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QUALITY OF ANTENATAL CARE AND ITS DOSE–RESPONSE RELATIONSHIP WITH BIRTH WEIGHT IN A MATERNAL AND CHILD HEALTH TRAINING INSTITUTE IN BANGLADESH

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Summary. Four hundred and sixty-five pregnant women and their newborn babies were studied at a maternal and child health training institute in Dhaka, Bangladesh, between July 2002 and June 2003 with the objective of (1) examining the relationship between birth weight and maternal factors, and, if there was a dose–response relationship between quality of antenatal care and birth weight, (2) predicting the number of antenatal visits required for women with different significant characteristics to reduce the incidence of low-birth-weight babies. The study revealed that 23·2% of the babies were of low birth weight according to the WHO cut-off point of <2500 g. Mean birth weight was 2674·19 ± 425·31 g. A low birth weight was more common in younger (<20 years) and older (≥30 years) mothers, the low-income group and those with little or no education. The mean birth weight of the babies increased with an increase in quality of antenatal care. The babies of the mothers who had 6+ antenatal visits were found to be 727·26 g heavier than those who had 1–3 visits and 325·88 g heavier than those who had 4–5 visits. No significant relationship was found between number of conception, birth-to-conception interval, BMI at first visit, sex of the newborn and birth weight. Further, from multiple regression analysis (stepwise), it was revealed that number of antenatal visits, educational level of the mother and *per capita* yearly income had independent effects on birth weight after controlling the effect of each variable. Using multiple regression analysis, the estimated number of antenatal visits required to reduce the incidence of low-birth-weight babies for women with no education and below-average *per capita* income status was 6; the number required for women with no education and above-average *per capita* income status was 5; and that for women with education and with any category of income status was 4 visits. So there is a need to stratify women according to their income and educational status so that, along with other measures, the required number of antenatal visits can be estimated beforehand to reduce the incidence of low-birth-weight babies.

Introduction

The World Health Organization has defined low birth weight as birth weight less then 2500 g at birth irrespective of gestational age. Birth weight is the single most important determinant of survival, subsequent growth and development of a child. A low birth weight carries a five times greater risk of dying in the perinatal period and three times greater risk of dying in infancy (Singh, 1991). There is now extensive evidence from many countries that conditions before birth and in early childhood have an influence in adult life. For example, low birth weight is now known to be associated with increased rates of high blood pressure, heart disease, stroke and diabetes (Barker, 2004). In developing countries, there are more babies with poor growth resulting in more diabetic, hypertensive and coronary heart disease patients. Moreover, with the demographic transition increasing life expectancy at birth, these countries are going to face an increased burden of chronic diseases.

The causes of low birth weight are complex and multi-factorial. It is influenced by maternal characteristics, including age, parity, marital status, BMI, educational attainment, social history and antenatal care visits (Herbert *et al*., 2001). Many studies have demonstrated an association between lack of antenatal care and adverse pregnancy outcomes such as maternal mortality, perinatal mortality, low birth weight and premature delivery (Ahmed & Das, 1992; Fawcus *et al*., 1996; Hollander, 1997; Mohsin *et al*., 2006). In 2006, White *et al*. recommended that prenatal care should focus on providing health education and advice to pregnant women (White *et al*., 2006). Moreover, those women who received most prenatal care procedures were more likely to have a skilled institutional delivery (Barber, 2006).

Antenatal care is recognized as an essential element for the screening, primary or secondary prevention and treatment of pregnancy complications. In Bangladesh, the factors that are considered to affect birth weight are biological and service related. Among these factors maternal undernutrition, teenage pregnancy, poor antenatal care and nutrition education may play crucial roles in causing low birth weight.

Early entry to antenatal care (ANC) is important for early detection and treatment of adverse pregnancy-related outcomes. The World Health Organization (WHO) recommends that pregnant women in developing countries seek ANC within the first 4 months of pregnancy (WHO, 1994). In developed countries such as the United Kingdom and the United States, ANC is recommended to start within the first 12 weeks of pregnancy (American Academy of Pediatrics, 2002). Forty-one per cent of Australian women start ANC after 12 weeks of gestation (Lieu Thuy Thi Trinh & Rubin, 2006).

In Bangladesh traditionally, fourteen ANC visits are recommended for each pregnancy – the recommendation of the British Government in 1930 (Great Britain Ministry of Health, 1930). In France, the average is four visits, and it is fourteen in Sweden (International Children Center, 1983). The number of recommended visits is three to four in Switzerland, and fourteen in Finland and Norway (Blondel *et al*., 1985). In 1989 in the United States, an expert panel on the components of the antenatal care programme recommended nine visits for low-risk nulliparous women (Donar *et al*., 1990). Several studies in Europe, Africa and the US have compared the traditional visit schedule with a reduced visit schedule. Although these studies varied in number of reduced visits, research design and participant demographics, they found no statistically significant differences in perinatal outcomes between women following a reduced-frequency schedule of approximately eight visits and those attending prenatal care for the more traditional fourteen visits (Mcduffie *et al.*, 1996; Munjanja *et al.*, 1996; Berglun & Lindmark, 1997; Walker & Koniak-Griffin, 1997).

The World Health Organization recently recommended a reduction in the number of ANC visits in developed countries because of evidence suggesting that having fewer ANC visits does not affect the outcomes of care, other than women's satisfaction levels (Carroli *et al.*, 2001).

Quality maternal care is also important in preventing newborn deaths and morbidity. The adequacy of prenatal care can be assessed by examining two components: (a) the timing and quantity of visits, and (b) the quality of health services. A WHO technical working group committee has recommended a minimum of four antenatal visits for a woman with a normal pregnancy. They have also set the standard for quality of antenatal care.

