Matern Child Health J (2008) 12:606–612
DOI 10.1007/s10995-007-0226-z

Determinants of Birthweight; Gender Based Analysis

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Published online: 8 May 2008

Abstract The objective of this cross sectional study is to look at determinants of birth weight and their association with the gender of the baby in 2,795 full term children living in the occupied Palestinian territory, derived from a stratified random sample of 2,994 households in the West Bank and 2,234 households in the Gaza Strip. The response rate was 85%. Multivariable analysis using analysis of variance for mixed models showed that sex and birth order, maternal age and education and to a lesser extent region were determinants of birth weight for all children. The effect of maternal education on birth weight differed for female and male infants, tending to be relatively unchanged for male infants and with mean birth weights increasing with maternal education in female infants. The effect of birth order differed by maternal age, with mean birth weight increasing with maternal age for first and second births; but being unaffected by maternal age for infants of birth order greater than two. We conclude that birth weight is influenced by common biological determinants across cultures, but is also influenced by social, ethnic, and environmental factors that are culture specific, of which some might be gender related.

Keywords Birthweight · Occupied Palestinian territory · Gender differences · Birth order · Maternal education · Maternal age · Gaza Strip · West Bank

Introduction

The distribution of birth weights of children in the occupied Palestinian territory as published by the Palestinian Central Bureau of Statistics (PCBS) in the Demographic Health Surveys (DHS) of 2000 and 2004 and in the nutritional survey of 2002 showed males to have significantly higher birth weights compared to females, with a greater prevalence of low birth weight (< 2,500 g) in girls compared to boys. Although the epidemiology of birth weight has been researched extensively in the literature, including its associations with infant and neonatal mortality [1], and with high blood pressure in adults [2–4] and diabetes in adults [5] and children [6], variation in birth weight between the sexes, previously observed [7–9], has received little attention.

Several medical conditions are known to impair fetal growth by interfering with the placenta, the foetus or with the general health and nutrition of the mother [10–13]. Several studies have confirmed that women receiving prenatal care have a lower incidence of low birth weight (LBW) [14]. In addition systematic differences in fetal growth have been described in several studies, in association with social class [15, 16], maternal size [17], birth order [8], maternal age [18], sibling weight, maternal smoking habit [19] and others such as maternal diabetes

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[20], fish and fish oil consumption [21], night work [22], maternal attitude towards the pregnancy [23, 24] and social support [25].

Sex differences in birth weight have been researched less extensively [26, 27]. One of the explanations is the higher energy intake in women carrying a boy. Tamimi [28], in a study of 304 pregnant women in Boston, USA, suggested a relation between testosterone secretion by the fetal testicles (strongly anabolic in nature), and maternal food intake. Similar results were found in UK infants with androgen dysfunction [29], who were lighter by 300 g compared with control boys. A couple of studies from Jordan suggested that a mother's pre-birth knowledge of fetal sex might have influenced her diet and psychological well being, in favor of a male foetus [30, 31]. Qutob et al. showed that the mean birth weight of males ($n = 594$) was higher than females ($n = 601$), which after adjusting for prenatal knowledge of fetal sex, showed males of known sex to have the highest mean birth weight, and females with known sex to have the lowest mean birth weight and that the risk of LBW increased for females from OR = 1.10 to OR = 1.27 if her sex was known. On a different line of research, Suarez et al., found an association between the Vitamin D Receptor (VDR) gene polymorphism and sex dependent growth in the first 2 years of life in 423 infants in Paris, France [32], suggesting that VDR genotype influences intrauterine and early postnatal growth, directly or via interactions with gender-related growth regulators.

Objectives

This paper seeks to study determinants of birth weight and their association with the gender of the baby in 2,795 full term Palestinian children.

Methods

A household nutritional survey was conducted in the occupied Palestinian territory by the PCBS in 2002,[1] involving a stratified multi-stage random sampling procedure, in which four levels of stratification were made. The master sample is the sample frame of the 1997 census data. The overall sample contained 234 enumeration areas: 142 in the West Bank and 92 in the Gaza Strip. These enumeration areas were then divided into cells and one cell was then randomly selected from within each enumeration area.

The number of households in the sample was 5,228 households with 2,994 in the West Bank and 2,234 in the Gaza Strip. Field workers, trainers and trainees, were recruited separately in each area. Trainers were trained using video tapes (Israeli closure of the Palestinian territory precluded joint training meetings) while trainees in each area had 12 days of intensive training. Questionnaires and reports were transported back and forth through ambulances of the Red Crescent Society and UNICEF cars. The overall response rate was 85%.

Data were collected by questionnaire on all children in each household who had been born in the previous 3 years. Birth weight was obtained from the parent-held delivery records (16.2%) and via parental recall (83.8%) [33]. No significant differences in mean or median birth weights were found between data obtained via recall versus records for the different sexes and categories of mother's education. Maternal hemoglobin was measured on site.

