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Association of geographic distribution and birth weight with sociodemographic factors of the maternal and newborn child of hilly and mountain regions of eastern Nepal: a cross-sectional study

Bharosha Bhattarai,[1] Sagar Panthi ,[1] Gopal Kumar Yadav ,[1] Swotantra Gautam,[2] Rochana Acharya ,[1] Durga Neupane,[1] Nimesh Khanal,[3] Bharat Khatri,[1] Krishna Neupane,[1] Sugat Adhikari,[1] Nimesh Lageju,[1] Lila Bahadur Basnet,[4] Prajjwal Pyakurel,[5] Shankar Prasad Yadav[1]

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BB and SP are joint first authors.

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For numbered affiliations see end of article.

Correspondence to
Dr Sagar Panthi;
drsagarpanthi@gmail.com

ABSTRACT

Objectives To determine the association of geographic distribution, and birth weight with sociodemographic factors of the maternal and newborn child of hilly region (lower altitude) and mountain region (high altitude) of eastern Nepal as well as the prevalence of low birth weight (LBW) and large for gestational age (LGA) among term singleton deliveries in eastern Nepal.

Methodology A cross-sectional study was conducted in the district-level hospitals of Dhankuta, Tehrathum, Solukhumbu and Taplejung districts of eastern Nepal of Province 1. Mothers with preterm or post-term delivery, multiple pregnancies, stillbirth/intrauterine fetal death and incomplete records were excluded from the study with only 1386 term pregnancies (37–42 weeks) delivered at the respective facilities between 17 July 2019 and 16 July 2020 were included. The appropriate data were entered in Microsoft Excel 2019 V.16.0 and statistical analysis was performed by using the statistical package for social sciences, IBM SPSS V.29.

Results The low maternal age, Dalit ethnic group, low gravidity, low parity, higher antenatal care (ANC) visits (≥4), incomplete deworming and dT vaccination status, breech deliveries and LBW newborns were significantly attributed to hilly region (lower altitude) (p value <0.05). Similarly, the hilly region, lower and/or no ANC visits and early term gestation had significant negative association with birth weight at the lower quantiles only. Meanwhile, the female newborn had significant and negative association with birth weight distribution at all seven quantiles. The prevalence of the LBW, average for gestational age and LGA newborn child among term singleton deliveries in Eastern Nepal is 6.6%, 85.8% and 7.6%, respectively.

Conclusions The local organisations should focus on adequate antenatal care visits in mountain region and coverage of dT vaccine and deworming medications in hilly region. Appropriate measures and programmes should be initiated to bring down LBW in hilly region.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Birth weight is associated with infant sex, parity, maternal calorie intake, number of antenatal care visits, ethnicity, education and socioeconomic status of mother.

⇒ Nepal has a high proportion of teenage mothers (17% in 15–19 years of age).

WHAT THIS STUDY ADDS

⇒ The prevalence of low birth weight is higher among the term singleton newborn child delivering in the hilly region.

⇒ Nepal Government recommended antenatal care visits are higher in the hilly regions while deworming and complete dT dosing are found higher among the mothers in the mountain regions in eastern Nepal.

⇒ Mothers in the mountain region suffer higher pregnancy-related complications as compared with the hilly region in eastern Nepal.

⇒ Newborn child in the hilly region is two times likely of being low-birth weight than the mountain region.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study can help local organisationsfocus on adequate antenatal care visits in the mountain region and coverage of tetanus toxoid vaccine and deworming medications in the hilly region with appropriate measures and programmes initiated to bring down low birth weight in the hilly region.

INTRODUCTION

Birth weight is the first weight of fetus taken after birth preferably within the first hour of life.[1] In Nepal, 57% of deliveries takes place in the health facility.[2] The most common and easily measurable indicator of the newborn maturity is the birth weight.[3]

There is increased risk of neonatal problems in both the infants with low or high birth weight.[4] Abnormal birth weight contributes to the immediate and future burden of chronic diseases.[5] Low birth weight (LBW) contributing to a range of poor health is more common in developing countries than the developed countries.[6] LBW has the risk of infections and hypothermia and collectively contributes to neonatal morbidity and mortality.[3 6] Both LBW and large for gestational age (LGA) are important indicators to consider preventing obesity and metabolic disease in later age group.[7 8]

A United Nations Children's Fund report noted that the global rate of LBW was 15% and the major bulk is from developing country.[1] Analysis of Nepal's Demographic and Health Survey 2011 (NDHS-2011) shows that one in every six infants in Nepal is of small size at birth.[9] LBW children are at high risk of malnutrition, neurodevelopmental impairments, recurrent infection, which collectively adds to the emotional and economic burden to the individual family and health sector as a whole.[10] Newborn children with LGA are also significantly associated with the increased chances of caesarean section, instrumental delivery, increased need for neonatal resuscitation, intensive care unit care which further adds to the maternal and neonatal morbidity and mortality.[11]

Birth weight is associated with infant sex, ethnicity of mother, parity, maternal calorie intake.[12] Number of antenatal care (ANC) visit also contributes to the better outcome of neonate including its birth weight.[13] In developing countries, lack of ANC, primipara, illiteracy of mother, poor socioeconomic status significantly contributes to the birth weight.[14] Nepal has 17% of mother in age group of 15–19, showing massive proportion of teenage mother.[2] The impact of lower age of mother in birth weight is yet to be studied.