In Bangladesh several other studies have analysed the relationship between birth weight and antenatal care but only a few have recommended a specific number of antenatal care visits required for a reduction in incidence of low birth weight. Rahman *et al.* (1997) recommended ten antenatal check-ups starting from 10 weeks of pregnancy according to the 'Rule of Ten' model of antenatal care. Akhter *et al.* (1996) considered that all pregnant women should have a minimum of four antenatal visits (of at least 20 minutes duration) for prevention and early detection and management of complications. Balachet (1988) and Ahmed & Das (1992) recommended three visits to reduce low birth weight. The Ministry of Health and Family Welfare, Bangladesh, in its guidelines for antenatal care, recommended a minimum of three visits for a fruitful pregnancy outcome. But Sen and colleagues, in a retrospective analysis of births in Singapore, stated that a schedule of three visits per pregnancy would miss 16% of significant complications (Sen *et al.*, 1991).

So there is insufficient recent information about the quality of antenatal care visits provided, average number of antenatal visits and the relationship between the two and incidence of low birth weight. This study assesses the impact of quality of antenatal care and number of antenatal visits on the incidence of low birth weight in Bangladesh with the intention of determining the optimal number of antenatal visits to produce maximal reduction in incidence of low birth weight.

Operational definitions of the variables

Antenatal care: documented (by antenatal card) antenatal visits for health checks as per WHO guidelines, in Azimpur Maternal and Child Health Training Institute (AMCHTI) or other identified institutes.

Dose–response relationship: relationship between level of quality of antenatal care and number of antenatal visits (as level of exposure) and birth weight (as response).

Quality of antenatal care: only process quality was taken into account. The records of the activities done by the providers (physicians and midwives) were audited from the ANC card of the study participants. Also, the mothers were interviewed for their knowledge on antenatal advice and danger signs that were provided to them by the

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ANC providers. The following activities were looked for, i.e. whether or not they had been taken/done, on the ANC card: (1) personal history; (2) previous obstetric history; (3) present medical history; (4) menstrual history; (5) physical examination; (6) obstetric examination; (7) haemoglobin measurement; (8) urine analysis for albumin and sugar; (9) tetanus toxoid (TT) administered; (10) explaining danger signs to the patient; (11) providing pregnancy-related advice to the patient.

Frequency of antenatal visits: though quantity is an integral part of quality, the study analyses the two separately as the independent variable for this component.

Premature baby: baby born before 37 weeks of pregnancy.

Post-mature baby: baby born 14 days after expected date of delivery.

Body mass index (BMI) at pre-delivery stage: this was taken for all women who came for full-term delivery. Height and weight were measured again, although height was recorded on the ANC card. Hence pre-delivery BMI is taken at the same time for all women.

Number of antenatal care visits: as recorded on the ANC card.

Azimpur Maternal and Child Health Training Institute and antenatal care: This study was carried out at the Azimpur Maternal and Child Health Training Institute. This is the only nationalized training institute working in this area since 1958. A large number of pregnant women from different socio-demographic backgrounds receive regular, cost-free antenatal care from here. Physicians and trained midwives are used to provide antenatal care, as well as delivery, in the facility. Prospective mothers are enlisted first by a midwife, then personal, previous obstetric, present obstetric, medical and menstrual history are taken from them and recorded on their ANC cards. Height, weight and blood pressure are measured and clinical tests for jaundice and anaemia are done. Finally physicians conduct obstetric examinations and confirm some of the physical examinations. They record blood pressure, pulse rate, fundal height, fetal movement and fetal heart sound. Meanwhile women are sent for haemoglobin measurement, blood grouping, a VDRL (venereal disease research laboratory) test, urine analysis for albumin and sugar, on the first day, day of admission for delivery or on development of any complications. In the case of high-risk mothers, an ultrasound test is recommended and done in the centre at a reduced cost. Tetanus toxoid is given in certain doses accordingly by another midwife. Every day there is a 45-minute health education session for prospective mothers on antenatal health activities and the danger signs of pregnancy. Prospective mothers of any duration of pregnancy have to attend the health education session on each visit. All information is filed away carefully. Mothers come from Dhaka City and nearby as they know they will receive a good service. The centre was chosen for this research because of the above criteria, and also because of the high number of deliveries performed, 400–500 babies a month on average.

Data and Methods

The estimated sample size required for the study was calculated by using the following formula:

$$n = Z_1{}^2 - \propto/2[P(1-P)/d^2],$$

Table 1. Number of antenatal care visits, BDHS 2004

Number of visits	%	Sample size (*n*)
1	26	288
2	40	369
3	12	138
4	10·5	138
7–9	35	350

where *P* is the specific anticipated population proportion having a specific number of visits with a 95% confidence level ($Z_1 - \propto$) and 5% specified absolute precision (*d*) (Lwanga & Lemeshow, 1991). As there are different statistics on antenatal visits in Bangladesh available in the literature (BDHS 2004), ranging from 1 to 9, a specific number is taken primarily and the expected sample size is estimated (see Table 1).

There were 1467 births during the study period in AMCHTI; of these 56 had no ANC card, 109 were born prematurely, 17 were still-born, 27 mothers had diabetes mellitus, 9 had multiple pregnancies, 642 had Caesarean sections and 142 left just after delivery.

The estimated highest sample size was 369. Thus 465 respondents fitted the selection criteria of the study. Inclusion criteria for the mothers were: (1) had given birth to a live-birth singleton infant; and (2) had a normal vaginal delivery. Exclusion criteria for the mothers were: (1) non-antenatal care card holder; (2) had given birth to a premature baby; (3) had given birth to a still-born baby; (4) had any medical complication while pregnant (e.g. diabetes mellitus, heart disease, chronic lung disease, jaundice); (5) eclamptic and pre-eclamptic subjects; (6) multiple pregnancy; (7) Caesarian section case; (8) congenital abnormal baby; (9) post-mature baby.

The socioeconomic status of the mothers of antenatal card holders was poor; they were either street beggars or recently migrated people.

Mothers were interviewed in person using structured interview forms to determine their socioeconomic characteristics, obstetric history and knowledge of antenatal advice and danger signs of pregnancy. Record review format was used for reviewing antenatal care cards. Maternal anthropometrical measurements were taken from the records using a structured checklist. Spring type weighing scales were used to measure babies' birth weights within 24 hours of delivery.

