Factors associated with low birthweight in term pregnancies: a matched case–control study from rural Pakistan

Muhammad A. Habib [1,2], Camille R. Greenow [3], Shabina Ariff [2], Sajid Soofi [2], Abid Hussain [2], Qamar Junejo [2], Amjad Hussain [2], Fariha Shaheen [2] and Kirsten I. Black [1]

العوامل المرتبطة بانخفاض وزن المواليد في الحمل المكتمل: دراسة حالة ضابطة مقارنة من المناطق الريفية في باكستان

محمد عاطف حبيب، كميل رينز كرينوو، شبينة عارف، ساجد صوفي،عابد حسين، قمر جونجو، أمجد حسين، فريحه شاهين، كرستن بلاك

الخلاصة: لا يزال انخفاض الوزن عند الولادة مشكلة صحية عامة كبيرة في باكستان، ويلزم التوصل إلى فهم أعمق للعوامل المرتبطة بانخفاض الوزن عند الولادة. وقد أجرينا دراسة حالة ضابطة مقارنة في المستشفيات لتحديد عوامل الخطر المرتبطة بانخفاض الوزن عند الولادة في منطقة ريفية في باكستان. وتبيّن لنا أن الإلمام بالقراءة والكتابة (AOR: 2.68, ٪95 CI: 1.59 – 4.38)، وانعدام الحمل (AOR: 1.82, ٪95 CI: 1.26 – 2.44)، والتعرض لسقوط الحمل/ الإجهاض في السابق (AOR: 1.22, ٪95 CI: 1.06 – 2.35)، وإجراء أكثر من زيارتين لرعاية ما قبل الوضع خلال الحمل الأخير (AOR: 2.43, ٪95 CI: 1.34 – 2.88)، والسعي للحصول على الرعاية ما قبل الوضع خلال الثلث الثالث من الحمل (AOR: 3.62, ٪95 CI: 2.14 – 5.03)، وعدم استخدام حمض الفوليك الحديدي خلال الحمل الأخير (AOR: 2.72, ٪95 CI: 1.75 – 3.17)، والإصابة بارتفاع ضغط الدم خلال الحمل الأخير (AOR: 1.42, ٪95 CI: 1.13 – 2.20)، والإصابة بفقر الدم (AOR: 2.67, ٪95 CI: 1.65 – 5.24) ووصول الوزن بعد الولادة إلى أقل من 45 كغم (AOR: 3.30, ٪95 CI: 1.97 – 4.52)، يرتبط ارتباطاً ذا دلالة بتزايد احتمالات إنجاب طفل وزنه منخفض عند الولادة. وتحدِّد دراستنا عوامل الخطر القابلة للتعديل والتي تتطلب التزاماً فورياً من السلطات الصحية.

ABSTRACT Low birthweight (LBW) remains a significant public health problem in Pakistan and further understanding of factors associated with LBW is required. We conducted a hospital-based matched case control study to identify risk factors associated with LBW in a rural district of Pakistan. We found that illiteracy (AOR: 2.68; 95% CI: 1.59 - 4.38), nulliparity (AOR: 1.82; 95% CI: 1.26-2.44), having a previous miscarriage/abortion (AOR: 1.22; 95% CI: 1.06-2.35), having < 2 antenatal care (ANC) visits during last pregnancy (AOR: 2.43; 95% CI: 1.34-2.88), seeking ANC in third trimester (AOR: 3.62; 95% CI : 2.14-5.03), non-use of iron folic acid during last pregnancy (AOR: 2.72; 95% CI: 1.75-3.17), having hypertension during last pregnancy (AOR: 1.42; 95% CI: 1.13-2.20), being anemic (AOR: 2.67; 95% CI: 1.65-5.24) and having postpartum weight of <45 kg (AOR: 3.30; 95% CI : 1.97-4.52) were significantly associated with an increased odds of having a LBW baby. Our study identifies modifiable risk factors requiring immediate commitment from the health authorities.