Studies focusing on the association of birth weight with maternal factors are scarce in hilly and mountain regions of Nepal. Hence, this study was done to assess the association of geographic distribution and birth weight among term singleton deliveries with sociodemographic factors of maternal and newborn child of hilly (lower altitude) and mountain region (high altitude) of eastern Nepal. We also determined the prevalence of LBW and LGA in eastern Nepal among term singleton deliveries.

METHODOLOGY

Study design

We carried out a quantitative retrospective cross-sectional study in the district hospitals of Dhankuta, Tehrathum, Taplejung and Solukhumbu districts in eastern Nepal where a chart review of the hospital register was done on the information on delivery and outcomes of the newborn child.

Study setting

Nepal is a landlocked country situated in the South East Asia between China and India. It has topographically been divided into three regions, namely, terai, hilly and mountain region. The altitude ranges from approximately 195 feet to 29 029 feet, that is, lower altitude in terai regions to higher altitude in mountain regions. The 77 districts of Nepal have been grouped into seven administrative divisions called provinces. The province one has 14 districts. The four hospitals, namely, Dhankuta Hospital, Tehrathum Hospital, Taplejung Hospital and Phaplu Hospital, are the tertiary-level district hospitals under provincial government of province one, situated in Dhankuta, Tehrathum, Taplejung and Solukhumbhu district, respectively, of eastern Nepal of province one. The Dhankuta and Tehrathum districts belong to the hilly region (at lower altitude) while the Taplejung and Solukhumbhu districts belong to the mountain regions (at higher altitude). These hospitals were selected by convenient sampling technique.

Sample size and sampling technique

Complete sets of entries of all the mothers delivering at term at Dhankuta District Hospital, Tehrathum District Hospital, Taplejung District Hospital and Phaplu Hospital (Solukhumbu) between 17 July 2019 and 16 July 2020 were included in the study. Mother with preterm or post-term delivery, multiple pregnancies, stillbirth/intra uterine fetal death and the incomplete records were excluded from the study. Out of the 1645 deliveries that occurred in the respective hospitals in the considered timeframe (ie, 394 deliveries in Dhankuta District Hospital, Dhankuta; 367 deliveries in Tehrathum District Hospital, Tehrathum; 731 deliveries in Taplejung District Hospital, Taplejung and 153 deliveries in Phaplu Hospital, Solukhumbu), only 1386 entries fulfilling the inclusion criteria were taken into the final analysis with the exclusion of remaining 259 entries falling under the exclusion criteria.

Maternal age, ethnicity, gravidity, parity, number of antenatal care (ANC) visits, deworming status, tetanus toxoid (TT) vaccination status, complication in pregnancy, period of gestation, type of delivery and fetal presentation were considered the independent variables while geographical location or birth weight of the baby (LBW, appropriate for gestational age (AGA) and LGA)) was considered the dependent variable. Given the collection of sample from district hospitals of eastern Nepal, the sample was skewed.

Data entry and analysis

The required data for this study were collected from the medical records of the hospital and were directly entered into the Microsoft Excel 2019 V.16.0 (Microsoft, Washington). Coding was done to simplify the data entry wherever needed. Necessary editing and cross-checking were done immediately after the data collection. It was then analysed using statistical package for social sciences, IBM SPSS V.29 (IBM, Armonk, New York). Data were presented as frequency, percentages, means±or SD and median (minimum–maximum) as necessary. The bar

diagram has been used for pictorial description of data. The χ^2 test was used to test for group differences, that is, hilly and mountain regions. For binary logistic regression analyses, ORs and 95% CI were calculated. Likewise, the multivariate quantile regression analysis was performed to identify the independent variables related to the child's birth weight over the seven (5th, 10th, 25th, 50th, 75th, 90th,95th) percentiles using simplex approach and Frisch-Newton interior-point non-linear optimisation algorithm. The p value less than <0.05 was considered statistically significant.

Operational definitions

Term pregnancy

Term pregnancy is defined as pregnancy from 37 weeks period of gestation to 42 weeks period of gestation.[15]

Low birth weight

LBW is defined by WHO as birth weight less than 2500 g.[1]

Appropriate for gestational age

AGA is birth weight at term between 10th to 90th percentiles in Lubcheno growth chart.[16]

Large for gestational age

LGA is birth weight at term above the 90th percentile in Lubcheno growth chart.[16]

Gestational age

It is the weeks that elapsed between the first day of the last normal menstrual period (not presumed time of conception) and the date of delivery, irrespective of whether the gestation results in a live birth or a fetal death.[17]

Advanced age pregnancy

People who are pregnant at age 35 or older.[18]

Adolescent /teenage pregnancy

It is the pregnancy under 20 years of age.[19]

Janajati ethnicity

They are the indigenous groups of people of Nepal.

Dalit ethnicity

Although they were considered untouchable in the past, they are financially marginalised groups of people.

Patient and public involvement statement

The study did not have the direct involvement of the participants in the development of the study design, research questions, data collection, result analysis and interpretation.

