Maternal Anthropometry as a Predictor of Birth Weight.

A study performed at
Okhaldhunga Community Hospital in rural Nepal.

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Abstract

Background:
Birth weight is a powerful predictor of infant growth and survival and is dependent on maternal health and nutrition during pregnancy.

Objectives:
The overall objective of this study was to investigate the relation between maternal nutritional status, as measured by anthropometrics, and birth weight of children at Okhaldhunga Community Hospital in rural Nepal.

Methods:
A cross-sectional study among 515 singleton term births was conducted at Okhaldhunga Community Hospital (OCH) in rural Nepal from December 2011 to October 2012. The obstetric file recorded date of delivery, age, weight, height and MUAC of the mother and birth weight and sex of the new born. The effect of these variables on birth weight was investigated by bivariate analysis (ANOVA) and multivariate linear regression analysis.

Results:
Mean birth weight +/- SD was 2967 g +/- 399 g. There were found significant differences in birth weight within groups of sex-, height- and pregnant BMI (low, medium and high). Maternal pregnant BMI and height showed the highest significant correlations, with correlation coefficients respectively 0.254 and 0.148. The multivariate linear regression analysis showed that pregnant BMI and height made the strongest contribution explaining birth weight, with standardized coefficients respectively 0.398 and 0.273. These two variables was the only ones that turned out to be statistically significant ($p < 0.05$) in the multivariate regression analysis.

Conclusion:
Pregnant BMI and *height* were found to be the most important factors explaining birth weight. MUAC and sex of birth showed a weak correlation to birth weight. Season of birth and age of mother did not appear to have any influence of importance.

1. Introduction

1.1. Background for the study

In 2009 I heard about some Norwegian medical students who had done a study at Okhaldhunga Community Hospital (OCH) in rural Nepal. I became very interested in finding out more about this hospital, and the possibility of going there during my medical education. In 2010 I made contact with Dr Erik Bøhler, the medical coordinator of the hospital. He mentioned that it would be of great interest for the hospital if I could perform a study comparing the mother's nutritional status with the weight of new-borns at OCH.

1.2. Nepal – some general facts

Nepal is situated in southern Asia, between China to the north and India to the south. It is known for its famous mountains, the Himalayas, which are situated in the north-easterly part of the country. In fact two thirds of the country is covered by mountains, a feature which brings great challenges in developing Nepali infrastructure.

The population of Nepal is 30.49 million (2011) (1) and the number is increasing every year by a rate of 2,3 % (2). Nepal is one of the poorest countries in the world. In 2004, 55 % of the population was living in extreme poverty (3) with an average daily consumption of $1.25 or less, but the proportion that lived below the *national* poverty line was 30,9 % (1, 3). In 2011 the number of people living under the national poverty line had fallen to 25,2 % (1). Gross National Income (GNI) per capita in Nepal 2011 was 540 USD, compared to 88 890 USD in Norway (1, 4). Nepal has the second lowest Human Development Index compared with other countries in Asia and Oceania (5).

Figure 1: Nepal

Farming is the main occupation in Nepal. Agriculture sustains around 80 % of the population, and produce wheat, rice, corn, sugarcane, milk, root crops and buffalo meat. After the civil war ended in 2006, tourism has become an important income for the country again.

If you take a closer look at the population of Nepal, a great diversity of ethnic groups is found. The different ethnic groups do have clear differences in bodily constitution and looks, which influence birth weight and women's anthropometry. A study by Upadhayay (2011) showed that maternal BMI, gestational weight gain and birth weight of the new born were significantly higher in *Sherpa*/*Tamang* community compared to *Brahmin*/*Chhetri* community (6).

Most people in Nepal are Hindu or Buddhists (or a combination of the two), and the people used to be placed into a hierarchical system of castes. This system officially ended in 1963, but still has a lot of influence on Nepali society, especially in the rural districts. The people from the higher castes are still the people with the most education and best economic situation, and they are a minority. In general, the rate of illiteracy is about 40% (7). Both illiteracy and the other differences between the castes are slowly diminishing.