Facteurs associés à une insuffisance pondérale à la naissance dans les cas de grossesses à terme : étude cas-témoins appariés au Pakistan rural

RÉSUMÉ L'insuffisance pondérale à la naissance demeure un problème de santé publique significatif au Pakistan, et une compréhension approfondie des facteurs associés à ce problème est requise. Nous avons conduit une étude cas-témoins appariés en hôpital afin d'identifier les facteurs de risque associés à l'insuffisance pondérale à la naissance dans un district rural du Pakistan. Il est apparu que l'analphabétisme (OR ajusté : 2,68 ; IC de 95 % : 1,59-4,38), la nulliparité (OR ajusté : 1,82 ; IC de 95 % : 1,26-2,44), les antécédents de fausse couche ou d'avortement (OR ajusté : 1,22; IC de 95 % : 1,06-2,35), le fait d'avoir eu moins de deux visites de soins prénatals au cours de la dernière grossesse, (OR ajusté : 2,43 ; IC de 95 % : 1,34-2,88), de n'avoir recherché des soins prénatals qu'au troisième trimestre (OR ajusté : 3,62 ; IC de 95 % : 2,14-5,03), de ne pas avoir bénéficié d'une supplémentation en fer et en acide folique pendant la dernière grossesse (OR ajusté : 2,72 ; IC de 95 % : 1,75-3,17), d'avoir souffert d'hypertension durant la dernière grossesse (OR ajusté : 1,42 ; IC de 95 % : 1,13-2,20), d'anémie (OR ajusté : 2,67; IC de 95 % : 1,65-5,24) et d'avoir un poids post-partum de moins de 45 kg (OR ajusté : 3,30 ; IC de 95 % : 1,97-4,52) étaient significativement associés à des risques accrus d'avoir un bébé souffrant d'une insuffisance pondérale à la naisance. La présente étude a identifié les facteurs de risque modifiables nécessitant un engagement immédiat des autorités sanitaires.

[1]Department of Obstetrics, Gynecology and Neonatology, Central Clinical School, University of Sydney, Sydney, NSW, Australia (Correspondence to: M.A. Habib: atif.habib@aku.edu; habibatif@yahoo.com), [2]Women and Child Health Division, Aga Khan University, Karachi, Pakistan. [3]Sydney School of Public Health, University of Sydney, Sydney, NSW, Australia.

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Introduction

Low birthweight (LBW) is defined as < 2500 g (*1*) and remains a significant public health problem in developing countries like Pakistan (*2,3*). The prevalence of LBW is estimated to be 16% worldwide, 19% in the least developed and developing countries, and 7% in developed countries (*4*). LBW is well documented as a leading cause of neonatal morbidity and mortality and the long-term consequences include nutritional and developmental deficiencies (*5,6*). LBW may result from preterm birth or intrauterine growth restriction (*1*). In developing countries in Asia intrauterine growth restriction is the main cause (*2,3*) and is influenced by socioeconomic and maternal factors before and during pregnancy (*7*).

Pakistan has one of the highest global burdens of LBW, ranging from 19% in urban areas to 32% in rural areas (*8*). These high rates contribute towards both the high neonatal mortality and the high stunting rates in children aged < 5 years, which are estimated to be 58 per 1000 live births (*8*) and 44% (*9*), respectively. LBW due to its adverse health consequences played a key role in hindering Pakistan's progress towards achievement of the Millennium Development Goal 4 (*10*) and is likely to affect its ability to achieve the Sustainable Development Goals related to health and nutrition. In Pakistan the data on risk factors associated with LBW in term babies are scarce, especially for rural settings. The few studies that have been conducted were either limited to urban settings or used cross-sectional data (*11–13*).

Given that LBW exerts such a high burden of morbidity and mortality further understanding of the associated risk factors is required. The aims of this study were (*1*) to identify risk factors associated with LBW in term babies in a rural district of Pakistan; and (*2*) to inform the development of interventions aimed at modifying behaviour and other risk factors for LBW.

Methods

Study design and site

This study was a retrospective, hospital-based, matched case–control study in a rural district of Pakistan. The data were collected between August 2014 and September 2015 from a secondary care hospital (known as THQ KN Shah) located in Taluka (subdistrict) KN Shah of Dadu; a rural district in Sindh Province. This is a 20-bed public hospital with an average of 200 births per month. The hospital has a catchment area of ~150 000 people. The usual length of stay for women at the hospital is about 1 day postpartum.

Sample size

We determined the sample size using the proportion difference approach assuming a confidence level of 95%, power of 80%, case to control ration of 1: 1, detectable odds ratio (OR) of 1.5 and 20% exposure in the control group. A total sample size of 950 (475 cases and 475 controls) was achieved.