RESULTS

Sociodemographic profile of pregnant women and newborn child

Of the total deliveries taken into consideration (n=1386), the mean maternal age was found to be 24.4±5.3 years, ranging from 15 years to 44 years with maximum mothers (1075, 77.6%) lying under 20–35 years of age group. Likewise, the prevalence of teenage/adolescent pregnancy (TP/AP; <20 years) and advanced maternal age pregnancy (≥ 35 years) was 258 (18.6%) and 53 (3.8%). The greatest number of deliveries occurred in the Taplejung District Hospital (583, 42.1%) with the least number of deliveries occurring in the Phaplu Hospital, Solukhumbu (129, 9.3%). Mountain region hospitals, that is, Phaplu Hospital, Solukhumbu and Taplejung District Hospital comprised more than half of the total deliveries (712, 51.4%). Majority of the delivering mothers belonged to Janajati ethnic group (728, 52.5%) followed by Brahmin/Chettri (348, 25.1%). The mean gravidity and parity were 1.8±0.9 and 0.7±0.8, respectively, with the most being multigravida (721, 52.0%) and nullipara (699, 50.4%), respectively. The mean period of gestation of the delivering mother was 39.4±1.1 weeks.

Similarly, majority of the mothers had deworming done (1088, 78.5%) and complete dose of TT vaccine taken (1058, 76.3%) with the most of them having ≥4 ANC visits (872, 62.9%). More than one-tenth of the delivering mothers (180, 13.0%) encountered one or more of the complications during pregnancy, with prolonged labour (62, 4.5%) and retained placenta (41, 3.0%) being the most encountered complications. Most of the deliveries had a cephalic presentation of the baby (1358, 98.0%) with only remaining (28, 2.0%) having a breech presentation at the time of delivery. Spontaneous vaginal delivery (1163, 83.9%) followed by caesarean section (178, 12.8%) were the most common types of deliveries observed in the mentioned hospitals.

Newborn profile revealed that the male and female newborn child were 53.8% (n=745) and 46.2% (n=641)), respectively, with mean birth weight of the newborn child being 3147.4±442.2 g, ranging from 1000 g to 4600 g. Mean birth weights for male and female newborn child were 3204.6±449.8 g and 3080.9±423.9 g, respectively. The prevalence of the LBW, AGA and LGA newborn child among the term singleton deliveries was found to be 6.6% (n=91), 85.8% (n=1190) and 7.6% (n=105), respectively. Almost all newborn child had normal outcome (1366, 98.6%) with a few having abnormal outcome (asphyxia, gross congenital anomalies, stillbirth, etc) at birth (20, 1.4%) (table 1 and figures 1 and 2).

Association of the geographical distribution with the maternal and newborn child factors

In univariable logistic regression model, teenage mothers (OR: 1.67, 95% CI 1.27 to 2.22, p value: <0.001) compared with normal aged pregnancy, Dalit ethnic group (OR: 4.55, 95% CI 3.23 to 6.25, p valu<0.001) compared with Janajati, primigravida (OR: 1.34, 95% CI 1.08 to 1.66, p value: 0.006), nullipara (OR: 1.75, 95% CI 1.27 to 2.44, p value: 0.001) compared with multipara, higher ANC visits (≥4) (OR: 2.61, 95% CI 1.57 to 4.33, p value <0.001) compared with none, incomplete deworming status (OR: 6.67, 95% CI 5.00 to 9.09, p value <0.001), incomplete dT vaccination status (OR: 3.05, 95% CI 1.59 to 5.86, p

Table 1 Association of the geographical distribution with the maternal and newborn child factors (n=1386)

Variables	Geographical distribution		Binary logistic regression	
	Hilly* (%)	Mountain† (%)	OR, 95% of CI	P value
Maternal and pregnancy characteristics				
Maternal age				0.001‡
Mean±SD (in years)	23.98±5.22	24.82±5.29		
<20 years	152 (58.9)	106 (41.1)	Ref	
20–35 years	498 (46.3)	577 (53.7)	0.60, 0.45 to 0.79	<0.001
>35 years	24 (45.3)	29 (54.7)	0.57, 0.31 to 1.04	0.07
Ethnicity				<0.001‡
Dalit	142 (65.7)	74 (34.3)	Ref	
Janajati	222 (30.5)	506 (69.5)	0.22, 0.16 to 0.31	<0.001
Brahmin	256 (73.6)	92 (26.4)	1.45, 1.003 to 2.09	0.048
Others	54 (57.4)	40 (42.6)	0.70, 0.42 to 1.15	0.165
Gravidity				0.006‡
Mean±SD	1.64±0.80	1.86±1.03		
Primigravida	349 (52.5)	316 (47.5)	1.34, 1.08 to 1.66	0.006
Multigravida	325 (45.1)	396 (54.9)	Ref	
Parity				0.004‡
Mean±SD	0.59±0.77	0.75±0.90		
Nullipara	363 (51.9)	336 (48.1)	Ref	
Primipara	239 (47.9)	260 (52.1)	0.85, 0.67 to 1.07	0.169
Multipara	72 (38.3)	116 (61.7)	0.57, 0.41 to 0.79	0.001
Period of gestation				0.109‡
Mean±SD (in weeks)	39.37±1.17	39.35±1.11		
37–40 weeks	546 (47.6)	600 (52.4)	0.79, 0.60 to 1.05	0.109
40–42 weeks	128 (53.3)	112 (46.7)	Ref	
Variables	**Geographical distribution**		**Univariable model**	
	Hilly* (%)	**Mountain† (%)**	**OR, 95% of CI**	**P value**
Maternal and pregnancy characteristics				
ANC visits				0.001‡
No ANC visits	25 (35.7)	45 (64.3)	Ref	
<4 visits	133 (30.0)	311 (70.0)	0.77, 0.45 to 1.30	0.333
≥4 visits	516 (59.2)	356 (40.8)	2.61, 1.57 to 4.33	<0.001
Deworming status				<0.001‡
Done	432 (39.7)	656 (60.3)	0.15, 0.11 to 0.20	<0.001
Not done	242 (81.2)	56 (18.8)	Ref	
dT vaccine status				<0.001‡
Complete dose	416 (39.3)	642 (60.7)	0.24, 0.17 to 0.33	<0.001
Incomplete dose	106 (89.1)	13 (10.9)	3.05, 1.59 to 5.86	0.001
Not taken	152 (72.7)	57 (27.3)	Ref	
Complications in pregnancy				<0.001‡
Yes	47 (26.1)	133 (73.9)	0.32, 0.23 to 0.46	<0.001
No	627 (52.0)	579 (48.0)	Ref	
Presentation				0.040‡
Cephalic	655 (48.2)	703 (51.8)	0.44, 0.19 to 0.98	0.04
Breech	19 (67.9)	9 (32.1)	Ref	