After collection, data were checked, verified, cleaned, edited and entered into the SPSS PC program on the computer. Simple descriptive analysis, χ^2 test, analysis of variance and simple and multiple regression tests were carried out.

The one-way ANOVA procedure was performed to test whether there is a difference in the mean birth weight among three levels of quality of care received by the mothers. Simple regression analysis assumed the relationship between number of antenatal visits and birth weight. Here the number of antenatal visits was used to predict birth weight. The simple linear equation is $Y = a + bX$, where *a* is the intercept value on the *Y* axis and *b* is the regression coefficient or slope factor. The slope *b* tells us the increase in X. Here, mean birth weight increased by 149·74 g for each increase of one antenatal visit. The adjusted R^2 indicates the percentage of the variance of birth weight explained by number of antenatal visits. The R^2 tends to be an optimistic estimate of how well the model fits the population and adjusted R^2 (R^2_a) more closely reflects the goodness-of-fit of the model and is calculated as:

$$R^2_a = R^2 - \frac{P(1 - R^2)}{N - p - 1},$$

where p is the number of independent variables in the equation (1 in this example).

In the multiple regression analysis, prediction of the birth weight of the newborn is done from the significant independent factors that came from the bivariate analysis. The regression equation is:

$$Y = a + B_1X_1 + B_2X_2 + \ldots\ldots\ldots\ldots\ldots + B_K X_K,$$

where Y is the predicted value of the birth weight (dependent variable), a is the intercept (the value of Y when all the Xs are zero), the Xs represent the various independent variables and Bs are the regression coefficients for four independent variables. In this multiple regression example,

Predicted birth weight $= a + B_{\text{no. visits}}$ (number of antenatal visit) $+ B_{\text{education}}$(education) $+ B_{\text{income}}$(income).

The birth weight of the baby is obtained by substituting number of visits and educational and income levels of the mother.

In stepwise regression the equation starts out empty and independent variables are added one at a time if they meet statistical criteria ($p < 0{\cdot}050$) after controlling all the previous independent variables.

Scoring plan

A scoring plan was made for the measurement of quality of antenatal care. For each element of the quality item recorded a score of 1 was given if the element was fulfilled, and a score of 0 if not. The total score obtained for each quality item was expressed as a percentage of the maximum obtainable score. The level of quality of antenatal care for each visit was measured and an average of these levels plus percentage scoring for provision of pregnancy-related advice and explaining danger signs to the mother reflected the overall quality of antenatal care. Finally quality of antenatal care was graded as follows: mean + 1 SD above = good; mean ± 1 SD = average; mean − 1 SD = poor.

Results

Four hundred and sixty-five singleton life births out of a total of 1467 births during the study period were studied. Birth weight was categorized as <2500 g and ≥2500 g and designated as low birth weight and normal birth weight respectively according to

Table 2. Frequency distribution of variables

Variable	Frequency	Percentage
Birth weight (N=465)		
≤2499 g	108	23·2
≥2500 g	357	76·8
(Mean=2674·20 g, SD= ± 425·31, SE=19·72)		
Level of quality of antenatal care (N=465)		
≤51·89	68	14·6
51·90–67·04	320	68·8
≤67·05	77	16·6
(Mean=59·97, SD= ± 7·08, Range=45·61–76·51; SE=0·33)		
Number of antenatal visits (N=465)		
<4	127	27·3
≥4	338	72·7
(Mean=4·82, Median=5, SD= ± 2·19, Range=1–10, SE=0·10)		
Gestational duration when 1st visit happens (N=465)		
<12 weeks	91	19·6
12–24 weeks	268	57·6
<24 weeks	106	22·8
(Mean=21·03, SD= ± 5·46, Range=8–37, SE=0·25)		
Number of conception (N=465)		
1st	226	48·6
2nd–3rd	203	43·7
4th or more	36	7·7
(Mean=1·81, SD= ± 1·01, Range=1–6, SE=$4{\cdot}71\times10^{-2}$)		
Number of conceptions in mothers ≥30 years (N=148)		
(Mean=2·07, SD= ± 1·41, Range=1–6, SE=0·12)		

the WHO cut-off point. Rate of occurrence of low birth weight was 23·2 in one hundred live normal births. Quality of antenatal care ranged from 45·61% to 76·51% with a mean of 59·97% and SD of ± 7·08. Most births belonged to the average group (n=320, 68·8%). Number of ANC visits attended was grouped into <4 visits and ≥4 visits and it was found that 72·7% of mothers attended 4 or more visits, with a mean of 4·82 visits (SD ± 2·19) (Table 2).

Mother's gestational duration at their first antenatal visit was given as within 1st trimester, 2nd trimester and 3rd trimester; 57·65 % of women (n=268) made their first visit during their 2nd trimester (within 12–24 weeks of pregnancy). The mean duration of gestation at first visit was 21·03 weeks of pregnancy with a range of 8–37 weeks and standard error of 0·25 (Table 2).

Number of conception (gravida) was categorized into 1st conception, 2nd or 3rd conception and 4th or more conception. More women were in the 1st group (n=226, 48·6%) than in the other groups (Table 2). Only 7·7% (36) had 4th or more pregnancy. There was a mean number of pregnancies of 1·81, ranging from 1 to 6 and standard error of $4{\cdot}71\times10^{-2}$. The mean number of conceptions in women of ≥30 years of age was 2·07, with a range of 1 to 6.