Analysis of birth weight was carried out on full term infants (2,795) and 514 preterm babies were excluded from the analysis. Full term (completed at least 37 weeks of pregnancy) was calculated from expected date of delivery with the help of the field worker. Of those mothers, 95.2% had attended at least three antenatal visits with 95.6% seen by a doctor, a nurse or a midwife [34].

Preliminary analyses to explore bivariate relationships used measures of association appropriate for the scale of measurement of the variables. A cross tabulation of categorical variables with gender (mean levels of birth weight) was obtained and tests of significance for the association were Fisher's exact test when there are only two categories or a χ-square test, otherwise. The variables were: mother's age, education and hemoglobin level, sex, age and birth order of the child, in addition to locality (city, village and camp), region (West Bank and Gaza Strip) and durable goods at home as an indirect measure of socioeconomic status [35].

Multivariable analysis using analysis of variance for mixed models was used to accommodate the design of the sample. Because infants are clustered with families which are in turn clustered with numeration units, the categorical variables representing the enumeration units and families were used as random factors in the analysis. The remaining factors were considered as fixed factors. This procedure takes into account clustering and intraclass correlation. The analysis was implemented using SAS PROC MIXED (Russell D. Wulfinger, PROC MIXED, SAS/STAT User's Guide, Version 8. SAS Institute Inc., Cary, North Carolina, 1999).

PCBS did not require a review of research procedures by a human subject review committee for this study. However the study was reviewed and approved by a board consisting of representatives from Birzeit University, UNICEF/Jerusalem office, and the Palestinian Ministry of Health. A verbal informed consent for each interview was obtained

[1] PCBS.gov.ps

by the field workers after explaining the objectives and the content of the questionnaire to the participants.

Results

Despite the political turmoil, the field work was completed with an 85% response rate, 80.6% in the West Bank and 90.9% in the Gaza Strip.

What made it possible were the determination of field workers and supervisors, and the assistance of UNICEF and the Red Crescent Society.[2]

The sample had slightly more males than females (52% vs. 48%), with 71% of the children at a birth order of three or more. Half of the mothers were 25–35 years and 13.3%were illiterate compared to 10% who had higher education. Forty one percent of the mothers were anemic with hemoglobin levels less than 12 mg/dl. Half of the families lived in urban areas while the rest were equally distributed between refugee camps and villages. Almost 19% of families had commodities at home indicating higher socioeconomic status.

Table 1 summarizes the infants' categorical characteristics by gender. The relationships of gender and most factors were not statistically significant with the exception of low birth weight, with 8.9% of female and 5.3% of male infants having low birth weight ($P = .0002$), and maternal education, with male infants having higher maternal education ($P = .02$).

Table 2 exhibits mean birth weights for all levels of factors considered in the analyses. Low mean birth weight is associated with female gender ($P < .0001$), higher birth order ($P < .0001$), lower maternal age ($P < .0001$) and education ($P = .03$), and living in the West Bank ($P = .02$). The associations of birth weight with anemia in mothers, socioeconomic status, and type of locality were not statistically significant.

Table 3 exhibits the results of the multivariable analysis of variance using mixed models. Only significant factors and their possible interactions with each other are retained. Gender, birth order, mother's age, and mother's education are significant main factors. Interactions of gender with mother's education and birth order with mother's age are the only statistically significant two-way interactions. Mean birth weight is lower in female infants, and in infants with higher birth order, and with mothers with less education. Mean birth weight of male infants is not affected by increasing mother's education; but female infants of illiterate mothers tend to have lower mean birth weights and

Table 1 Bivariate relationship between categorical variables for full term infants and infants' gender

Factor	Female	Male	P*
Low birth weight			
Low	120 (8.9%)	76 (5.3%)	.0002
Normal	1229 (91.1%)	1370 (94.7%)	
Birth order			
2nd or less	392 (29.1%)	415 (28.7%)	.8
3rd or more	957 (70.9%)	1031 (71.2%)	
Mother's age (years)			
15–24	313 (23.2%)	294 (20.6%)	.2
25–34	714 (53.1%)	777 (54.3%)	
35–50	319 (23.7%)	360 (25.2%)	
Mother's education			
Illiterate	161 (11.9%)	202 (14.0%)	.02
Preparatory and elementary	834 (61.9%)	822 (57.1%)	
Secondary	239 (17.7%)	255 (17.7%)	
Higher education	114 (8.5%)	161 (11.2%)	
Anemia in mothers (g/dl)			
1–11.99	579 (43.5%)	589 (41.6%)	.3
12 or more	751 (56.5%)	828 (58.4%)	
Socioeconomic status			
Low	1106 (82.0%)	1178 (81.5%)	.7
High	243 (18.0%)	268 (18.5%)	
Region			
West Bank	635 (47.1%)	646 (44.7%)	.2
Gaza Strip	714 (52.9%)	800 (55.3%)	
Type of locality			
City	720 (53.4%)	743 (51.4%)	.4
Village	312 (23.1%)	335 (23.2%)	
Refugee camp	317 (23.5%)	368 (25.4%)	

* Denotes significance level for a bivariate test of association using Fisher's exact test when there are only two categories or a χ-square test, otherwise

female mean birth weights increase as mother's education increases (Fig. 1, $P = .0007$). The mean birth weight of infants with birth order two or less tends to increase relative to infants with birth order three or more as the mother's age increases (Fig. 2, $P = .0002$).