Continued

Table 1 Continued

Variables	Geographical distribution		Univariable model	
	Hilly* (%)	Mountain† (%)	OR, 95% of CI	P value
Newborn child characteristics				
Gender of the baby				0.805‡
Male	360 (48.3)	385 (51.7)	0.97, 0.78 to 1.2	0.805
Female	314 (49.0)	327 (51.0)	Ref	
Outcome of the baby				0.093‡
Normal	668 (48.9)	698 (51.1)	2.23, 0.85 to 5.84	0.093
Abnormal	6 (30.0)	14 (70.0)	Ref	
Birth weight (in grams)				0.002‡
Mean±SD	3096.94±454.36	3195.08±425.13		
AGA	572 (48.1)	618 (51.9)	Ref	
LBW	59 (64.8)	32 (35.2)	1.99, 1.27 to 3.10	0.002
LGA	43 (41.0)	62 (59.0)	0.75, 0.50 to 1.12	0.163

*Hilly region (low altitude).
†Mountain region (High altitude).
‡P value with χ^2 tests; Dhankuta and Tehrathum lie in hilly region while Solukhumbu and Taplejung lie in mountain region.
AGA, average for gestational age; LBW, low birth weight; LGA, large for gestational age.

value: 0.001) compared with no dT vaccine, no complications in pregnancy (OR: 3.13, 95% CI 2.17 to 4.35, p value <0.001), breech presentation (OR: 2.27, 95% CI 1.02 to 5.26), p value: 0.040) compared with cephalic and LBW newborn (OR: 1.99, 95% CI 1.27 to 3.10, p value: 0.002) compared with average weight newborn were found to be significantly higher in the hilly region (table 1).

Association of the birth weight with the maternal and newborn child factors

From the quantile regression findings, it was seen that the maternal age had positive significant association with birth weight at the 90th percentile. The hilly region had negative and statistically significant association with birth weight at the 5th, 10th, 25th, 50th and 75th percentile compared with the mountain region. Compared with others category of ethnicity, the Janajati had positive and significantly increasing coefficients at the 25th and 75th percentiles, and the Brahmin had positive and significantly decreasing coefficients at the 75th and 90th percentiles of the birth weight. The primigravida compared with multigravida had significantly negative association at the 5th percentile of the birth weights. The nullipara had statistically significant negative association at 5th, 50th, 75th, 90th percentiles of the birth weight compared with multipara group.

The early term gestation (37–39+6 weeks) had statistically significant negative association with birth weights at the 25th, 50th, 75th and 90th percentiles compared with late-term gestation (40–42 weeks). The participants with 'No ANC' and '<4 ANC' visits had statistically significant negative association with birth weights at the 5th, 10th and 25th percentiles compared with those with '≥4 ANC' visits. With the decreasing ANC visits, the coefficient values decrease and increase with increasing quantiles.

The status of 'not done' deworming, complications of pregnancy and cephalic presentation had significant association at the 95th percentiles of the birth weight. The female newborn had significant and negative association with birth weight at of the seven percentiles (5th, 10th, 25th, 50th, 75th, 90th and 95th) (table 2).

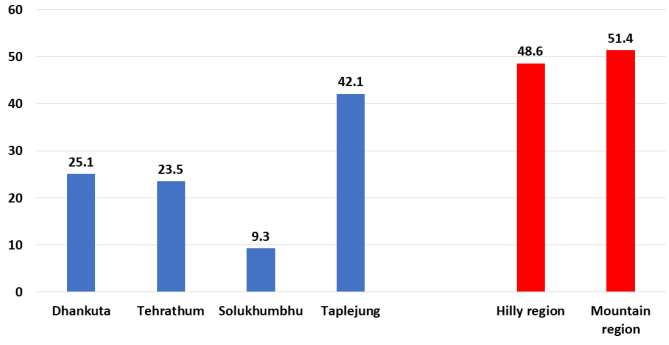

Figure 1 Proportions of participants based on hospital locations and their categorisation into geographical regions.

DISCUSSION

The present study depicts the association of maternal and pregnancy characteristics as well as newborn child characteristics with geographical location (hilly and mountain regions) of the eastern Nepal and birth weight. In our study, the TP/AP was 18.6%. This is in accordance to other studies from Nepal where the prevalence of AP varied from 7.8% to 29.1%.[20–22] Similarly, the prevalence of advanced maternal age (AMA) pregnancy in our study was 3.8%. This is lower as compared with other studies.