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Table 3. Maternal factors and birth weight of newborn babies

	Birth weight (g)	No.	Mean	SD	t value	p
Age	<2500	108	29·83	5·36	7·554	0·001
	≥2500	357	25·62	3·98		
Income (taka)	<2500	108	5297·22	4130·54	−7619	0·001
	≥2500	357	8983·19	5219·26		
BMI on 1st visit	<2500	108	20·68	1·86	1·81	0·072
	≥2500	357	20·34	1·69		
BMI at pre-delivery stage	<2500	108	21·72	1·88	−4·88	0·001
	≥2500	357	22·73	1·88		
Gravida	<2500	108	1·96	1·44	1·38	0·170
	≥2500	357	1·76	0·84		
Birth-to-conception interval	<2500	44	23·55	16·84	−1·25	0·213
(months)	≥2500	195	27·52	19·51		

The mean age of the mothers with underweight babies (29·83 ± 5·36) was significantly higher than that of the mothers of normal-weight babies (25·62 ± 3·98) (t=7·554, p=0·001) (Table 3). Mean birth weight was below 2500 g in both ≤19 (2150 g) and ≥30 and above (2415·54 g) age group. This difference in birth weight among different age group mothers was significant (F=44·890, p=0·000) (Fig. 1).

Mothers who delivered normal-weight babies had a significantly (t= −7619, p=0·001) higher monthly family income (8983·19 taka) than those delivering underweight babies (5297·22 taka) (Table 3).

Mean pre-delivery BMI was significantly (t= −4·880, p=0·001) higher in mothers with normal-weight babies (22·73 ± 1·9) than those with underweight babies (21·72 ± 1·87) (Table 3). But there was no significant difference in BMI at first ANC visit between mothers of underweight and normal-weight babies (t=1·806, p=0·072) (Table 3).

Mean number of conception (gravida) was slightly higher in mothers with underweight babies (1·96 ± 1·44) than in those with normal-weight babies (1·76 ± ·84), but this was not significant (t=1·381, p=0·170). Similarly, a non-significant difference was found for mean birth-to-conception interval and birth weight (t= −1·248, p=0·213) (Table 3).

Level of educational attainment of the mother was graded into six groups from ‘no education’ to ‘masters’. Mothers with normal-weight babies had significantly (χ^2=181·073, df=5, p=0·001) higher education than those with underweight babies (Table 4). There is a significant gradual increment of mean birth weight as education level increases from no education to Higher Secondary Certificate and above (Fig. 2).

The association between sex of newborn and birth weight was not significant (χ^2=4·216, df=1, p=0·051) (Table 4). Variance analysis showed a significant difference (f=59·97, p=0·001) in mean birth weight among the different grade of quality of antenatal care. There was significant heterogeneity between means. There was 358·01 g

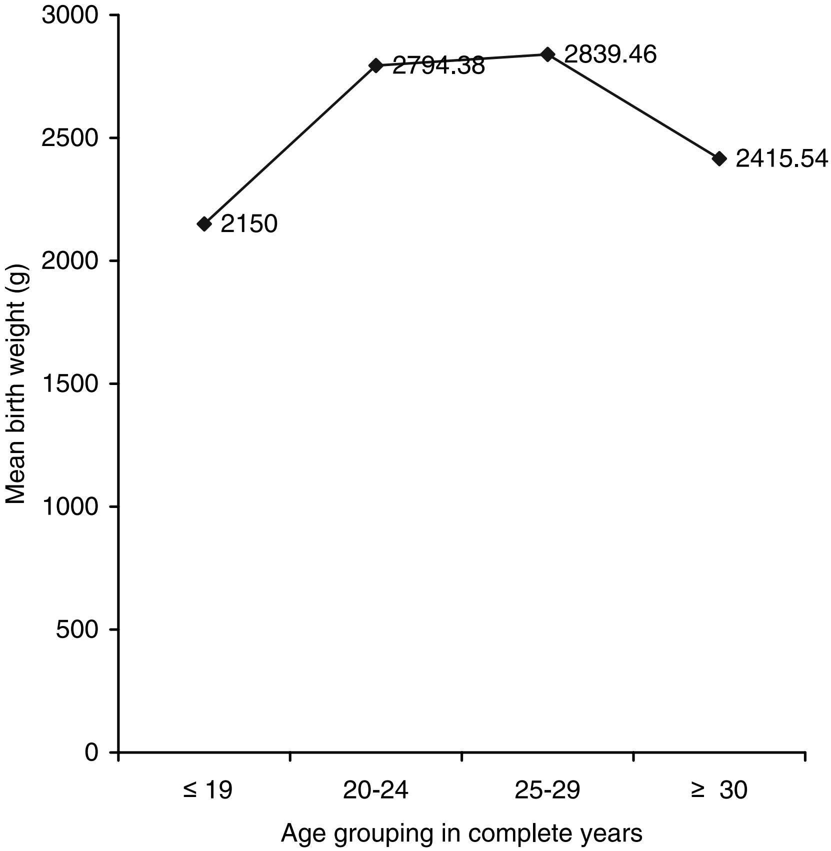

Fig. 1. Age of the mother and mean birth weight of baby.

more weight when the grade of quality turned to average from poor, and 333·94 g more when it turned to good from average (Table 5).

The number of antenatal visits has a significant (p=0·001) effect on birth weight (linear regression equation: 1956·403+149·006×no. of visits; F=662·74, R^2=0·588). Thus there is a possibility of a 149·006 g increase in weight of the newborn for an increase of one antenatal visit. The adjusted R^2 indicates that nearly 58% of the variance of weight was explained by number of antenatal visits.

Multiple regression analysis (stepwise) was carried out to observe which individual variable or combination of variables explain the variation of birth weight maximally. In the model, number of antenatal visits attended by the mother, quality of antenatal care, age of the mother, education and *per capita* monthly income were included as independent variables and birth weight of the newborn was considered as the dependent variable. Fifty eight per cent of the variation was explained by the number of antenatal visits, education 61% and *per capita* income per month 62%. Age of the mother and quality of antenatal care were excluded as they did not follow the criteria (Table 6).