History

The history of Nepal is quite complicated, but it is important to know a bit about it to understand the present socio-cultural context. Nepal has been a monarchy throughout most of its history. In early times the area of Nepal consisted of several independent kingdoms. In 1768 a man called Shah, the ruler of the small kingdom Gorkha, unified these diverse kingdoms approximately into what we today know as Nepal, and founded the Shah dynasty. Quite a few times they were threatened by Tibet, the Indian kingdoms and the British East India Company. In 1962 the king introduced the party-less panchayat system; a decentralized form of government based on village assemblies, but the real power remained with the king. In 1990 the king was forced to accept constitutional monarchy and to allow the establishment of a multiparty parliament.

There have always been many political disturbances in Nepal, but in 1996 the Communist Party, the Maoist, officially started a civil war to replace the royal parliamentary system. The civil war ended in 2006 and democratic elections were held in April 2008, when the Maoist Party won. Maoist and government officials signed a peace agreement, and the Maoist rebels established an interim government. The monarchy was abolished following a Constituent Assembly vote, which ended a period of 240 years of royal rule in Nepal.

In 2008 the major parties agreed to write a constitution that should replace the interim one. The deadline for the launching of the constitution has been extended several times. On May 28 2012, Prime Minister Baburam Bhattarai dissolved the Constituent Assembly after it failed to complete the constitution in its final version, ending four years of drafting the constitution and leaving the country in a legal vacuum. This implicates that there still is political turbulence in Nepal.

1.3. Malnutrition and definitions

It is known that birth weight is a powerful predictor of infant growth and survival and that it is dependent on maternal health and nutrition during pregnancy (8). *Low birth weight* (LBW) (<2500 g) results in impaired growth, a higher mortality risk, increased morbidity (9), impaired mental development (10) and risk of chronic adult disease (8). According to international estimates from Unicef, which cover the period 2000–2007, 15 % of all new-borns are born with LBW (11). A Unicef-publication from 2004 describe the worldwide situation of LBW: The level of LBW in developing countries is more than double the level in developed regions, 16.5 % vs. 7 % (12) . The highest incidence of LBW worldwide occurs in the sub-region of South-Central Asia (27 %), as distinct from the low incidence in China (6%). Even though there is a considerable variation in prevalence of LBW in Asia, almost 70 % of all LBW births occur here (12).

Full-term infants (gestational age ≥ 37 weeks) with LBW are often termed *intrauterine growth restriction*-low birth weight (IUGR-LBW) (13). IUGR strictly indicates the presence of a pathophysiologic process *in utero* that restricts normal foetal growth. In developing countries, 11 % of all full-term new-borns are LBW due to IUGR; a rate six times higher than in developed countries (13). There are two major categories of IUGR; asymmetric and symmetric growth restriction. Most growth retarded infants have *asymmetric growth restriction*. First there is restriction of weight and then length, with a relative “head sparing” effect. Therefore it is of interest to study head circumference of new-borns. The asymmetric growth is more commonly due to extrinsic influences that affect the foetus later in gestation. *Symmetric growth restriction* affects all growth parameters, including head circumference. Early gestational growth retardation would be expected to affect the foetus in a symmetrical manner, resulting in permanent neurological consequences for the infant (14).

There are several factors that cause LBW and many of them are interdependent. One of the most important causes is *the mother's anthropometry and her nutritional status* (8). Her *socio-economic status (SES)* is also often related to her nutritional status. Maternal illiteracy and low SES are known to be major risk factors for IUGR (15) (16). Whether dietary *macro- and micronutrient* supplementation in pregnancy can increase birth weight is a controversial issue (8). A meta-analysis showed only modest increases in maternal weight gain and foetal growth following dietary supplementation. On the other hand, several randomized controlled trials have shown a significantly decreased risk of LBW of multiple micronutrient supplementations, such as in Nepal (17) and Tanzania (18). Factors that have specifically shown an increased risk of babies born with LBW or IUGR are iron deficiency (19, 20), low serum values of B12 (21, 22) and low intake of essential fatty acids (DHA) (23).

Low weight-for-height (WHZ) in children is termed *wasting* and indicates in most cases a recent and severe process of weight loss, which is often associated with acute starvation or severe disease (24). Provided there is no severe food shortage, the prevalence of wasting is usually below 5%, even in poor countries. The Indian subcontinent, where a higher prevalence is found, is an important exception. A prevalence exceeding 5% is alarming given a parallel increase in mortality that soon becomes apparent.