Cases and controls

We defined cases as the mothers delivering a live-born singleton baby at term with birthweight < 2500 g and controls as mothers delivering live-born singleton term baby weighing 2500–4000 g. We excluded babies weighing > 4000 g, those with congenital anomalies, multiple births and preterm births. We matched the cases and controls on the basis of neonatal sex and maternal age on the same day when cases were identified. In the event that there were > 2 eligible controls, 1 was selected randomly.

Data collection

We used a structured and pretested data collection form that was translated into the local language. The data collection from eligible mothers was completed within 24 hours of birth. The data collection form had sections on sociodemographic status and medical and reproductive history of the women. Some data were extracted from the antenatal care (ANC) cards and transcribed onto the data collection form. After completion of the data collection form, the female medical officer also documented women's postpartum weight with the use of Seca weighing scales. For each woman, 3 readings were taken and the mean weight in kilograms was recorded . The female medical officer also recorded the weight of the neonates soon after birth using Tanita 1584 electronic baby weighing scales. After 3 readings the mean weight in grams was recorded.

Explanatory variables

The explanatory variables comprised sociodemographic and maternal variables (Table 1). The sociodemographic variables included address of residence and socio-economic status; the latter derived from household assets and utilities score using standard demographic health survey questions. The wealth quintiles were divided into five categories (poorest, poorer, middle, richer and richest). For maternal factors, we collected data on age, education, past reproductive history and information related to the last pregnancy. We recorded age in years, categorized as < 20, 20–30 and > 30. For maternal education we collected information on number of years of completed schooling and categorized as illiterate (no formal education), primary or less (1–5 years), middle (6–8 years), matric (9–10 years) and intermediate and above (> 10 years). We collected information on parity, defined as the number of previous births and categorized as nulliparous (0), primiparous (1), multiparous (2–4), grand multiparous (≥ 5).

We also collected information on the history of miscarriage, abortion and stillbirth. We sought information about the last pregnancy around the number

Table 1 Description of variables

Variables	Description
Socioeconomic status of the household	Measured as quintiles of a linear index derived from household assets and utilities score; wealth quintiles were divided into 5 (poorest, poorer, middle, richer and richest)
Maternal age	Categorized as < 20, 20–30 and > 30 yr
Maternal education	Years of education completed and categorized as illiterate (no formal education), primary or less (1–5), middle (6–8), matric (9–10) and intermediate and above (> 10)
Parity	Number of previous births and categorized as nulliparous (0), primiparous (1), multiparous (2–4), grand multiparous (≥ 5)
History of miscarriage/abortion	History of miscarriage (involuntary loss) or abortion (voluntary loss) and characterized as 1 for Yes and 2 for No
History of stillbirth	History of stillbirth (birth to a child that showed no signs of life) and categorized as 1 for Yes and 2 for No
Number of ANC visits	Number of ANC visits during last pregnancy and categorized as < 2, 2 or 3, and ≥ 4
Time when ANC was sought	Time of pregnancy when 1st ANC was sought and categorized as 1 for 3rd, 2 for 2nd and 3 for 1st trimester
Iron folic acid supplementation	Iron folic acid supplementation during pregnancy and categorized as 1 for Yes and 2 for No
Calcium supplementation	Calcium supplementation during pregnancy and categorized as 1 for Yes and 2 for No
History of hypertension during pregnancy	Hypertension during pregnancy and categorized as 1 for Yes and 2 for No
History of gestational diabetes	Diabetes during pregnancy and categorized as 1 for Yes and 2 for No
Anaemia during pregnancy	Haemoglobin concentration < 110 g/L in whole blood
Postpartum maternal weight	Categorized as < 45, 45–55 and > 55 kg.

ANC = antenatal care.

and timing of the ANC visits; the latter grouped into the following categories < 2, 2–4 and > 4 visits. The timing of the first ANC visit was documented as having occurs in the 1st, 2nd or 3rd trimester. We also collected the data on the use of iron and folic acid supplementation, calcium supplementation, any history of hypertension and any history of diabetes. The haemoglobin status of the women measured at 1st ANC encounter was also recorded as either anaemic (<110 g/dL) or nonanaemic (≥ 110 g/dL). We also measured the postpartum weight of the women, using as proxy for maternal body mass index (BMI) and categorized weight as < 45, 45–55 and > 55 kg.