Table 4. Socio-demographic factors and birth weight of the newborn babies

Variable	*n* (%) Birth weight <2500 g	Birth weight ≥2500 g	Total	Test statistics
Education of mother				$\chi^2=181{\cdot}07$, df=5, $p=0{\cdot}001$
None	66 (14·2)	24 (5·2)	90 (19·4)	
Primary	33 (7·1)	94 (20·2)	127 (27·3)	
SSC	5 (1·1)	82 (17·6)	87 (18·7)	
HSC	2 (0·4)	54 (11·6)	56 (12)	
BA	1 (0·2)	49 (10·5)	50 (10·8)	
MA	1 (0·2)	54 (11·6)	55 (11·8)	
Sex of baby				
Male	45 (9·7)	187 (40·2)	232 (49·9)	$\chi^2=4{\cdot}216$, df=1, $p=0{\cdot}051$
Female	63 13·5)	170 (36·6)	233 (50·1)	

SSC, secondary school certificate; HSC, higher school certificate; BA, bachelors degree; MA, masters degree.

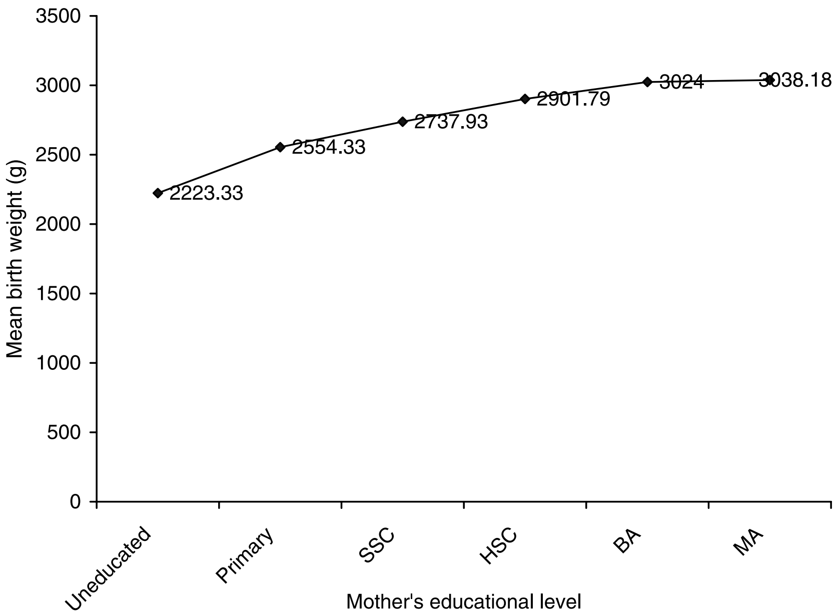

Fig. 2. Mother's educational level and birth weight. Sample sizes: uneducated, 90; primary, 127; SSC, 87; HSC, 56; BA, 50; MA, 55. $F=71{\cdot}604$; $p=0{\cdot}000$.

Discussion

This study was done on 465 mother–baby pairs to assess (i) the relationship between birth weight and different maternal factors and (ii) the dose–response relationship of

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Table 5. Quality of antenatal care and birth weight

Quality of antenatal care	n	Mean birth weight	± SD	F (p)
Poor	68	2313·24	285·94	59·97 (0·001)
Average	320	2671·25	400·76	
Good	77	3005·19	361·24	

Table 6. Multiple regression equations for estimating birth weight from significant maternal factors

Multiple regression equations	Adjusted R^2	p value	Confidence intervals
Y=1956·403+(149·006×no. ANC visits)	0·58	0·000	No. antenatal visits 137·63–160·38
Y=1880·936+(131·131×no. ANC visits) +(200·350×education)	0·61	0·000	Education 130·18–270·51
Y=1880·885+(127·227×no. ANC visits) +(158·716×education)+(102·444×income)	0·62	0·000	Income 0·005–0·015

quality of antenatal care and number of antenatal visits with birth weight. An observational study design was chosen because it is relatively simple to carry out, inexpensive and allows the study of multiple risk factors.

The literature is replete with studies dealing with risk factors for low birth weight, but unanimity cannot be reached for two reasons. Firstly, the risk factors are not universally applicable (Anderson *et al.*, 1984). Secondly, the methodologies used by researchers are not uniform. Basically, two methodologies have been used: evaluation of the effect of factors (in isolation) through cross-tabulations, or utilizing statistical techniques to control for confounding variables. The latter is more likely to give a better indication of the contribution to low birth weight for each of the various risk factors (Dougherty & Jones, 1982). The current study's results are discussed with reference to studies utilizing both methodologies.

The study found a mean birth weight of 2674·19 g (SD 425·31 g) and the rate of occurrence of low birth weight was 23·2% among newborns during the study period. Hosain *et al*. (2006) found a mean birth weight of 2961 g in rural Bangladesh in 2005. Dhar *et al.* (2002) found a mean birth weight of 2889 g and a rate of low birth weight rate of 15·18%. Karim & Mascie-Taylor (1997) found a low-birth-weight rate of 21% and mean birth weight of 2860 g. Ahmed & Das (1992) found a mean birth weight of 2667 g and low-birth-weight rate of 26·7%. This study applies an evaluation of process to quality of antenatal care. The structural setting was assessed afterwards but was not added for measurement of final level of quality of antenatal care. Because of its complexity and elusive nature, the outcome was not assessed in this study. The quality of antenatal care was assessed using a scoring system based on the record review of some elements of antenatal care and interviewing the mother for some elements, as described in the Methods section. If it had been possible to cross-check the mother's interview answer and records then it would have been better. This was one of the other limitations of the study. The scores obtained were used to classify the quality of antenatal care into three categories, viz. good, average and poor. The level of quality of antenatal care ranged from 45·61% to 76·51% with a mean score of 59·97%. Dr Than Tun Sein in his study in Myanmar in 1998 (Than Tun Sein, 1998) found that quality of antenatal care on performance of midwives ranged from 51% to 79% and he concluded that the quality was satisfactory. In Sikosana *et al.*'s (1994) study in Northern Matabeleland, the professional performance of health workers at the rural health centre level was found to be unsatisfactory, though there was consumer satisfaction with the antenatal care services: the mean score for quality of antenatal care was 67% and the range was 46·7–88·3% (SD 7·48). So, there are very similar results in all studies.