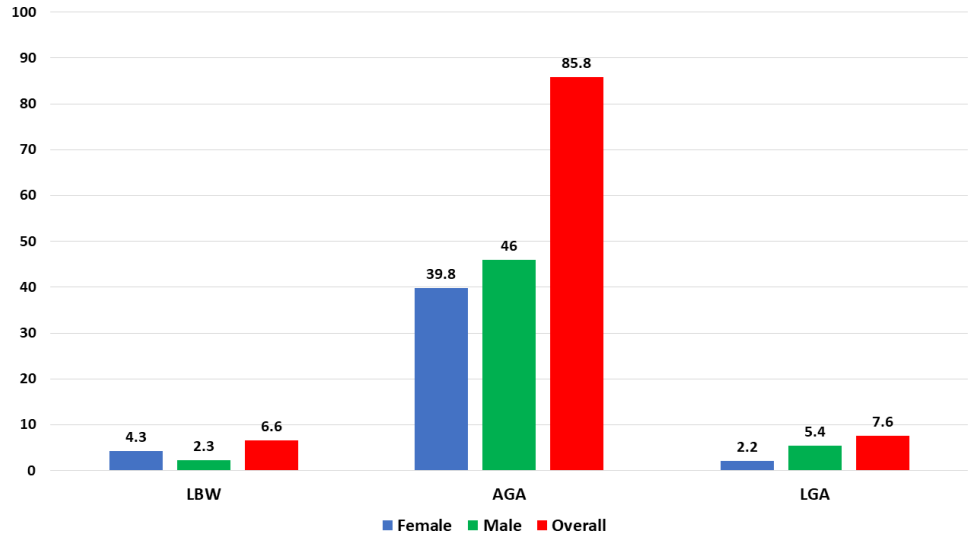

Figure 2 Proportion of different categories of birth weights. AGA, average for gestational age; LBW, low birth weight; LGA, large for gestational age.

A study from tertiary centre of Nepal revealed the prevalence of AMA pregnancy was 5.3%.[23] On a global level, a study done in 29 countries (Africa, Asia, Middle East and Latin America) revealed that the magnitude of pregnant women with advanced maternal age was 12.3%.[24] In our study, the prevalence of caesarian section (CS) was 12.8%. This is lower as compared with national level prevalence of CS, which was 16.6% in 2016, and global prevalence of 21.1%.[25 26] Our study findings are consistent with WHO that recommends the national caesarian rate to be between 10% and 15%.[27]

In our study, the prevalence of the LBW among term singleton newborn child was found to be 6.6%. This is lower as compared with other studies from Nepal. In a study by Kayastha *et al*, the prevalence of LBW at a tertiary hospital of Nepal was 9.8%.[28] The national level prevalence of LBW in a study by NDHS showed that it was 11.5%.[9] The lower prevalence was due to the fact that we included term singleton pregnancies only which could be more likely to be physically sound.

The mothers' ethnicity had statistically significant association with hilly region compared with the mountain regions of Nepal. The proportion of at least four ANC visits as per recommendations of government of Nepal was higher in hilly regions (59.2%) as compared with mountain regions (40.8%), but the proportion of deworming status and complete doses of dT (two doses) was higher in mountain regions compared with those of hilly regions. This could be due to the fact that the timing of deworming medication and first dose of dT vaccination is same, and a greater number of pregnant women of the mountain regions could have at least one ANC visit at this fourth or fifth month of gestation. Likewise, the likely explanation for the higher proportions of complications among pregnant women of mountain regions (73.9%) as compared with those of hilly regions (26.1%) could be due to their lower proportion of complete ANC (≥4) visits.

In our study, the newborn child being delivered at the hilly region had two times the odds of being LBW as compared those of the mountain region. This finding is contradictory to multiple other studies, which showed that high altitude (mountain regions in our study) acts independently to reduce birth weight.[29–32] The likely explanation could be due to high proportion of Dalit pregnant women in hilly regions as compared with those of mountain regions (65.7% vs 34.3%) in our study who are considered economically marginalised groups of the nation and maternal nutritional status may not be good. This highlights that there may be influence of maternal nutrition on birth weight.[33 34] Similarly, our study showed that the female newborn had significant and negative association with birth weight distribution at all seven quantiles than the male newborns. There have been studies showing that male and female fetuses respond differently to the intrauterine environment, and the growth of the male fetuses appears to be greater than the female fetuses from very early stages of gestation.[35 36]

The maternal age had positive significant association with birth weight at the 90th percentile but not significant at other percentiles of the birth weight. This could be explained by a study that revealed that the birth weight increased with maternal age after 24 years of age up to 35 years of age then decreased.[37]

Limitations of the study

The information of this study was collected from the delivery records register of the mothers. If it was possible to cross-check the record with the mothers' response to questions, better and adequate information (educational status, economic status, the height of mother, iron taking, etc) would have been collected. This was the major limitation of the study. Being a cross-sectional study, we could not study the cause of variation in birth weights. Owing to the geographic design, lack of access to transportation, fear of discriminations and high costs of births in

Table 2 Quantile regression estimations for the different quantiles of the newborn's, dependent variable that is, birth weight