Data management and statistical analysis

The female medical officer checked the questionnaires for completeness and consistency and coded them before data entry. The Data Management Unit of Aga Khan University, Karachi, Pakistan, entered the data on predesigned data entry screens on Visual Fox Pro software. All data were analysed using SPSS version 19 and conditional logistic regression was used for analysis. Crude and adjusted ORs were used to investigate the factors affecting the incidence of LBW, by bivariate and multiple logistic regression, respectively. We used bivariate analysis to explore the associations between independent variables and LBW, and calculated the crude ORs and confidence intervals (CIs) were calculated. The $\chi 2$ test was used to test possible bivariate associations between independent variables and LBW. Variables significant at $P < 0.25$ were considered for inclusion in the multivariate model. Based on the bivariate analysis and a priori information, a multiple logistic regression model was constructed to examine the relationship between variables and LBW. Independent associations between variables were characterized by adjusted ORs and 95% CIs and variables with $P < 0.05$ were considered statistically significant.

Ethical clearance

The Ethics Review Committee of Aga Khan University granted approval for the study. The female medical officer explained the study and obtained verbal consent from all participants. The confidentiality of all participants was ensured.

Results

A total of 950 mothers, comprising 475 cases and 475 controls, were included in the study. There were no significant differences in the socioeconomic characteristics or maternal age distribution

between the cases and controls (Table 2). However, there were differences in literacy levels, parity, and history of abortion or miscarriage and stillbirth. Cases were less likely to have attended > 4 antenatal visits (17.9 vs 25.9) and to have presented later in pregnancy (23.8% vs 15.6%). The use of calcium supplementation during the last pregnancy was low (14.8% and 13.9%) among the cases and controls, respectively. The use of iron and folic acid supplementation was higher in the controls (46.4%) compared to cases (25.7%). Anaemia status based on low haemoglobin concentration (< 110 g/L) showed that 68.3% of the cases were anaemic compared to 42.8% of the controls. About half of the cases (52.6%) and 37.2% of the controls had a postpartum weight < 45 kg.

Univariate analysis was performed to determine the association between maternal risk factors and LBW (Table 3). The analysis revealed that illiteracy (OR 2.9, 95% CI 1.74–4.88), nulliparity (OR 1.77, 95% CI 1.19–2.63), previous miscarriage or abortion (OR 1.15, 95% CI 1.14–2.28), < 2 ANC visits during last pregnancy (OR 2.06, 95% CI 1.45–2.92), seeking ANC in the 3rd trimester during last pregnancy (OR 3.57, 95% CI 2.49–5.12), non-use of iron and folic acid in last pregnancy (OR 2.51, 95% CI 1.91–3.30), hypertension during last pregnancy (OR 1.72, 95% CI 1.22–2.42), anaemia (OR 3.28, 95% CI 1.80–5.97) and postpartum weight < 45 kg (OR 3.02, 95% CI 2.0–4.57) were significantly associated with an increased risk of having an LBW infant.

In multivariable analysis all these factors remained significant (Table 4). Illiteracy (AOR 2.68, 95% CI 1.59–4.38), nulliparity (AOR 1.82, 95% CI 1.26–2.44), previous miscarriage or abortion (AOR 1.22, 95% CI 1.06–2.35), < 2 ANC visits during last pregnancy (AOR 2.43 95% CI 1.35 – 2.88), seeking ANC in third trimester during last pregnancy (AOR 3.62, 95% CI 2.14–5.03), non-use of iron and folic acid in last pregnancy (AOR 2.72, 95% CI 1.75–3.17), hypertension during last pregnancy (AOR 1.42, 95% CI 1.13–2.20), anaemia (AOR 2.67, 95% CI 1.65–5.24) and postpartum weight < 45 kg (AOR 3.30, 95% CI 1.97–4.52) were significantly associated with an increased risk of having an LBW infant (Table 2).

Discussion

This study identified a range of modifiable factors related to LBW in term babies in a rural region of Pakistan. These factors included illiteracy, nulliparity, previous miscarriage or abortion, number and timing of ANC visits, lack of iron and folic acid supplementation during pregnancy, presence of hypertension or anaemia during pregnancy and postpartum maternal weight < 45 kg.