In this study, the mean number of antenatal visits and those who attended <4 visits were exactly the same as in a study by NIPORT (BDHS, 2000), but higher in the case of $\geq$4 visits. The mean number of weeks at which women had their first antenatal care visit was 21·03 weeks. This is the same as the survey findings of NIPORT in Bangladesh in 2001 (BDHS, 2001).

The average number of conception for mothers is less than that documented by Khanum & Shahidullah (1996), but the numbers for the two other groups (2nd and 3rd gravida and $\geq$4) are similar to those of Naher *et al.* (1998).

In the present study mean birth weight was below 2500 g in extreme age groups ($\leq$19 and $\geq$30 and above). This is in agreement with many similar studies, both in developed (Canosa, 1989) and developing countries (Ahmed & Das, 1992; Karim & Mascie-Taylor, 1997; Naher *et al.*, 1998; Khan & Jamal, 2003).

Family income had a significant influence on birth weight of newborns, as found in other studies in Bangladesh (Ahmed & Das, 1992; Karim & Mascie-Taylor; 1997; Naher *et al.*, 1998).

The relationship between pre-delivery BMI and birth weight is consistent with a large number of studies in the West (Taren & Graven 1991; Bener *et al.*, 1996) and in developing (Villar & Belizan, 1982) and Gulf countries (Youssef *et al.*, 1991), though most of them used post-delivery BMI. But there was a negative correlation between maternal BMI at 1st visit and birth weight in this and the studies of Hua *et al.* (1996) and Osman *et al.* (2001).

Whilst younger women are more likely to be primiparous than older women, and conversely, older women are more likely to be of the highest parity, primiparity and multiparity are in some studies independent predictors of low birth weight. In this study, when number of conception (gravida) was taken as the continuous variable, no association was found between number of conception and birth weight, in contrast with the studies of Khanum & Shahidullah (1996), Goodburn *et al.* (1994), Begum & Barua (1996) and Nahar *et al.* (1998).

Mean birth-to-conception interval was less in low-birth-weight babies, but this is not significant. The result of the present study is in disagreement with many other studies (Husaini, 1986; Elenice *et al.*, 1988; Moller *et al.*, 1989; Ahmed & Das, 1992). One study showed similar findings: 'no increased risk of low birth weight for short pregnancy intervals after adequate multivariate control for confounding' (Papiernik & Kaminski, 1974). This may be because it is not only the interval or the number of conception but, specially, the nutritional factor that is responsible for the birth weight of the baby. If a woman can regain her nutritional status before the conception of her baby and maintain it for the next period, it may be possible for her to have a normal weight baby.

Mother's educational status has a large influence on the birth weight of the baby. The present study is in common agreement with other studies that incidence of low birth weight decreases as mother's educational status increases. The present study also shows that there is a gradual increment of mean birth weight as education level increases from no education to Higher Secondary Certificate (HSC) and above. Many other studies have shown similar findings (Karim & Mascie-Taylor, 1997; Naher *et al.,* 1998). But the opposite was found in the studies of Shusma *et al*. (1997) and Herbert *et al.* (2001): they found no correlation between mother's educational status and birth weight of the baby.

Mean birth weight was almost the same for both male and female babies. The finding is inconsistent with that of the study by Karim & Mascie-Taylor (1997).

A study by Nair *et al*. (2000) examined the dose–response relationship between quality of antenatal care and birth weight. In that study quality was scored based on the number of antenatal care visits, place of antenatal care, status of tetanus toxoid immunization and iron and folic acid supplementation, recording of weight and blood pressure during each visit and blood and urine examination. In AMCHT, a modified WHO standard was used for antenatal care visits. In this study, along with some other variables (details in Methods section), all of the above-mentioned variables were taken, except place of antenatal care, because this was not relevant to this study, and number of antenatal care visits was taken as an independent variable. A significant dose–response relationship was found between quality of antenatal care and birth weight, as was found by Nair *et al.* (2000). Because birth weight increases with different ordinal grade of quality care, it is treated it as different doses.

The present study shows the positive effect of number of antenatal care visits on birth weight. The regression equation shows that there is a significant dose–response relationship between number of antenatal care visits and birth weight (for each extra antenatal visit there is a 149·006 g increase in birth weight). This finding is consistent with those of Desjardins & Hardwick (1999), Nobrega *et al*. (1989), Hasin & Begum (1996), Bener *et al*. (1996) and Naher *et al.* (1998). But Moller *et al*. (1989), Ramachandran (1989) and Youssuf *et al*. (1991) found opposite results. However, Greenberg (1983) showed that the strength of association between antenatal care and birth weight varies with different social group and is modified by social situation.

The number of antenatal visits required to reduce the probability of a low-birth-weight baby for a woman with no education and below-average *per capita* income is estimated to be 6 in the present study. It is 5 for a woman with no education and above-average *per capita* income status, and 4 for a woman with education and at any category of income status. No such prediction has been done previously in any of the above-mentioned studies.

The above results clearly indicate that there are several interplaying factors that lead to low-birth-weight babies. This study revealed six key factors: quality of antenatal care, number of antenatal visits, age of the mother, educational level of the mother, *per capita* yearly income and pre-delivery BMI. There is a significant dose–response relationship between quality of antenatal care and number of antenatal visits with birth weight of the newborn. Furthermore, multiple regression analysis using the forward method found the variables that had a significant independent effect on weight of the newborn were: number of antenatal visits, educational level of the mother and *per capita* yearly income. And from the equation obtained from multiple regression analysis, there is a need to categorize women according to their income and educational status so that, along with other measures, the predicted number of antenatal visits can be estimated beforehand to get a normal-weight baby.

References

Ahmed, F. U. & Das, A. M. (1992) Three ANC visits might be the divergent point in lowering low birth weight babies in Bangladesh. *Integration* **33**, 50–53.