Variables	0.05	0.1	0.25	0.5	0.75	0.9	0.95
Maternal and pregnancy characteristics							
Maternal age	2.07	2.18	0.001	5.89	4.19	10.91*	7.92
	(–7.07,11.20)	(–7.72, 12.08)	(–5.49, 5.50)	(–0.63, 12.41)	(–1.64, 10.02)	(3.12, 18.71)	(–0.25, 16.10)
Geographical distribution							
Hilly region	–180.67*	–147.82*	–100.11*	–103.37*	–68.71*	–11.52	39.31
	(–282.14, –79.20)	(–257.84, –37.80)	(–161.15, –39.06)	(–136.99, –119.82)	(–133.45, –3.96)	(–98.07, 75.04)	(–51.55, 130.16)
Mountain region	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Ethnicity							
Dalit	–169.11	–175.62	–0.26	–8.58	21.18	67.62	–139.25
	(–348.89, 10.67)	(–370.55, 19.32)	(–108.42, 107.90)	(–136.99, 119.82)	(–93.53, 135.90)	(–85.74, 220.98)	(–300.22, 21.72)
Janajati	37.26	72.81	99.91*	88.31	123.86*	84.37	8.11
	(–127.04, 201.55)	(–105.33, 250.93)	(1.07, 198.75)	(–29.04, 205.66)	(19.03, 228.69)	(–55.78, 224.53)	(–138.99, 155.21)
Brahmin	–28.39	–21.83	0.02	97.49	161.04*	157.36*	39.53
	(–198.75, 141.97)	(–206.55, 162.88)	(–102.47, 102.51)	(–24.19, 219.17)	(52.34, 269.74)	(12.03, 302.69)	(–113.01, 192.07)
Others	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Gravidity							
Primigravida	–311.48*	–147.79	0.11	140.10	82.27	166.13	–7.48
	(–526.04, –96.93)	(–380.43, 84.85)	(–128.98, 129.19)	(–13.14, 293.35)	(–54.64, 219.17)	(–16.90, 349.16)	(–199.59, 184.63)
Multigravida	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Parity							
Nullipara	366.25*	155.98	–100.09	–219.93*	–163.97*	–262.41*	–145.36
	(121.25, 611.25)	(–109.67, 421.63)	(–247.49, 47.31)	(–394.92, –44.94)	(–320.30, –7.63)	(–471.41, –53.41)	(–364.73, 74.02)
Primipara	147.22*	133.01	–0.09	–14.99	–20.81	–19.97	–108.61
	(16.28, 278.16)	(–8.97, 274.99)	(–78.87, 78.68)	(–108.52, 78.53)	(–104.36, 62.74)	(–131.67, 91.73)	(–225.84, 8.64)
Multipara	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Period of gestation							
37–39+6	–10.30	–85.72	–99.90*	–160.59*	–103.67*	–122.43*	–1.22
	((–113.99, 93.40)	(–198.15, 26.72)	(–162.29, –37.52)	(–234.65, –86.52)	(–169.84, –37.51)	(–210.89, –33.98)	(–94.07, 91.62)
40–42	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
ANC visits							
No ANC	–445.07*	–304.29*	–200.10*	–37.73	19.03	341.68*	486.34*
	(–674.49, –215.65)	(-553.05, –55.54)	(-338.12, –62.07)	(–201.59, 126.13)	(–127.36, 165.42)	(145.97, 537.39)	(280.92, 691.76)
<4	–111.32*	–139.74*	–99.90*	–76.39*	–48.45	–59.80	–21.37
	(–201.67, –20.97)	(–237.70, –41.77)	(–154.26, –45.54)	(–140.92, –11.86)	(–106.10, 9.20)	(–136.87, 17.28)	(–102.27, 59.53)

Continued

Table 2 Continued

Variables	0.05	0.1	0.25	0.5	0.75	0.9	0.95
≥4	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Deworming status							
Not done	116.13	64.71	−0.09	9.46	−27.10	−116.04*	−192.67*
	(−12.42, 244.68)	(−74.68, 204.10)	(−77.44, 77.24)	(−82.36, 101.28)	(−109.13, 54.92)	(−225.71, −6.38)	(−307.77, −77.57)
Done	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
dT vaccine status							
Complete dose	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Incomplete dose	41.88	−40.11	100.10*	64.74	−18.86	−4.57	93.37
	(−107.99, 191.75)	(−202.61, 122.39)	(9.94, 190.26)	(−42.29, 1711.79)	(−114.49, 76.77)	(−132.42, 123.27)	(−40.82, 227.56)
Not taken	68.30	16.43	0.10	−72.97	−27.42	−3.99	−138.40*
	(−82.96, 219.58)	(−147.60, 180.45)	(−90.91, 91.11)	(−181.02, 35.08)	(−123.95, 69.10)	(−133.04, 125.05)	(−273.85, −2.95)
Complications in pregnancy							
Yes	−14.82	−27.16	0.28	20.69	29.27	130.49*	169.27*
	(−133.07, 103.43)	(−155.37, 101.05)	(−70.86, 71.42)	(−63.77, 105.15)	(−46.19, 104.72)	(29.63, 231.37)	(63.39, 275.14)
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Presentation							
Cephalic	275.10	153.08	132.87	54.52	34.43	186.05	301.21*
	(−2.26, 552.46)	(−147.65, 453.82)	(−33.99, 299.74)	(−143.58, 252.62)	(−142.54, 211.41)	(−50.55, 422.66)	(52.87, 549.55)
Breech	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Newborn child characteristics							
Gender of newborn							
Female	−113.91*	−159.69*	−99.90*	−114.91*	−115.82*	−138.57*	−124.62*
	(−192.09, −35.73)	(−244.46, −74.92)	(−146.94, −52.87)	(−170.75, −59.07)	(−165.71, −65.94)	(−205.26, −71.88)	(−194.62, −54.62)
Male	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Outcome of the baby							
Normal	661.06*	208.53	99.91	−3.01	−31.21	10.12	−23.51
	(333.25, 988.862)	(−146.90, 563.96)	(−97.30, 297.13)	(−237.14, 231.12)	(−240.37, 177.96)	−269.52, 289.75)	(−317.02, 269.99)
Abnormal	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.