Malnutrition in a population over time will lead to *stunted growth*, low height-for-age (HAZ). Stunted growth is often described as "chronic malnutrition" and is a primary manifestation of malnutrition in early childhood, including malnutrition during foetal development brought on by malnourishment in the mother (24). This may lead in to a vicious circle, *the intergenerational cycle of growth failure*. Young girls who grow poorly become stunted women and are more likely to give birth to LBW children (25). If those infants are girls, they are likely to continue the cycle by being stunted in adulthood, if something isn't done to break the cycle. Adolescent pregnancy heightens the risk of low birth weight and the difficulty of breaking the cycle (25).

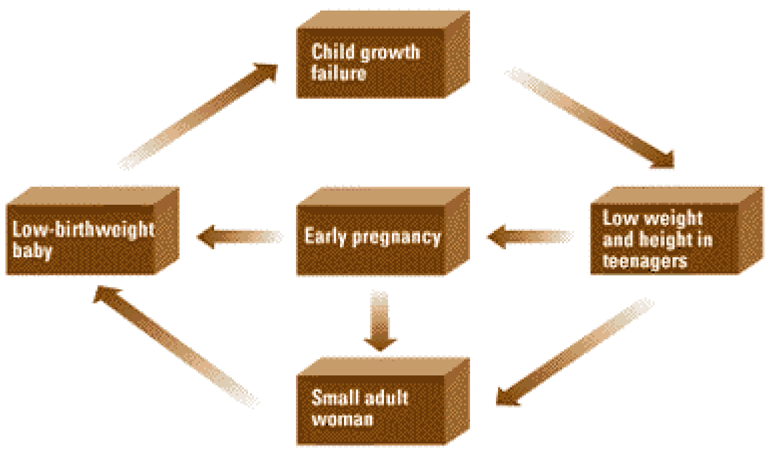

Figure 2 (25): Intergenerational cycle of growth failure

The WHO Global Database on Child Growth and Malnutrition uses a Z-score cut-off point of < -2 SD to classify low WHZ and low HAZ as moderate under-nutrition, and < -3 SD to define severe under-nutrition (26). The prevalence ranges shown in figure 3 are those currently used by WHO to classify levels of stunting and wasting of children in a population.

Figure 3 (27): Classification for assessing severity of malnutrition by prevalence ranges among children under 5 years of age

Indicator	Severity of malnutrition by prevalence ranges (%)			
	Low	Medium	High	Very high
Stunting	<20	20-29	30-39	>=40
Wasting	< 5	5-9	10-14	>=15

In adults, body mass index (BMI, kg/m^2) is a usual measure of WHZ. BMI < 18.5 or an unintentional weight loss of 6% or more in 6 months is regarded as wasting.

Mid-Upper Arm Circumference (MUAC) is another anthropometric parameter for analysis of nutritional status. MUAC is a good indicator of muscle mass and subcutaneous fat and can be used as a parameter of wasting and also as a predictor of the risk of death (27). MUAC is mainly used for detecting individuals in need of nutrition treatment, especially at the onset of a food crisis, rather than for measuring population trend data. MUAC is mainly measured on children aged 6 to 59 months, but it has also been recommended for targeting intervention to pregnant women at risk of poor pregnancy outcome. Women who have low MUAC and low BMI are more likely to give birth to LBW babies than their counterparts (28, 29). MUAC doesn't vary much during pregnancy and is therefore a better measure of nutritional status than BMI or weight (28, 30). Cut-off values may be population specific. The study "Wealth Status, Mid Upper Arm Circumference (MUAC) and Antenatal Care (ANC) Are Determinants for Low Birth Weight in Kersa, Ethiopia" by Assefa (2012) use a MUAC of less than 230 mm as an indicator of poor nutrition (31).

1.4. Health and malnutrition in Nepal

Most hospitals in Nepal are located in larger cities. This means that there is a poor accessibility to advanced healthcare services for the people in rural areas of Nepal. Many of the Health Posts and Sub-Health Posts are of poor quality and there is a lack of trained staff. Figure 4 gives an overview of the health infrastructure. OCH is a District Hospital.

Health Infrastructure
Central Hospital
Regional Health Directorate
Zonal Hospital
District Hospital
Primary Health Centre
Health Post
Sub-Health Post

Figure 4:(32).

In Nepal the life expectancy at birth is 69 years, compared to Norway where it is 81 years (1, 4). The number of doctors in Nepal is about 2 per 10 000 inhabitants. In comparison, Norway has 38 doctors per 10 000 inhabitants (33).

When it comes to children's health, the statistics are sensational. Most of the rates below are collected from WHO statistics (7).