Akhter, H. H., Elahi, M. E., Chowdhury, K. & Sen, A. (1996) A cross sectional study on maternal mortality in Bangladesh. *BIRPERHT, Institute of Research for Promotion of Essential and Reproductive Health and Technologies.* December, pp. 28–52.

American Academy of Pediatrics (2002) *Guidelines for Prenatal Care*. American Academy of Pediatrics, Elk Grove Village, IL; American College of Obstetricians and Gynaecologists Washington, DC.

Anderson, G. D., Blinder, I. N., McClemont, S. & Sinclair, J. C. (1984) Determinants of size at birth in a Canadian population. *American Journal of Obstetrics and Gynecology* **150**, 236–144.

Balachet, T. (1988) *Maternal Mortality in Bangladesh. An Anthropological Assessmen*t. NORAD, Bangladesh.

Barber, S. (2006) Does the quality of prenatal care matter in promoting skilled institutional delivery? A study in rural Mexico. *Maternal Child Health Journal* **10**(5), 19–25.

Barker, D. J. (2004) The developmental origins of chronic adult disease. *Acta Paediatrica Supplement* **93**, 6–33.

BDHS (2001) *Bangladesh Demography and Health Survey 1999–2000.* NIPORT, Dhaka.

Begum, R. & Barua, S. (1996) Birth weight in relation to other anthropometric indices and some biological and socio-economic factors: A study in a city hospital. Bangladesh. *Journal of Nutrition* **9**, 1–2.

Bener, A., Razzaq, Y. M. & Dawodu, A. (1996) Sociodemographic risk factors associated with low birth weight in United Arab Emirates. *Journal of Biosocial Science* **28**, 339–346.

Berglun, A. C. & Lindmark, G. C. (1997) Health services effects of a reduced routine program for antenatal care: an area based study. *European Journal of Obstetrics Gynecology and Reproductive Biology* **7**, 193–199.

Blondel, B., Pusch, D. & Schmidt, E. (1985) Some characteristics of antenatal care in 13 European countries. *British Journal of Obstetrics and Gynaecology* **92**, 565–568.

Canosa, C. A. (1989) Intrauterine growth retardation in India and Bangladesh 1983. In Senterre, J. (ed.) *Intrauterine Growth Retardation.* Nestle Nutrition Workshop Series, Vol. 18, Nestle Ltd, pp. 183–204.

Carroli, G. *et al.* (2001) WHO systematic review of randomised controlled trials of routine antenatal care. *Lancet* **357**, 1565–1570.

Desjardins, E. & Hardwick, D. (1999) How many visits by health professionals are needed to make a difference in LBW? A dose–response study of the Toronto healthiest babies possible program. *Canadian Journal of Public Health* **90**(4), 224–228.

Dhar, B., Mowla, G., Nahar, S. & Islam, N. (2002) Birth weight status of newborns and its relationship with other anthropometric parameters in a public maternity hospital in Dhaka, Bangladesh. *Journal of Health Population and Nutrition* **20**(1), 36–41.

Ding Phuong Hoa, To Thanh Huong, Vuong Thi Hoa, Bengt Hojer, B. & Persson, L. A. (1996) Maternal factors influencing the occurrence of low birth weight in northern Vietnam. *Annals of Tropical Paediatrics* **16**, 327–333.

Donar, A., Brown, K. S. & Brasher, P. A. (1990) Methodological review of nontherapeutic intervention trials employing cluster randomization, 1979–1989. *International Journal of Epidemiology* **19**, 795–800.

Dougherty, C. R. S. & Jones, A. D. (1982) The determinants of birth weight. *American Journal of Obstetrics and Gynecology* **144**, 190–200.

Elenice, M., Ronald, H., Patricia, L. & Tarcisio, M. (1988) Inter-pregnancy interval and low birth weight: findings for a case control study. *American Journal of Epidemiology* **128**(5P), 1111–1116.

Fawcus, S., Mbizvo, M., Lindmark, G. & Nystrom, L. (1996) A community-based investigation of avoidable factors for maternal mortality in Zimbabwe. *Studies in Family Planning* **27**, 319–327.

Goodburn, E., Chowdhury, M. & Gazi, R. (1994) Low birth weight in rural Bangladesh. *Journal of Tropical Pediatrics* **40**, 76–81.

Great Britain Ministry of Health (1930) *Memorandum on Antenatal Clinics; Their Conduct and Scope*. Great Britain Ministry of Health, London.

Greenberg, R. S. (1983) The impact of prenatal care in different social groups. *American Journal of Obstetrics and Gynecology* **145**, 797–801.

Hasin, A. & Begum, R. (1996) Relationship between birth weight and biochemical measures of maternal nutritional status at delivery in Bangladesh urban poor. *International Journal of Food Science and Nutrition* **47**(3), 273–279.

Herbert, R., Peters, J., Vince, D. & Friesen, H. (2001) Low birth weight at a Papua New Guinea Highlands Hospital. *Journal of Tropical Pediatrics* **47**, 17–23.

Hollander, D. (1997) Prenatal benefits improve birth outcomes among working Mexican women. *International Family Planning Perspectives* **3**, 94–95.

Hosain, G. M., Chatterjee, N., Begum, A. & Saha, S. C. (2006) Factors associated with low birth weight in rural Bangladesh. *Journal of Tropical Pediatrics* **52**(2), 7–91.

Husaini, Y. K., Sulaiman, Z., Jahari, A. B., Barizi, S. Hudono, T. & Karyadi, D. (1986) Maternal malnutrition, outcome of pregnancy, and a simple tool to identify women at risk. *Food and Nutrition Bulletin* **8**(1), 71–76.

International Children Center (1983) *Prevention and Management of High Risk Pregnancies: A Document for Planners, Administrators.* Programme of Development of information on Early Childhood. International Children Center, Paris, France.

