after controlling all the other factors. Usually, in China, women will move and live with their partners once they get married. This may explain why paternal family location, but not maternal family location, was closely related with offspring low birth weight. In addition, medical care availability and accessibility is more difficult in rural area. Pregnant women with lower income and less educated have poor access to health care and pregnancy related knowledge in rural areas [31]. And then less nutrition for fetus in rural areas, which increase the incidence of LBW in rural areas.

As shown in the univariate analysis (left part of **Table 2**), the paternal factors of education and height were related to birth weight. However, multivariate multinomial analysis revealed that the influence of paternal height on birth weight disappeared after adjusting family location and education. Meanwhile, after controlling dietary factors, the influence of education became no significant. Both of these indicated that the effect sizes from education and height are not big enough. Paternal smoking has no influence on birth weight which is in line with previous study [29]. However, in contrast to other study, we found that paternal drinking was not related to birth weight. In China, with the development of economy, people pay more attention on preparation to have a child. Pre-father usually decreases or even gives up drinking when they prepare to get a baby. In our study, 91% of the pre-fathers drink alcohol less than 15 g per day. That might be the reason that our findings is different from others.

Univariate analyses indicated that maternal dietary and exercise habit, instead of paternals, had influence on birth weight, suggesting the smaller effect size from paternal factors than from maternals'. Maternal education, height, history of chronic disease, increase non-staple food consumption during pregnancy, weight gain, gestational age and parity all make contributions to birth weight. Our findings revealed that maternal education and paternal family

Table 2. Contributions of Paternal factors to newborn body weight were identified by Multinomial Logistic regression

Paternal factor		Univariate regression		Multinomial Logistic Regression						
				Low Birth Weight			Normal	High Birth Weight		
		B	P	β	OR	95% CI	Reference	β	OR	95% CI
Socioeconomic	Age	0.002	0.879							
	Family Location	0.069	0.000							
	Capital city				1.000					
	Medium size city			0.661	1.936	0.718-5.221	1.000	0.299	1.348	0.591-3.077
	Small size city			0.652	1.92	0.697-5.292	1.000	-1.758	0.172	0.023-1.303
	Town			0.8	2.226	0.845-5.860	1.000	-0.656	0.519	0.139-1.932
	Rural			1.506	4.511	2.083-9.766	1.000	-1.15	0.317	0.094-1.064
	Education (year)	0.074	0.000							
	≥16				1.000				1.000	
	14~15			0.259	1.296	0.535-3.138	1.000	0.193	1.213	0.619-2.379
	10~12			0.368	1.445	0.606-3.442	1.000	-0.127	0.881	0.35-2.160
	7~9			0.861	2.365	1.005-5.567	1.000	0.442	1.556	0.580-4.175
	≤6			1.02	2.772	0.940-8.178	1.000	-0.56	0.571	0.073-4.478
	Drinking	0.031	0.160							
	Smoking	0.013	0.452							
Pre-pregnancy	Chronic disease	-0.319	0.000							
	Scree time (hours per day)	0.057	0.012							
	≥5				1.000				1.000	
	1~5			0.303	1.354	0.624-2.938	1.000	-0.200	0.819	0.335-1.999
	≤1			0.203	1.225	0.494-3.035	1.000	-0.014	0.986	0.534-1.819

location exerted substantial influence on fetal birth weight, suggested that socioeconomic status is closely associated with birth weight. Parents being highly educated and better living condition can reduce the risk of giving birth to a LBW baby.

For the 829 respondents, 152 (18.3%) pregnancy women had changed the main food from staple food to subsidiary food during pregnancy, which means these women had changed their health diet habit to non-health. Therefore, the incidence of high birth weight increases, this is related with the lack of nutrition knowledge. Previous research has confirmed that reasonable nutrition supplement during pregnancy can reduce the incidence of abnormal birth weight [32]. Excessive consumption of subsidiary food results in lack of microelement and general malnutrition, then affects fetal development [33]. Therefore, pregnant women should pay close attention to their dietary consumption to maintain the maternal and children health.

A study found that child whose maternal height exceed 165 cm had a significantly risk to be a macrosomia [34], and our study showed that mothers with height 160~163 cm have 3.56 higher LBW incidence than ones with height exceeding 164 cm, suggesting the important role of genetic factors in regulation of body weight. It is well established that the body weights of the second and third children are heavier than the first one's. Our findings supported the close relationship between parity and LBW. The reason might be that the differences in maternal physique between primiparous and multiparous females would affect their pregnancy and delivery.

