Letter to the Editor

Seasonal Variations in Birth Weight in Suzhou Industrial Park*

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Many environmental factors have been shown to adversely influence birth weight, and new insight has been gained into 'seasonal programming'. We studied a total of 23,064 infants. The mean birth weight varied across seasons. Logistic regression analysis was used to obtain the crude and adjusted odds ratios (*ORs*) for dichotomous outcomes (e.g., macrosomia, low birth weight). There were significant differences in the risks for macrosomia in infants born in different seasons. Compared with those for infants born in spring, the *ORs* for macrosomia were 0.85 [95% confidence interval (*CI*): 0.75-0.98] and 0.87 (95% *CI*: 0.77-0.99) for infants born in summer and autumn, respectively. These findings suggest that environmental factors may have public health implications and should be considered when primary prevention programs are developed for macrosomia or low birth weight.

Increasing epidemiological data have shown that adverse environmental insults (e.g., low-protein diets, nicotine use, high-sucrose diets, and others) during pregnancy may 'program' the development of adult diseases (e.g., diabetes mellitus, hypertension, cancer, and others)[1-2]. Birth weight is an important indicator of infant mortality, and it affects health outcomes in both childhood and adulthood[1,3]. Abnormal size at birth, including both low birth weight and macrosomia, has been associated with increased susceptibility to diseases in later life, causing great personal and societal burdens. Increased risks for cardiovascular diseases[4-7] and diabetes mellitus[8] in later life were reported to be associated with low birth weight, while an increased risk of cancer was found to be correlated with a higher birth weight[9]. Both genetic and environmental factors have been shown to influence birth weight. The fragile biochemical stability of the intrauterine environment during pregnancy is significantly influenced by environmental factors, such as high or low temperatures, with considerable effects on fetal growth and infant development. It is well known that a fetus has a limited ability to regulate its temperature and that such regulation depends largely on the mother's thermoregulatory capacity. Hitherto, different reports worldwide have gained attention regarding the effect of 'seasonal programming'. However, there is considerable controversy about which season is associated with abnormal birth weight.

Early investigations in developed countries found no significant differences among seasons in birth weights[10-11]. In contrast, subsequent studies of large populations found statistically significant seasonal fluctuations in birth weight[12-13]. We have the opportunity to study seasonal fluctuations in birth weight in Suzhou, China, which has a humid, subtropical climate characterized by hot, humid summers and mild, cool winters. The primary objective of the present investigation was to determine whether birth weight fluctuated by season for infants born in Suzhou between 2006 and 2010.

The study was approved by the Suzhou Industrial Park Centers for Disease Control and Prevention Ethics Committee. Information regarding 23,064 infants born full-term (at least 37 weeks and <42 weeks gestation) between January 2006 and December 2010 at hospitals in Suzhou Industrial Park, Jiangsu Province, was obtained via public birth records. The information included date of birth, sex, birth weight (g), and gestational age (weeks). Information for infants who died after birth also was included.

A logistic regression analysis was used to obtain the crude and adjusted odds ratios (*ORs*) for dichotomous outcomes (macrosomia and low birth

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weight). Previous studies showed a U-shaped relationship between birth weight and adult-programmed diseases[14-15]. Therefore, because the relationship between weight and risk is not linear, including infants with macrosomia and infants with low birth weight in the same data set may cause risk effects to be obscured. Hence, we used two separate databases for analyses: a database for infants with low birth weight (<2500 g) and a database for infants with macrosomia (≥4000 g). Initial analyses that incorporated cases categorized into months of birth demonstrated common patterns based on the different seasons of the year. Thus, all data were re-analyzed according to date of birth using categorizations for spring (March-May), summer (June-August), autumn (September-November), and winter (December-February). Data were presented as means±standard deviations (SDs) for continuous variables, and percentages for categorical variables. Data analyses were conducted using SPSS Statistics 21. A *P* value of <0.05 was considered statistically significant.

A total of 23,064 (52.80% boys) infants were studied. The mean birth weight of the study population was 3400.60±416.06 g. The average gestational age was 39.27±1.18 weeks. Overall, 90.30% of infants were first-borns, and 39.70% were delivered via caesarean section (Table 1). The average birth weight was significantly higher in spring and winter. In the contrast, there was no significant difference between summer and autumn with respect to birth weight (Table 2).

The present study demonstrated that the risk of macrosomia varied by season. The ORs for macrosomia were 0.85 [95% confidence interval (*CI*): 0.75-0.98] and 0.87 (95% *CI*: 0.77-0.99) for infants born in the summer and autumn, respectively, compared to infants born in the spring. However, compared with infants born in spring, the *OR* for macrosomia was 1.00 (95% *CI*: 0.88-1.14) for infants born in the winter (Table 3). As shown in Table 4, compared with infants born in the spring, the *OR* for low birth weight was 0.75 (95% *CI*: 0.56-1.11) for infants born in the summer. Similarly, compared with infants born in the spring, the *ORs* for low birth weight were 0.98 (95% *CI*: 0.70-1.20) and 0.82 (95% *CI*: 0.61-1.10) for infants born in the autumn and winter, respectively (Table 4). Seasonal variation was not associated with a risk for low birth weight. The major strength of our study is that it included a large, population-based sample. We used a logistic regression analysis to determine the effect of seasonal variations. *ORs* were used to estimate which season protected against macrosomia, and we compared them with a chi-squared analysis. To our knowledge, this is the first study reporting the effects of 'seasonal programming' on birth weight in China.