Karim, E. & Mascie-Taylor, C. G. N. (1997) The association between birth weight, socio-demographic variables and maternal anthropometry in an urban sample from Dhaka, Bangladesh. *Annals of Human Biology* **24**(5), 387–401.

Khan, N. & Jamal, M. (2003) Maternal risk factors associated with low birth weight. *Journal of College of Physicians and Surgeons Pakistan* **13**(1), 25–28.

Khanum, S. & Shahidullah (1996) A study of correlation of mid thigh and arm circumference of newborns and birth weight. *Bangladesh Medical Journal* **19**(2), 45–50.

Lieu Thuy Thi Trinh & Rubin, G. (2006) Late entry to antenatal care in South Wales, Australia. *Reproductive Health* **3**(8), doi: 10·1186/1742–4755-3-8.

Lwanga, S. K. & Lemeshow, S. (1991) *Sample Size Determination in Health Studies: A Practical Manual.* World Health Organization, Geneva, p. 25.

McDuffie, R. S., Beck, A., Bischoff, K., Cross, J. & Orleans, M. (1996) Effect of frequency of prenatal visit on perinatal outcome among low-risk women: a randomised controlled trial. *Journal of the American Medical Association* **275**, 847–851.

Ministry of Health and Family Welfare of Bangladesh & UNICEF (1995) *Reference Manual for Health Care Outdoor: Thana level.* Ministry of Health and Family Welfare of Bangladesh and UNICEF.

Mohsin, M., Bauman, A. F. & Jalaludin, B. (2006) The influence of antenatal and maternal factors on stillbirths and neonatal deaths in New South Wales, Australia. *Journal of Biosocial Science* **38**(5), 43–57.

Moller, B., Lushino, O., Mebre-Medhin, M. & Lindmark, G. (1989) A study of antenatal care at village level in rural Tanzania. *Indian Journal of Gynaecology and Obstetrics* **30**(2), 123–131.

Munjanja, S. P, Lindmark, G. & Nystrom, L. (1996) Randomised controlled trial of a reduced-visits program of antenatal care in Harare, Zimbabwe. *Lancet* **348**, 364–369.

Naher, N., Afroza, S. & Hossain, M. (1998) Incidence of LBW in three selected communities of Bangladesh. *Bangladesh Medical Research Council Bulletin* **24**(2), 49–54.

Nair, N. & Sreekumaran *et al.* (2000) Sociodemographic and maternal determinants of low birth weight: A multivariate approach. *Indian Journal of Pediatrics* **67**, 9–14.

Nobrega *et al.* (1989) Anthropometry in Brazilian newborn infants: Studies of association with some maternal factors. *Nestle Nutrition Workshop Series* **18**, 157–164.

Osman *et al.* (2001) Perinatal outcome in an obstetric cohort of Mozambican women. *Journal of Tropical Pediatrics* **47**, 503–509.

Papiernik, E. & Kaminski, M. (1974) Multifactorial study of the risk of prematurity at 32 weeks of gestation: A study of the frequency of 30 predictive characteristics. *Journal of Pediatric Medicine* **2**, 30–36.

Rahman, M. M., Barkat-e-khuda, K. T. T., Mazumder, K. A. & Reza, M. M. (1997) *Determinants of Antenatal Care Seeking Behaviour in Rural Bangladesh.* MCH-FP Extension Division Working Paper 126. ICDDRB, Bangladesh, pp. 1–21.

Ramachandran, L. (1989) The effect of antenatal care and natal services on pregnancy outcome and health of the mother and the child. *Journal of Family Welfare* **35**(5), 34–46.

Sen, D., Yusof, K. & Rajaswari, K. (1991) Are three antenatal visits enough for low risk mothers? *Singapore Journal of Obstetrics and Gynaecology* **22**, 83–86.

Sikosana, P. L. N. (1994) An evaluation of the quantity of antenatal care at rural health centre in Matabeleland North Province. *Central African Journal of Medicine* **40**, 10–15.

Singh, M. (1991) Disorders of weight and gestation. In Singh, M. (ed.) *Care of the New Born*, 4th edn. New Delhi.

Srinivasa, D. K., Danabalan, M. & Rangachari, R. (1982) Method to assess quality of services in antenatal clinics of primary health centers. *Indian Journal of Medical Research* September, 458–466.

State of World Children (2005) UNICEF.

Sushma, M., Radha, G., Ghidiyal, R. U. & Waingankar, P. (1997) Maternal biosocial factors affecting low birth weight. *Indian Journal of Pediatrics* **64**, 373–377.

Taren, D. L. & Graven, S. N. (1991) The association of prenatal nutrition and educational services with low birth weight rates in a Florida program. *Public Health Reports* **106**, 426–436.

Than Tun Sein (1998) *Quality of Antenatal Care Performance of Midwives in a Rural Area of Myanmar.* WHO Regional Publication, South-East Asia Series No. 16, pp. 121–125.

Viller, J. & Belizan, J. M. (1982) The relative contribution of prematurity and fetal growth retardation to low birth weight in developing and developed countries. *American Journal of Obstetrics and Gynecology* **143**, 793–798.

Walker, D. & Koniak-Griffin, D. (1997) Evaluation of a reduced frequency prenatal visit schedule for low risk women at a free-standing birthing center. *Journal of Nursing and Midwifery* **42**, 295–303.

White, D. E., Fraser-Lee, N. J., Tough, S. & Newburn-Cook, C. V. (2006) The content of prenatal care and its relationship to preterm birth in Alberta, Canada. *Health Care Women International* **27**(9), 77–92.

WHO (1994) *WHO Antenatal Care Randomized Trial: Manual for the Implementation of the New Model.* WHO/RHR/ 01·30. World Health Organization, Geneva.

Youssef, A., Al-Ellissa, Baaqeel, H. S. & Haque, K. H. (1991) Low birth weight in Riyadh, Saudi Arabia: incidence and risk factors. *Annals of Tropical Peadiatrics* **11**, 75–82.