*Statistically significant at P-value<0.05
ANC, antenatal care.

hospital, a high proportion of births must be happening at home and we have not been able to analyse such data.

Strengths and prospects of the study

This study focuses on areas with less health access (ie, the hilly and mountain regions) to identify the gap of evidence in such region. These district hospitals have been providing safe motherhood services. The socio-demographic profile of the mother and newborn child delivering at Dhankuta District Hospital, Tehrathum District Hospital, Taplejung District Hospital and Phaplu Hospital (Solukhumbu) can give an overview to maternal and neonatal health in and around the hilly and mountain regions of Eastern Nepal and also help in determining the contributors of maternal and neonatal morbidity and mortality. Identification of the factors affecting maternal and neonatal mortality can help us make plans to address them and help bridging the gap in evidence. Health policy and practice can be designed according to the area of dearth in maternal and neonatal health that can help Nepal to achieve Sustainable Development Goal 3.

CONCLUSIONS

In our study, low maternal age, Dalit ethnic group, low gravidity, low parity, higher ANC visits (≥4), incomplete deworming and dT vaccination status, breech deliveries and LBW newborns were significantly attributed to hilly region (lower altitude). This study provides evidence for effects of maternal and newborn characteristics on birth weight distribution. The hilly region, lower and/or no ANC visits, and early term gestation had significant negative association with birth weight at the lower quantiles only. But the female newborn had significant and negative association with birth weight distribution at all seven quantiles. The prevalence of the LBW, AGA and LGA newborn child among term singleton deliveries in Eastern Nepal is 6.6%, 85.8% and 7.6%, respectively. The local organisations should focus on adequate ANC visits in the mountain region and coverage of TT vaccine and deworming medications in the hilly region.

Author affiliations
[1]Department of Pediatrics and Adolescent Medicine, BP Koirala Institute of Health Sciences, Dharan, Nepal
[2]Department of Internal Medicine, Advent Health, Orlando, Florida, USA
[3]Department of Internal Medicine, Tower Health Reading Hospital, Reading, Pennsylvania, USA
[4]Curative Service Division, Ministry of Health and Population, Department of Health Services, Kathmandu, Nepal
[5]School of Public Health and Community Medicine, BP Koirala Institute of Health Sciences, Dharan, Nepal

Twitter Gopal Kumar Yadav @drgopalr

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ORCID iDs
Sagar Panthi http://orcid.org/0000-0002-7539-0539
Gopal Kumar Yadav http://orcid.org/0000-0002-2195-9152
Rochana Acharya http://orcid.org/0000-0001-7293-8207

REFERENCES

1 Wardlaw TM. UNICEF. United Nations Children's Fund and World Health Organization, Low Birthweight: Country, regional and global estimates. Geneva: New York World Health Organization, UNICEF; 2004: 27. https://apps.who.int/iris/bitstream/handle/10665/43184/9280638327.pdf
2 Ministry of Health. Nepal demographic and health survey 2016. Kathmandu, Nepa New ERA, ICF; 2017. https://www.dhsprogram.com/pubs/pdf/fr336/fr336.pdf
3 Krishnan KD, Avabratha KS, D'Souza AJ. Estimation of average birth weight in term newborns: a hospital-based study in coastal Karnataka. *Int J Contemp Pediatr* 2014;1:156–9. doi:10.5455/2349-3291.ijcp20141112
4 Bettercare. *Newborn care: managing normal and high-risk infants in the newborn nursery*. 5th. Cape Town: Electric Book Works, 2014. https://www.glowm.com/pdf/EBWHealthcare-Newborn-Care-CC%20BY%20NC%20ND.pdf
5 Abubakari A, Kynast-Wolf G, Jahn A. Prevalence of abnormal birth weight and related factors in northern region, Ghana. *BMC Pregnancy Childbirth* 2015;15:335.
6 Lives SN. *State of the world's newborns: Nepal*. Washington, DC: Save the Children, 2002. https://www.healthynewbornnetwork.org/hnn-content/uploads/State-of-the-Worlds-Newborns-Nepal-2002.pdf
7 Nam H-K, Lee K-H. Small for gestational age and obesity: epidemiology and general risks. *Ann Pediatr Endocrinol Metab* 2018;23:9–13.
8 Shan X, Chen F, Wang W, *et al*. Secular trends of low birthweight and macrosomia and related maternal factors in Beijing, China: a longitudinal trend analysis. *BMC Pregnancy Childbirth* 2014;14:105.
9 Khanal V, Sauer K, Karkee R, *et al*. Factors associated with small size at birth in Nepal: further analysis of Nepal demographic and health survey 2011. *BMC Pregnancy Childbirth* 2014;14:32.
10 Mishra S. Maternal risk factors and consequences of low birth weight in infants. *IOSR J Humanit Soc Sci IOSR-JHSS* 2013;13:39–45 https://www.iosrjournals.org/iosr-jhss/papers/Vol13-issue4/G01343945.pdf?id=3404
11 Ng S-K, Olog A, Spinks AB, *et al*. Risk factors and obstetric complications of large for gestational age births with adjustments for community effects: results from a new cohort study. *BMC Public Health* 2010;10:460.