Previous research has documented that educated women are less likely to have an LBW baby and maternal education has a 33% protective effect against LBW (*14*). This has been observed in similar low-resource settings such as Nepal (*15*) and Bangladesh (*16*), and in a previous study from Pakistan (*17*). We also found that illiteracy was associated with LBW delivery, which is likely related to reduced service utilization and less knowledge of positive health behaviour (*18*). Improving attendance and access to education by young girls will address this issue, although any effect will require a long lead time and long-term investment that ensures maximum enrolment and continuation of the girls in school. Increasing health literacy among illiterate women is complex and requires additional resources directed toward individual counselling (*18*).

We found that nulliparous mothers were more likely to deliver LBW babies compared to multiparous women. This finding is in agreement with previous meta-analyses (*19*) showing that nulliparous women are consistently more likely to have LBW babies compared to their multiparous and grand multiparous counterparts. Several hypotheses have been put forward to explain this association, including the biological immaturity of young mothers and maternal–fetal competition for nutrients in women still trying to achieve their own growth potential (*20,21*). Recent estimates by the United Nations Children's Fund (UNICEF) revealed that 21% of the girls in Pakistan are married before the age of 18 years (*22*). Throughout the country this has changed from 16 years in 1960 to 22 years in 2015 (*23*) but the mean age for marriage in rural areas remains around 16–18 years (*8*). Primary reasons for this early age of marriage in Pakistan are connected with tradition, social and gender inequality and lack of awareness of the harmful impact of early marriages (*24*). Pakistan's Child Marriage Restraint Act 1929 sets the legal age for marriage to 16 years for women and 18 years for men. While preliminary efforts are being made to increase the minimum age for women to 18 years, this has not yet been enacted (*25*). Greater political will and public education are required to address the issue of early marriage and childbearing, along with greater access to modern methods of contraception.

In our study, a previous history of abortion or miscarriage was significantly associated with increased odds of delivering LBW infants. This was in agreement with previous studies (*26,27*) and a systematic review (*28*) that showed a significant relationship between miscarriage and abortion and LBW; the risk of LBW appears to increase with increasing number of previous abortions (*29*). The underlying biological mechanisms responsible for this association may be cervical insufficiency as a result of damage caused by stretching of the cervical canal through dilatation and curettage, and cervical and uterine adhesions as a result of post abortion complications (*30,31*). Also, miscarriages can lead to cervical incompetence and uterine

Table 2 Sociodemographic and maternal characteristics of cases and controls (*n* = 950)

Variables	Cases (*n*)	%	Controls (*n*)	%
Socioeconomic status of the household				
1 Poorest	80	16.8	78	16.4
2 Poorer	101	21.3	106	22.4
3 Middle	94	20	96	20.3
4 Richer	104	21.9	97	20.5
5 Richest	95	19.9	97	20.4
Maternal age, yr				
< 20	114	24	114	24
20–30	242	50.9	242	50.9
> 30	119	25.1	119	25.1
Maternal education (years of schooling)				
Illiterate	297	62.5	208	43.8
Primary or less (1–5)	77	16.2	89	18.7
Middle (6–8)	41	8.6	79	16.6
Matric (9–10)	35	7.4	48	10.2
Intermediate and above (>10)	25	5.3	51	10.7
Parity				
Nulliparous	73	15.3	50	10.5
Primiparous	136	28.6	103	21.6
Multiparous	266	56.1	323	67.9
History of miscarriage/abortion				
Yes	72	15.2	49	10.4
No	403	84.2	426	89.6
History of stillbirth				
Yes	31	6.6	18	3.1
No	93.4	444	457	96.9
Number of ANC visits				
< 2	210	44.3	149	31.4
2–4	181	38.2	203	42.7
> 4	84	17.5	123	25.9
Time when ANC was sought				
3rd trimester	180	37.8	74	15.6
2nd trimester	182	38.4	240	50.5
1st trimester	113	23.8	166	34.9
Iron folic acid supplementation				
No	353	74.3	256	53.6
Yes	122	25.7	219	46.4
Calcium supplementation				
No	405	85.2	409	86.1
Yes	70	14.8	66	13.9
History of hypertension during pregnancy				
Yes	102	21.4	65	13.7
No	373	78.6	410	86.3
History of gestational diabetes				
Yes	27	5.6	25	5.2
No	448	94.4	450	94.8
Anaemia during pregnancy, haemoglobin				
Anaemia < 110 g/dL	324	68.3	203	42.8
Normal ≥ 110 g/dL	151	31.7	272	57.2
Postpartum maternal weight, kg				
< 45	250	52.6	177	37.2
45–55	183	38.5	208	43.8
> 55	42	8.9	90	19.0

ANC = antenatal care.