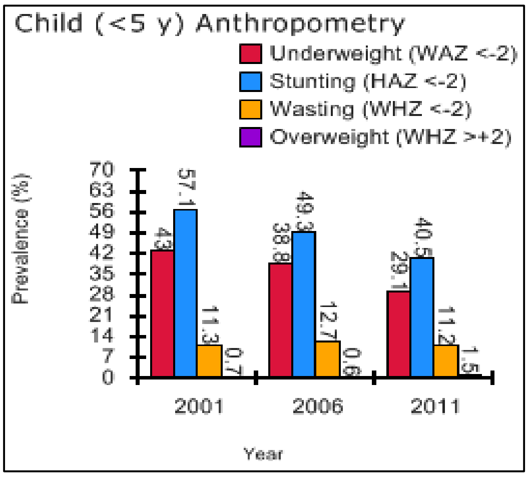

Figure 5 (35)

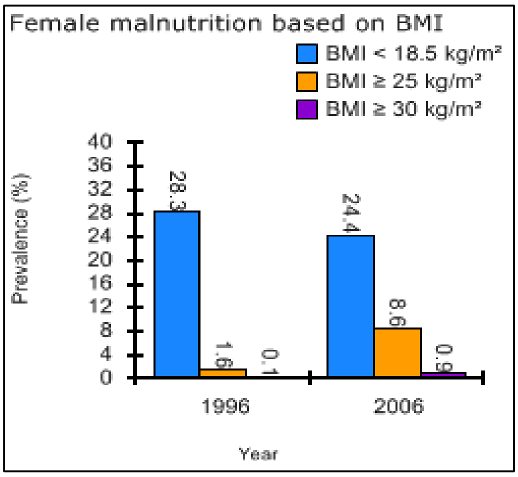

Figure 6 (35)

In 2011, 29 % of children in Nepal below 5 years of age were *underweight* (defined as 2 SD below WHO reference standard of 2006). Even though the prevalence is very high, it is almost 10 % less than in 2006 (figure 5). Concerning *stunted* children under 5 years of age, we see a similar decreasing progression, but still the prevalence is extremely high; at 40, 5 %.

The prevalence of *LBW* of new-borns in Nepal in 2006 was 21 % (7), but according to the study by P. Christian (2003), 43 % of new-borns in *rural* Nepal weigh less than 2500 g at birth (21). In economically developed countries the prevalence of LBW is a lot lower. In USA, for instance, the prevalence of LBW in 2002 was 8 % and in Norway 5 % in 2000 (7).

When it comes to malnutrition in females, the prevalence is decreasing (figure 6). In 2006, 24.4 % of women of reproductive age were underweight (*BMI* < 18.5 kg/m ^{2}). At the same time we can see that the number of overweight women (BMI > 25 kg/m ^{2}) is increasing. Landmann *et al* have suggested a BMI cut off point of 23.0 for obesity in Asian countries (14), which WHO also recommends (34). This indicates that the number of Nepali women who is overweight is even higher.

The *infant mortality* rate in Nepal 2010 was 41 per 1000 and maternal mortality rate was 170 per 100 000. In Norway the corresponding rates are 3 per 1000 and 7 per 100 000 (7). The rate of stillbirths was 23 per 1000 in 2010 (7). In fact, only 36 % of all deliveries in Nepal is attended by skilled health personnel (7), but there are strong differentials in urban- rural residency and low social status of women (33). Fortunately there is a remarkable increasing trend in deliveries attended by skilled personnel which have been almost doubled the last five years (35).

1.5. Okhaldhunga Community Hospital

Okhaldhunga Community Hospital is situated in the Okhaldhunga District (Figure 7), which has a population of about 180 000 people. Access is very hard and most of the patients have to walk or are carried for hours, even days, in order to reach the hospital. About 85 % of the patients are from the Okhaldhunga District and the rest are from neighbouring districts.

Figure 7: Okhaldhunga Community Hospital is the group of buildings which is seen in the upper part of the picture

OCH was established by Dr James Dick in 1962 and is today run by Normisjon and United Mission to Nepal. The hospital has 32 registered beds, but normally there are between 40-60 inpatients. In addition to the ordinary beds, they do also have an Outpatient Department (OPD), a department for patients with tuberculosis, a delivery room and both a minor and a major operating theatre. There is also a waiting home for pregnant women where women who travel from distant areas can stay at the hospital before delivery and have education in labour, breastfeeding, post-natal period, nutrition and vaccination. In 2012, 288 women where admitted to the waiting home. In the same building there is a nutrition rehabilitation centre (NRC) where severely malnourished women and children get food, and courses are given on i.e. how to make nutrient-rich food.