12 Kramer MS. Determinants of low birth weight: methodological assessment and meta-analysis. *Bull World Health Organ* 1987;65:663–737.
13 Mohammed S, Bonsing I, Yakubu I, *et al*. Maternal obstetric and socio-demographic determinants of low birth weight: a retrospective cross-sectional study in Ghana. *Reprod Health* 2019;16:70.
14 Mahumud RA, Sultana M, Sarker AR. Distribution and determinants of low birth weight in developing countries. *J Prev Med Public Health* 2017;50:18–28.
15 American College of Obstetricians and Gynecologists. ACOG committee opinion no 579: definition of term pregnancy. *Obstet Gynecol* 2013;122:1139–40.
16 Lubchenco LO, Hansman C, Boyd E. Intrauterine growth in length and head circumference as estimated from live births at gestational ages from 26 to 42 weeks. *Pediatrics* 1966;37:403–8.
17 Skrivankova V, Zwahlen M, Adams M, *et al*. Spatial epidemiology of gestational age and birth weight in Switzerland: census-based linkage study. *BMJ Open* 2019;9:e027834.
18 Mehari M-A, Maeruf H, Robles CC, *et al*. Advanced maternal age pregnancy and its adverse obstetrical and perinatal outcomes in ayder comprehensive specialized hospital, Northern Ethiopia, 2017: a comparative cross-sectional study. *BMC Pregnancy Childbirth* 2020;20:60.
19 American Pregnancy Association. Teenage pregnancy, 2017. Available: https://americanpregnancy.org/unplanned-pregnancy/teenage-pregnancy/ [Accessed 27 Aug 2022].
20 Khaniya B. Maternal and perinatal outcome in adolescent pregnancies as compared to adult pregnancies. *Nep J Health Sci* 2021;1:43–7.
21 Gurung R, Målqvist M, Hong Z, *et al*. The burden of adolescent motherhood and health consequences in Nepal. *BMC Pregnancy Childbirth* 2020;20:318.
22 Maharjan M, Thapa N, Maharjan N, *et al*. Prevalence of teenage pregnancy in a community hospital of rural Nepal: a cross-sectional study. *JNMA J Nepal Med Assoc* 2019;57:176–80.
23 Mahato V, Shrestha P, Shrestha S. Advance age pregnancy in a tertiary care centre: a descriptive cross-sectional study. *JNMA J Nepal Med Assoc* 2021;59:380–3.
24 Laopaiboon M, Lumbiganon P, Intarut N, *et al*. Advanced maternal age and pregnancy outcomes: a multicountry assessment. *BJOG* 2014;121 Suppl 1:49–56.
25 Bhandari AKC, Dhungel B, Rahman M. Trends and correlates of cesarean section rates over two decades in Nepal. *BMC Pregnancy Childbirth* 2020;20:763.
26 Betran AP, Ye J, Moller A-B, *et al*. Trends and projections of caesarean section rates: global and regional estimates. *BMJ Glob Health* 2021;6:e005671.
27 Luz G, Belizán J, Lauer J. The global numbers and costs of additionally needed and unnecessary caesarean sections performed per year: overuse as a barrier to universal coverage health systems financing World Health Report; 2010: 30. https://www.who.int/healthsystems/topics/financing/healthreport/30C-sectioncosts.pdf
28 Kayastha P, Manandhar SR. Incidence and risk factors of low birth weight among babies delivered at tertiary level teaching hospital in Nepal. *Med J Shree Birendra Hosp* 2019;18:29–35.
29 Bailey BA, Donnelly M, Bol K, *et al*. High altitude continues to reduce birth weights in Colorado. *Matern Child Health J* 2019;23:1573–80.
30 Jensen GM, Moore LG. The effect of high altitude and other risk factors on birthweight: independent or interactive effects? *Am J Public Health* 1997;87:1003–7.
31 Waldhoer T, Klebermass-Schrehof K. The impact of altitude on birth weight depends on further mother- and infant-related factors: a population-based study in an altitude range up to 1600 M in Austria between 1984 and 2013. *J Perinatol* 2015;35:689–94.
32 Yip R. Altitude and birth weight. *J Pediatr* 1987;111:869–76.
33 Lechtig A, Yarbrough C, Delgado H, *et al*. Influence of maternal nutrition on birth weight. *Am J Clin Nutr* 1975;28:1223–33.
34 Englund-Ögge L, Brantsæter AL, Juodakis J, *et al*. Associations between maternal dietary patterns and infant birth weight, small and large for gestational age in the Norwegian mother and child cohort study. *Eur J Clin Nutr* 2019;73:1270–82.
35 Alur P. Sex differences in nutrition, growth, and metabolism in preterm infants. *Front Pediatr* 2019;7:22.
36 Broere-Brown ZA, Baan E, Schalekamp-Timmermans S, *et al*. Sex-specific differences in fetal and infant growth patterns: a prospective population-based cohort study. *Biol Sex Differ* 2016;7:65.
37 Wang S, Yang L, Shang L, *et al*. Changing trends of birth weight with maternal age: a cross-sectional study in Xi'an city of northwestern China. *BMC Pregnancy Childbirth* 2020;20:744.