Table 1. Characteristics of Study Subjects Born at Full-term Gestation by Season of Birth

Variable	*N*	Mean±SD or Proportion
Season at birth	23,064	100.00%
Spring	4,654	20.20%
Summer	5,691	24.70%
Autumn	7,142	31.00%
Winter	5,577	24.10%
Birth weight (g)	23,064	3400.60±416.06
Gestational age (weeks)	23,064	39.27±1.18
Sex (male, %)	12,184	52.80%
Mother		
Age (year)	23,064	26.25±4.40
First born (%)	20,829	90.30%
Caesarean (%)	9,150	39.70%

Table 2. Distributions of Gestational Age and Birth Weight by Season of Birth

Season at Birth	Gestational Age# (weeks)	*P*-value*	Birth Weight (g)#	*P*-value*
Spring	39.29±1.96	0.63	3394.52±437.25	0.01
Summer	39.25±1.81		3379.37±422.17	
Autumn	39.26±1.62		3374.93±423.39	
Winter	39.29±2.29		3395.47±435.55	

Note. #The values shown are the means±standard deviation for gestational age and birth weight. *Tested using one-way ANOVA. Birth weight in spring *vs.* autumn *P* value is 0.01; birth weight in summer *vs.* winter *P* value is 0.04; birth weight in autumn *vs.* winter *P* value is 0.04.

Table 3. Distributions of the Subjects and the Results of the Logistic Regression Analyses for Macrosomia by Season at Birth

Seasons	N	Birth Weight (n,%)		χ^2	P-value*	OR (95% CI)[a]
		Normal	Macrosomia			
Spring	4,685	4,231 (90.30%)	454 (9.70%)			1
Summer	5,750	5,263 (91.50%)	487 (8.50%)			0.85 (0.75-0.98)
Autumn	7,177	6,556 (91.30%)	621 (8.70%)	8.72	0.03	0.87 (0.77-0.99)
Winter	5,633	5,088 (90.90%)	545 (9.10%)			1.00 (0.88-1.14)
Total	23,245	21,138 (90.90%)	2,107 (9.10%)			

Note. Values in bold are statistically significant (P<0.05), *Chi-squared test, [a]Adjustment by infant sex and mother's age.

Table 4. Distributions of the Subjects and the Results of the Logistic Regression Analyses for Low Birth Weight by Season of Birth

Seasons	N	Birth Weight (n,%)		χ^2	P-value*	OR (95% CI)[a]
		Normal	Low Birth Weight			
Spring	4,322	4,231 (97.90%)	91 (2.10%)			1
Summer	5,348	5,263 (98.40%)	85 (1.60%)			0.75 (0.56-1.11)
Autumn	6,685	6,556 (98.10%)	129 (1.90%)	4.15	0.25	0.92 (0.70-1.20)
Winter	5,178	5,088 (98.30%)	90 (1.70%)			0.82 (0.61-1.10)
Total	21,533	21,138 (98.20%)	395 (1.80%)			

Note. *Chi-squared test, [a]Adjustment for infant sex and mother's age.

In the present study, we identified that the average birth weight in spring and winter was significantly higher than that in summer and autumn. Flouris et al. found that there was a negative correlation between ambient temperature during the month of birth and birth weight[16]. Previous studies demonstrated that seasonal variation in birth weight was associated with seasonal fluctuations in vitamin D[17]. Prenatal exposure to vitamin D ensures fetal growth and development, and vitamin D deficiency during pregnancy may reduce birth weight.

It is well known that the delivery process for fetuses with macrosomia is associated with a high risk of health hazards for both the mother and infant. Chodick et al. found that infants born in Israel in the summer had an increased risk for macrosomia compared with those born in winter[18]. However, the present research showed that infants born during the summer and autumn seasons in Suzhou had a significantly decreased risk for macrosomia.

The present study had some limitations. We did not collect and analyze objective factors, such as the mother's health consciousness and exposure to sunshine, which, in addition to seasonal factors, might have influenced birth weight. Future research should examine these variables.

In conclusion, the influence of seasonal variation on birth weight varies by ethnicity and probably has various underlying mechanisms or results. Birth during the summer and autumn seasons was associated with a decreased risk for macrosomia in Suzhou, and a low birth weight in others cities. These findings suggest that environmental factors may have public health implications and should be considered when primary prevention programs are developed for macrosomia or low birth weight.

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