Discussion

The study on which this paper is based is the first national study to investigate child and infant growth and nutrition in exceptional circumstances. The main limitation of the study is the collection of birth weight data through maternal recall rather than birth records. But, it is an acceptable method [36–38] and there is good agreement between reported and recorded birth weights. Almost all

[2] This experience is internally documented at PCBS for the courageous work of the field workers and the most appreciated assistance of UNICEF and RCS.

Table 2 Bivariate relationship between infant's mean birth weight (grams) and categorical variables for full term infants

Factor	Number	Birth weight (SD)	P*
Gender			
Female	1346	3181.74 (585.85)	< .0001
Male	1429	3347.42 (600.33)	
Birth order			
2nd or less	1981	3312.08 (598.32)	< .0001
3rd or more	794	3154.73 (586.14)	
Mother's age (years)			
15–24	607	3150.54 (594.32)	< .0001
25–34	1489	3262.45 (582.62)	
35–50	679	3381.34 (618.08)	
Mother's education			
Illiterate	350	3273.81 (657.78)	.03
Preparatory and elementary	1656	3246.55 (598.33)	
Secondary	494	3276.98 (568.53)	
Higher education	275	3364.13 (570.22)	
Anemia in mothers (g/dl)			
1–11.99	1162	3256.60 (596.00)	.4
12 or more	1573	3276.85 (600.23)	
Socioeconomic status			
Low	509	3261.18 (589.93)	.8
High	2266	3268.38 (601.13)	
Region			
West Bank	1273	3238.61 (596.97)	.02
Gaza Strip	1502	3291.17 (599.84)	
Type of locality			
City	642	3262.41 (560.82)	.7
Village	1452	3260.59 (609.79)	
Refugee camp	681	3285.25 (610.98)	

* Denotes significance level for a bivariate test of association using a one way analysis of variance

(99.5%) of the children in the sample were weighed at birth [39] and all children were born within 5 years prior to the time of the survey.

The finding that females have nearly double the prevalence of low birth weight compared to males, raises the question of the appropriateness of using 2,500 g as a cut off point for both sexes, when it is known that boys are heavier at birth. This issue has been raised by many researchers, and it is probably time to omit the use of such an arbitrary threshold for both sexes.

The gender differences in mean birth weight are slightly higher than those previously reported [16, 40–43]. The lack of a trend of higher mean birth weight with higher maternal education observed in males but not females is surprising (Fig. 1).

Table 3 Multivariate relationship of full term infant's mean birth weight (grams) which retains infant characteristics that remains statistically significant

Factor	Number	Birth weight (SD)	P*
Gender			
Female	1346	3181.74 (585.85)	< .0001
Male	1429	3347.42 (600.33)	
Birth order			
2nd or less	1981	3312.08 (598.32)	.0007
3rd or more	794	3154.73 (586.14)	
Mother's age (years)			
15–24	607	3150.54 (594.32)	.05
25–34	1489	3262.45 (582.62)	
35–50	679	3381.34 (618.08)	
Mother's education			
Illiterate	350	3273.81 (657.78)	.05
Preparatory and elementary	1656	3246.55 (598.33)	
Secondary	494	3276.98 (568.53)	
Higher education	275	3364.13 (570.22)	
Gender by mother's education			
Female	159	3165.74 (632.35)	.0007
Illiterate	834	3138.04 (582.18)	
Preparatory and elementary	239	3271.00 (565.48)	
Secondary	162	3336.62 (546.38)	
Higher education			
Male	191	3363.77 (666.58)	
Illiterate	822	3356.65 (594.71)	
Preparatory and elementary	255	3282.59 (572.43)	
Secondary	161	3383.60 (587.41)	
Higher education			
Birth order by mother's age			.0002
2nd or less			
15–24	162	3131.53 (654.01)	
25–34	1180	3290.48 (576.29)	
35–50	639	3397.74 (610.61)	
3rd or more			
15–24	445	3157.46 (571.67)	
25–34	309	3155.39 (595.07)	
35–50	40	3119.25 (683.47)	

* Denotes significance level from a multivariate mixed model regression with family and census enumeration units considered as random effects and the remainder as fixed effects

This observation suggests that a social factor (maternal education) influences by some mechanisms, a biological factor (birth weight) selectively based on the infant's sex. This unusual finding [44] may contribute to the observed higher differences in gender mean birth weight in Palestine compared to other reports.