Table 3 Crude OR and 95% CI for factors associated with LBW in rural Sindh, Pakistan, 2014–2015

Variables	OR	95% CI	*P*
Socioeconomic status of the household			
1 Poorest	0.89	0.59–1.33	0.585
2 Poorer	1.04	0.72–1.50	0.829
3 Middle	0.97	0.67–1.42	0.885
4 Richer	0.82	0.56–1.20	0.311
5 Richest	Ref		
Maternal education (years of schooling)			
Illiterate	2.91	1.74–4.88	0.0001
Primary or less (1–5)	1.76	1.01–3.11	0.048
Middle (6–8)	1.05	0.57–1.94	0.854
Matric (9–10)	1.48	0.77–2.84	0.229
Intermediate and above (> 10)	Ref		
Parity			
Nulliparous	1.77	1.19–2.63	0.0045
Primiparous	1.60	1.18–2.17	0.0023
Multiparous	Ref		
History of miscarriage/abortion			
Yes	1.55	1.14–2.28	0.024
No	Ref		
History of stillbirth			
Yes	1.77	0.97–3.21	0.0595
No	Ref		
Number of ANC visits			
< 2	2.06	1.45–2.92	< 0.0001
2–4	1.3	0.92–1.83	0.126
> 4	Ref		
Time when ANC was sought			
3rd trimester	3.57	2.49–5.12	0.001
2nd trimester	1.13	0.83–1.54	0.411
1st trimester	Ref		
Iron folic acid supplementation			
No	2.51	1.91–3.30	0.0001
Yes	Ref		
Calcium supplementation			
No	0.93	0.64–1.34	0.71
Yes	Ref		
History of hypertension during pregnancy			
Yes	1.72	1.22–2.42	0.0017
No	Ref		
History of gestational diabetes			
Yes	1.08	0.62–1.89	0.775
No	Ref		
Anaemia during pregnancy, haemoglobin			
Anaemia < 110 g/L	3.28	1.80–5.97	0.0001
Normal ≥ 110 g/dL	Ref		
Postpartum maternal weight, kg			
< 45	3.02	2.00–4.57	< 0.0001
45–55	1.88	1.24–2.85	0.0029
> 55	Ref		

ANC = antenatal care; CI = confidence interval; OR = odds ratio; Ref = reference group.

abnormalities resulting in intrauterine growth restriction, which subsequently causes LBW (*32*). In Pakistan the burden of abortion and miscarriage is high, which was reported as 12% and 1.7%, respectively, in the recent Pakistan Demographic and Health Survey (PDHS) (*8*). Another study conducted in 2014 estimated that annually about 2.25 million abortions are conducted in Pakistan leading to a national abortion rate of 50 per 1000 women (15–49 years) (*33*). Averting miscarriages and abortions requires extra vigilance during ANC and greater access to more reliable contraceptive methods. However, the prevalence of using the most effective methods, including intrauterine devices and implants, is only 3% in Pakistan (*8*), which is well below the neighbouring countries.

Adequate and timely antenatal care is of paramount importance for pregnant women and improves pregnancy outcomes. Studies consistent with our findings from similar settings to Pakistan have demonstrated an increased risk of delivering an LBW baby with delayed initiation of ANC, with reduced ANC visits and with inadequate service provision during ANC (*34–36*). We reported similar results and showed

Table 4 AOR and 95% CI for factors associated with LBW in rural Sindh, Pakistan, 2014–2015

Variables	AOR	95% CI	*P*
Maternal education (years of schooling)			
Illiterate	2.68	1.59–4.38	0.0001
Primary or less (1–5)	1.70	1.09–2.97	0.037
Middle (6–8)	1.02	0.54–1.98	0.882
Matric (9–10)	1.36	0.68–2.56	0.310
Intermediate and above (>10)	Ref		
Parity			
Nulliparous	1.82	1.26–2.44	0.0022
Primiparous	1.42	1.10–1.99	0.0017
Multiparous	Ref		
History of miscarriage/abortion			
Yes	1.22	1.06–2.35	0.035
No	Ref		
Number of ANC visits			
< 2	2.43	1.34–2.88	0.0001
2–4	1.52	1.21–2.76	0.0001
> 4	Ref	–	–
Time when first ANC was sought			
3rd trimester	3.62	2.14–5.03	0.001
2nd trimester	1.21	0.81–1.51	0.490
1st trimester	Ref	–	–
Iron folic acid supplementation			
No	2.72	1.75–3.17	0.0001
Yes	Ref	–	–
History of hypertension during pregnancy			
Yes	1.42	1.13–2.20	0.023
No	Ref	–	–
Anaemia during pregnancy, haemoglobin			
Anaemia < 110 g/L	2.67	1.65–5.24	0.0001
Normal ≥ 110 g/dL	Ref	–	–
Postpartum maternal weight, kg			
< 45	3.30	1.97–4.52	0.0001
45–55	1.76	1.17–2.91	0.0125
> 55	Ref	–	–