At the hospital they are able to do conventional x-rays, ultrasound and they have their own simple laboratory. There are 64 people employed by the hospital altogether, of whom 1-3 are doctors. 18 of the employees work with improvement of community health out in the district. The Medical Coordinator, Dr Erik Bøhler, is a Norwegian paediatrician who has worked at the hospital since 2004. The other doctors are Nepali, and most of them work at the hospital for five months as a part of their specialist program in general medicine.

The economy of the hospital is mainly based on the patient's own payments, but 15-20 % of the expenses are covered by the Medical Assistant Fund (MAF). MAF is administrated by the social service at the hospital and gets a substantial share of their capital from different organizations throughout the world. Almost 10 % of all patients get support from MAF to be able to pay their bill. In addition, *all* patients below 12 kg get their treatment at the hospital for free. This system was started in 2006 and is a result of the Government agreeing to cover parts of the obstetric expenses (33). In 2011 delivery services became free of charge too, which is a big improvement for mother- and child care in Nepal. In 2012 the number of deliveries was 688, a number which is constantly increasing.

2. Rationale and objectives

The overall objective of this study was to investigate the relation between maternal nutritional status, as measured by anthropometrics, and birth weight of children at Okhaldhunga Community Hospital in rural Nepal. No such study has been performed here before. The study present:

- Descriptive statistics of birth weight and maternal characteristics; height, BMI, MUAC and age.
- Bivariate association, correlation and relative association between the independent variables and birth weight. The independent variables include maternal height, pregnant BMI, MUAC and age, sex of the child and season of birth.

3. Methods

A cross-sectional study based on patient files from the maternity ward was conducted at Okhaldhunga Community Hospital (OCH) in rural Nepal from December 2011 to October 2012. The obstetric file recorded date of delivery, age, weight, height and MUAC of the mother and birth weight and sex of the new born. Women who had a stillbirth, preterm deliveries and twin deliveries were excluded from the study. Many of the women in the sample had incomplete data, but they were not excluded from the study. Overall, 554 deliveries were conducted during the period, whereas 39 of them were excluded. This left a total of 515 recruits. 380 of the women included had their weight recorded, 317 included height measurement and only 181 of the samples included MUAC.

All deliveries were accomplished with a nurse and/or obstetric assistant present. The maternal measurements were collected one or two days before delivery. The women were weighed with minimum clothing using a spring scale (not digital). The weight was recorded to the nearest 1 kg. The height was measured keeping the women standing on level ground, without footwear, against a wall, by using measuring tape to the nearest of 1 cm. MUAC was measured using a MUAC tape to the nearest 1 mm. The maternal weight and height were used to calculate maternal BMI (kg/m2), which I here call “pregnant BMI”. ”Estimated BMI” is based on a general weight gain of 10 kg during pregnancy (Est. BMI = (weight-10 kg)/height^2). Similarly, the new-borns were weighed unclothed, immediately after delivery using a spring balance baby weighing scale. Gestational age at birth was calculated as the number of completed weeks of gestation from the first day of the last menstrual period to date of delivery.

Statistical analyses

All analyses were done using SPSS Statistics (version 20). The analysis focused on the association between birth weight and anthropometric measurements of the mother. Results are presented as means +/- standard deviations (SD), as the variables were approximately normally distributed. The variables of the mothers are divided into groups of low, medium and high respectively to the first 25 %, the middle 50% and the last 25 % of the sample. The mean birth weight in each group are compared to one another using one-way analysis of variance (ANOVA) or independent t-test (if the independent variable was divided into two groups), see table 3. Multivariate linear regression analysis was used to investigate the effect of the independent variables on neonatal birth weight, see table 5 and 6. P-values < 0.05 were considered statistically significant.

4. Results

Descriptive statistics

Descriptive statistics of birth weight, maternal height, MUAC, BMI and age are shown in table 1. The birth weight ranged between 1900 and 4350 g and the mean birth weight +/- SD was 2967 g +/- 399 g (n=515). 39 infants (7.6 %) were of LBW (<2500 g) and 74 infants (14.4 %) ≤ 2500 g.