For women with normal prepregnancy BMI, the optimal gestational weight gain during pregnancy is 10-20 Kg. below or over this criteria will result in higher incidence of LBW or macrosomia. Mumbare SS confirmed that poor weight gain during pregnancy is a significant predictors for delivery of a low birth weight neonate [35]. Demont-Heinrich found inadequate weight gain and not receiving any prenatal care are top two risk factors associated with very low birth weight [36]. Birth weight was revealed to be positively correlated with gestational weight gain, and Ferrari N deemed that an excessive weight gain would accompanied by macrosomia [37]. Our finding was consistent with previous reports. The odds ratio of giving birth to infants weighing less than 2500 g in mothers with GWG<10 Kg was 2.92 when compared with the mothers with GWG≥20 Kg. Meanwhile, the odds ratio of giving birth to infants weighing more than 2500 g in mothers with GWG<10 Kg and 10~20 Kg were only 0.39 and 0.40 respectively.

In agreement with previous studies [37, 38], our study confirmed that there was a greater risk of LBW in preterm neonates than the term ones. We found pregnancy length was the top risk factor associated with low birth weight. Since preterm birth increases the risk of numerous adverse outcomes such as neurodevelopmental impairments, respiratory and gastrointestinal complications, as well as low birth weight [39, 40], preventing premature labor is a priority in controlling of LBW.

Additionally, priori to pregnancy, mothers suffering from chronic diseases, such as diabetes, hypertension, hypercholesterolemia and nephritis, has also been shown to be relevant to birth weight. Chronic diseases may provoke alterations in fetal growth [24], and are always associated with reduced fetal growth [41].

Numerous surveys showed smoking during pregnancy related to infant birth weight. The smoking rate of women in China is 3.08% [42], which is much lower than that in England (17.0%) [43] and USA (14.0%) [44]. Further, only 15%~20% of Chinese smoking women still smoke during pregnancy [42], As only 8 women smoking during pregnancy in our investigation, the sample size is unable to do statistical analysis. Our hospital based study design might be the reason that the smoking rate is much lower in our participants than the general female population. Another reason might be that women under family pressure to quit smoking before and during pregnancy.

Our study has several strong points: first, we collected participant's information using face-to face interview. Second, all the questionnaires were from both mother and father. There are also several limitations in our study: hospital based study design cannot represent general pregnant population in China. The lower efficiency of questionnaires due to absence of father during antenatal care or labor. Further research is needed to observe the impact of lifestyle on neonatal birth weight.

In conclusion, except the well-established maternal factors such as parity, GWG, GA and history of chronic diseases, we found that paternal family location contributes to newborn birth weight. This study suggests that the special strategies which target at antenatal care for women lived in rural area is important.

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Supplement Table 1. Coding for dependent variables

	Parameters	Code
Basic information	Age (year)	1: ≤29, 2: 30-35, 3: ≥35
	Maternal Height (cm)	1: ≥164, 2: 160-163, 3: ≤160
	Paternal Height (cm)	
	Pre-pregnancy BMI (Kg/cm^2)	1: ≤18.5, 2: 18.5-23.9, 3: 24-27.9, 4: ≥28
	Gestational weight gain (Kg)	1: ≥20 Kg, 2: 10-20 Kg, 3: ≤10 Kg
Socioeconomic	Family location	1: Capital city, 2: medium size city, 3: small-size city, 4: Town, 5: Rural area
	Education (year)	1: ≥18, 2: 12-16, 3: 10-12, 4: 7-9, 5: ≤6
	Occupation	1: worker and related, 2: professional staff, 3: government staff, 4: other
	Household monthly income (RMB)	1: ≥10000, 2: 3000-10000, 3: ≤3000
	Food expense percentage (%)	1: Half of total income, 2: 1/2-1/3 of total income, 3: <1/4 of total income
	House	1: Rent, 2: Own
	Medical insurance	1: Self covered, 2: fully covered, 3: other insurance
Pre- and During pregnancy	Chronic diseases	1: No, 2: Yes
	Dietary supplement	1: No, 2: Yes
	Increase non-staple food	1: No, 2: Yes
	Exercise (minutes)	1: ≥120, 2: 30-120, 3: ≤30
	Screen time (hour)	1: ≥5, 2: 1-5, 3: ≤1
	Smoking	1: No, 2: Yes
	Drinking	1: No, 2: Yes
	Parity	1: 1, 2: 2, 3: ≥3
Pregnancy outcomes	Gestational Age (week)	1: ≥37, 2: 32-37, 3: ≤32
	Delivery	1: vaginal birth, 2: cesarean section