ANC = antenatal care; CI = confidence interval; OR = odds ratio; Ref = reference group.

that the odds of delivering an LBW baby were greater in women who had fewer than the recommended minimum 4 ANC visits and started ANC late in their pregnancy. The recent PDHS showed that 37% of pregnant women had ≥ 4 ANC visits with a median 3.7 months duration of pregnancy at first ANC encounter. However in rural areas only 26% had ≥ 4 ANC visits and the median gestation at booking was 4.3 months (*8*). Given this and the acknowledged importance of ANC it is reasonable to call for reforms to the maternal neonatal and child health policy to ensure that ANC is delivered to all pregnant women as per the WHO guidance and recommendations.

Studies have demonstrated that non-use of iron supplements and maternal anaemia during pregnancy have a negative effect on birthweight (*37, 38*). In our study, maternal anaemia and non-use of iron supplementation during pregnancy were independently significantly associated with increased risk of LBW. A seminal study conducted in 2001 explored the potential mechanisms of the association between anaemia and LBW and concluded that anaemia can induce maternal and fetal stress, which stimulates the release of corticotropin releasing hormone. In turn, this increases fetal cortisol production, which consequently inhibits longitudinal growth of the fetus (*39*). Pakistan has a high anaemia burden and use of iron supplementation among pregnant women is alarmingly low (45%) (*8*). To reduce the burden of anaemia among women, efforts should be made to increase the use of iron and folic acid supplementation, and the best strategies are iron supplementation and food fortification (*40*).

In our study postpartum weight < 45 kg was significantly associated with increased odds of having an LBW baby. We used postpartum weight to assess the status of maternal undernutrition and used it as a proxy for maternal BMI. Previous studies have also demonstrated the association between maternal underweight and LBW (*41,42*). This results from the fact that underweight mothers tend to have gross nutritional deficiencies and lower placental weight that lead to insufficiency (*42,43*). Recent population-based surveys in Pakistan (PDHS in 2013 and National Nutrition Survey in 2011) revealed that the prevalence of underweight (BMI < 18.5) in Pakistani women was 14 and 18%, respectively (*8,9*). This is a high burden that requires immediate attention and interventions for mothers, such as nutritional counselling and food supplementation during pregnancy for improved neonatal outcomes.

Similarly, hypertension was significantly associated with LBW in our study, which is supported by previous research (*44,45*). It is believed that hypertension causes a decrease in uteroplacental blood flow, which results in LBW and other complications (*46*). Data from Pakistan have reported a 15% frequency of hypertensive disorders during pregnancy (*47*). Therefore, early detection and management of gestational hypertension is imperative. To achieve this target in Pakistan, first-line healthcare workers should be trained and encouraged to manage hypertension in community settings using the WHO recommended guidelines (*48*).

We used a matched case–control design to explore the risk factors for LBW, which was an acceptable design for an analytical risk factor study. However our study had some limitations. First, we used the postpartum maternal weight as a proxy indicator for maternal BMI so our finding of the association between maternal underweight and LBW should be viewed with caution. Second, this study was carried out in a rural hospital of Sindh Province, therefore, the findings cannot be generalized to the whole country. Third, the retrospective nature and use of hospital records might have introduced recall bias.

In conclusion, we identified important risk factors associated with LBW, which are all modifiable with little investment and commitment. Therefore, a holistic approach is required from government institutions, nongovernmental organizations and civil society to ensure: proper education and counselling for women; legislation for the revised age of marriage; provision of timely and adequate ANC; universal coverage of iron and folic acid supplementation during pregnancy; and an improved family planning programme with long-acting reversible contraceptives as key options.

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