Cut-off points for the maternal variables are based on cut-off points used by Unicef and comparable studies (31, 36-38).

Table 1: Descriptive statistics of mothers and infants

Infant birth weight (n = 515)	
- Mean +/- SD	2967 g +/- 399 g
- Females: mean +/- SD	2922 g +/- 426 g
- Males: mean +/- SD	2999 g +/- 372 g
- Median	3000 g
- % < 2500 g	7,6 %
- % ≤ 2500 g	14,4 %
Mother's height (n = 317)	
- Mean +/- SD	152 cm +/- 5,6 cm
- % below cut-off (145 cm)	9 %
- Mean birth weight among those < 145 cm	2955 g
Mother's MUAC (n = 181)	
- Mean +/- SD	242 mm +/- 20 mm
- % below cut-off, 230 mm	24 %
- Mean birth weight among those < 230 mm	2951 g
Mother's pregnant BMI (n= 305)	
- Mean +/- SD	24,7 +/- 2,8 kg/m^2
Mother's estimated BMI* (n=305)	
- Mean +/- SD	20,3 +/- 2,8 kg/m^2
- % below cut-off (18,5 kg/m^2)	27 %
- Mean birth weight among those < 18,5 kg/m^2	2845 g
Mother's age (n = 508)	
- Mean +/- SD	23,6 +/- 5,1 years
- % below cut-off (20 years old)	20 %
- Mean birth weight among those < 20 years	2923 g

* Estimated BMI (non-pregnant) = (weight – 10kg)/height^2

<u>Mother's current anthropometric status according to height and season</u> (table 2).

Bivariate associations between height and MUAC, and between height and pregnant BMI was found (table 2). The tallest women had a bigger MUAC than the lowest women (group 1 vs. group 3) with a significant p-value < 0.017. The differences in pregnant BMI was found between height-group 1 and 3 (p < 0.015) and height-group 2 and 3 (p < 0.006). The highest women had a higher pregnant BMI than the women with a medium and low height.

There was no significant difference in MUAC or pregnant BMI between any of the seasonality-groups.

Table 2: Mother's current anthropometric status according to height and season.

	Mother's MUAC			Pregnant BMI		
	Mean (mm)	SD	Sig.	Mean (kg/m^2)	SD	Sig.
Mother's height	242 (n = 167)	20,4	0.023 [a]	24.7 (n = 305)	2,8	0.005[b]
1. Short (mean 145 cm)	237	21,8		25.0	2,9	
2. Medium (mean 152 cm)	242	17,2		25.0	2,7	
3. High (mean 157 cm)	248	21,9		23.7	2,7	
Seasonality	242 (n = 181)	20,2	0.520	24.7 (n = 305)		0.244
Autumn – Higher food supply	242	19,2		24.6	2,9	
Spring - Lower food supply	244	23,2		24.8	2,7	

[a] **Significant** difference in MUAC between height-group 1 and 3
[b] **Significant** difference in Pregnant BMI between height-group 1 & 3 and 2 & 3

Table 3: Bivariate associations between one explanatory variable birth weight [a].

	N	Mean	Birth weight	
			Mean	**SD**
Sex	509	-	2964 g *	398 g
1.Female	229	-	2922 g	426 g
2.Male	280	-	2999 g	372 g
Season	515	-	2967 g	399
1.Autumn	203	-	2966 g	387 g
2.Spring	312	-	2968 g	408 g
Mother's characteristics				
Height	317	152 cm	2989 g *	385 g
1.Short	86	145 cm	2905 g	382 g
2.Medium	161	152 cm	2989 g	377 g
3.High	70	159 cm	3094 g	384 g
MUAC	181	242 mm	3003 g	287 g
1.Low	43	217 mm	2951 g	276 g
2.Medium	94	241 mm	3032 g	416 g
3.High	44	269 mm	2991 g	415 g
Pregnant BMI	305	24.7 kg/m^2	2998 g *	383 g
1.Low	77	21.5 kg/m^2	2849 g	362 g
2.Medium	152	24.5 kg/m^2	2995 g	374 g
3.High	76	28.3 kg/m^2	3155 g	365 g
Age	508	23,6 years	2968 g	401 g
1.Teenagers (<20)	104	18,1 years	2923 g	397 g
2.Not teenagers	404	25,0 years	2980 g	401 g
Total	515		2967 g	399 g