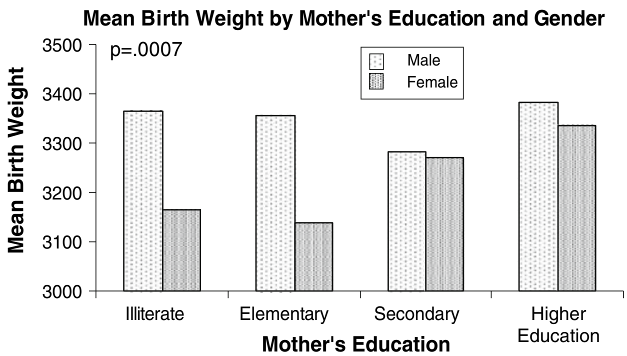

Fig. 1 Mean birth weight by mother's education and gender

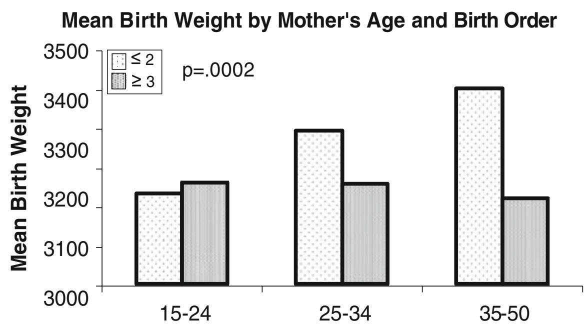

Fig. 2 Mean birth weight by mother's age and birth order

A second statistically significant interaction is observed between birth order and mother's age ($P = .0002$). Mean birth weight for lower birth order increases with mother's age; however mean birth weight remains relatively the same for higher birth order as mother's age increases (Fig. 2). The first finding implies that increasing mother's age selectively increases birth weight for newborns of lower birth order through unknown mechanism. While the second finding, that mean birth weight remains the same for higher birth order as mother's age increases, may be explained partially by the fact that birth spacing, a risk factor for both maternal and newborn health [45], is short, less than 18 months [46] for half of the women in the occupied Palestinian territory. This may contribute to the relatively persistent low mean birth weights for higher birth order as mother's age increases, compared to increasing mean birth weight for lower birth order as mother's age increases.

The observed regional variation, with higher mean birth weights in the Gaza Strip is difficult to explain, but could be associated with higher maternal education in the Gaza Strip compared to the West Bank, or with other variables not measured in this survey.

In this study, maternal anemia was not associated with lower birth weight. This may have been due to the small number of women (2.2%) with severe anemia of less than 9 g/dl. Maternal socioeconomic status was also found not associated with birth weight. This may have been due to the lack of specificity of the variable used to measure maternal socioeconomic status, which is possession of specific durable goods at home.

The observed results support the hypothesis that both biological and psychosocial factors contribute to differences in birth weight between the sexes in this population. Biological factors are likely to play a major role in determining the different sizes of male and female fetuses, as they do subsequently in determining differences in growth between the sexes. However, other psychosocial factors including preference for boys [47, 48], stress during pregnancy, lack of social support and rejecting a pregnancy [49–51] may also contribute. It is hypothesized that these factors may act collectively against a female foetus in countries where there is a clear and strong preference for boys, such as China, India [52] and the Middle East [53]. This hypothesis is supported by the observation documented by the PCBS in the Demographic Health Surveys of 2000 and 2004, that 90.2% of women have at least one ultrasound during pregnancy for medical indications as well as sex determination. This observation is consistent with that of Qutob et al. from Jordan.

Other variables, reported in the literature and not available for this study, such as singleton versus multiple pregnancy, maternal size and medical complications during pregnancy, biological factors and adverse maternal practices such as smoking are important determinants of birth weight. In the case of smoking, one can argue that this is less important in the Palestinian context, given that the prevalence of smoking in women of reproductive age (15–49 years) is only 5.5% and varies little between women of differing educational levels after adjusting for age [54].

It is difficult to draw general conclusions from the results, due to the lack of supporting evidence from the literature. The complexity of the relationships between genetic, well established medical conditions and psychosocial, cultural issues in addition to the effects of multiple risk factors acting cumulatively across cultures are beyond the scope of this paper. However, the relationships of maternal education and age to the effects of gender and birth order on birth weight merit further investigation, particularly within specific cultural as well as socio-demographic contexts.

Acknowledgements This survey was conducted as part of a cooperative work between the Palestinian Central Bureau of Statistics, the UNICEF office in Jerusalem and the Palestinian Ministry of Health.

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