[a] Tested for equal variance.
* Significant

<u>Total p-value of birth weight between groups in each category:</u>
Sex: p-value < 0.031
Height: p-value < 0.009
MUAC: p-value < 0.51
Pregnant BMI: p-value < 0.0001
Age: p-value < 0.19
Seasonality: p-value < 0.96

<u>Bivariate associations between one explanatory variable and birth weight</u> (table 3)

There were significant differences in birth weight within **sex-, height-** and **pregnant BMI-**groups (low, medium and high). The differences were found between height-group 1 and 3 (p-value < 0.006), between all of the BMI-groups (total p-value < 0.0001) and between sex (p-value < 0.031). The tallest women, with high BMI who gave birth to a male child turned out to have a child with highest birth weight.

There was no significant difference in birth weight within any of the MUAC-, Seasonality- or Age-groups.

<u>Correlation between one explanatory variable and birth weight</u> (table 4).

Table 4 shows the correlation coefficients between birth weight and the various independent variables. Maternal pregnant BMI and height showed the highest correlations, with correlation coefficients respectively 0.254 and 0.148. Sex of infant showed a weak correlation with birth weight (correlation coefficient 0.095). Both pregnant BMI, height and sex had a p-value < 0.05. Maternal MUAC did also show a weak correlation (correlation coefficient 0.095), but were not statistically significant (p-value < 0.102).

Table 4: Correlation coefficients

	Correlation coefficient	Sig.
Sex	0.095	0.016*
Height (cm)	0.148	0.004*
MUAC (mm)	0.095	0.102
Pregnant BMI (kg/m^2)	0.254	0.000*
Age (year)	0.020	0.330
Season	0.002	0.479

* Significant

<u>Multiple linear regression analysis</u>
<u>– Relative association importance of the independent variables</u> (table 5).

In addition to the bivariate analysis, the study include a multivariate linear regression analysis (table 5). This model investigated the effect of maternal anthropometry, age, sex of new born and season of birth *on new-born's birth weight*. A statistically significant model (p-value < 0.001) for the birth weight was found.

Linear regression equation:
Birth weight = $B_0 + B_1$ (sex) + B_2 (Height) + B_3 (MUAC) + B_4 (BMI) + B_5 (age) + B_6 (season)
The standardized coefficients, B_0-B_6, and p-values are listed in table 5.

Table 5:

Linear regression of variables associated with birth weight [a]			
	Unstandardized coefficient	**Standardized coefficient, B_{1-6}**	**Sig.**
Sex	70	0.088	0.244
Height (cm)	20	0.273	0.001*
MUAC (mm)	-3,3	- 0.165	0.084
Pregnant BMI (kg/m^2)	56	0.398	0.000 *
Age (year)	2,1	0.027	0.723
Season	- 8,8	- 0.011	0.723
B_0: -814 R-square: 0.135			

a: Tested for linearity: The residuals are normal distributed and there are no deviation from linearity.
* : Significant

R Square was 0.135, which means that the model explains only 13.5 % of the birth weight variance. The model shows that pregnant BMI and height made the strongest contribution explaining birth weight, with standardized coefficients respectively 0.398 and 0.273. These two variables were the only ones that turned out to have statistically significant independent effect on birth weight in the multiple regression analysis.
Disregarding the influence of sex, with standardized coefficient 0.088 and p< 0.244, this result agrees well with the results of the bivariate evaluation in table 3.

Table 6 shows calculated birth weight at reference categories. This table display easily how birth weight increases/decreases with one unit change of the independent variable using the unstandardized coefficient.

Birth weight at reference categories:
-814 + (0*-70) + (150*20) + (240*-3.3) + (24*56) + (23*2.1) + (0*8.8) = 2786 g

Table 6:

Reference categories	
Birth weight at reference categories	2786 g
Constant, B_0	- 814
Sex: Male	0
Female	- 70 g
Height: 150 cm	0
+ 1 cm	+ 20 g
MUAC: 240 mm	0
+ 1 mm	-3,3 g
BMI: 24 kg/m^2	0
+ 1 kg/m^2	+ 56 g
Age: 23 years	0
+ 1 year	+ 2,1 g
Seasonality	
Autumn	0
Spring	- 8,8 g

5. DISCUSSION

Nutritional status of mothers have long been known to influence birth weight of children. Here anthropometric measurements were used as proxies for nutritional status. Using both bivariate analysis and confirming by multivariate linear regression model, this study have demonstrated that pregnant BMI, height and sex seems to have an effect on birth weight.

Descriptive statistics

A study published in Journal of Nepal Health Research Council in 2012 investigated the birth weight of 9710 new-borns and reported a mean birth weight of infant born at 40 weeks gestation of 3023 g (39). The mean birth weight ranged from 2670g – 3124 g when 37-42 weeks of gestation were included. This coincidence with the mean birth weight in my study.

The prevalence of LBW (<2500 g) in my study (8%) was only one-half of the international estimates from Unicef (15%) (11). If new-borns in my study included also those that weighed exactly 2500 g and not only those below 2500 g, as the conventional cut-off prescribes, the prevalence coincides well with Unicef's findings. Either this reflects a big part of new-borns weighing exactly 2500 g or, more likely, it reflects inexact measuring. An inaccurate measure could be caused by a digit preferences at 2500 g when using a manual weighing scale (12).

In any case, the number of LBW in this study was not even close to the indication in the study of P.Christian of 43% (21). Due to the high number of women who give birth at home, it is difficult to retrieve the actual number of low birth weight, especially in rural areas like Okhaldhunga. In a study done in Nepal 2012 the majority of the women who had home delivery mentioned lack of transportation, distance to health centre, common perception of unimportance of delivering in health institution, financial constraints, dominance of mother in-law and shyness as the main reasons (35). An analysis by Blanc and Wardlaw (2005) showed that babies who are not weighed (i.e. those who do not come to health clinics for delivery) tend to be of lower socioeconomic status and tend to have lower birth weight (40). This would probably be a part of the explanation of the relatively low prevalence of LBW my study. It is also important to remember that my study only included full-term live births, singleton deliveries, which differed from e.g. the study of P. Christian, which included twins and preterm deliveries (21).

Correlation between one explanatory variable and birth weight

A similar study from Sri Lanka, which did only include birth weight and anthropometry of the mother, also found that BMI (and weight) showed highest correlation and height the second highest correlation to birth weight (41). Larger studies and meta-analysis normally include more variables, but do also point at BMI and height as important determinants (8, 42-44). A study from Sudan found that all maternal characteristics (age, weight, height and MUAC) were significantly positively correlated with birth weight, but MUAC and weight showed the strongest correlation (44).

Multiple regression analysis
<u>– Relative association importance of the independent variables.</u>

Pregnant BMI and height:

Among the variables included in this model, "pregnant BMI" was found to be the major factor affecting birth weight and maternal height the second most important parameter. It is important to remember that "pregnant BMI" does not reflect the actual weight of the mother. There are high individual differences in weight gain and changes in body composition during pregnancy (such as amount of water in the uterus). No other comparable studies were found, using "pregnant BMI" as an indicator, but several studies have shown a clear association between pre-pregnant BMI and birth weight. The polynomial regression analysis in the study of Jananthan (2009) showed that maternal weight, BMI and height respectively were the best predictors of birth weight (41). The weight was measured ≤ 13 weeks gestation and gave a better picture of the women's nutritional status than my study did. In spite of that difference, the results agree well with the results in my study.

MUAC

Surprisingly MUAC showed a negative effect on birth weight in the multivariate regression analysis (standardized coefficient -0.165). The effect is small and not statistically significant ($p<0.084$) and so should not be emphasized. We see a similar negative relation in the bivariate analysis, which showed almost no difference in mean birth weight between MUAC-groups and all had a high p-value < 0.51.

In contrast, several previous studies have shown a clear association between MUAC and low birth weight (31, 45). A study done by Assefa et.al among 1295 women in Ethiopia, found that women with MUAC < 230 mm had a significant higher risk of giving birth to a child with LBW, with an OR 1.6 (31).

Sex and age

The low standardized coefficient, indicate that neither sex nor age of the mother appeared to be relatively strong predictors of birth weight. Standardized coefficients were respectively 0.088 and 0.027. A general comprehension is, nevertheless, that girls weigh less than boys and young women have smaller babies (12).

Season

The study did not show any effect of the season of birth on the child's birth weight (weather it was born during spring or during autumn). This differs from what several previous studies proclaim (46-48). An old, but huge study from Tanzania (1993) found that mean birth weight was lowest during the rainy season and highest during the dry season, immediately after harvest (48). Generally we expect a slow rise and fall in birth weight, but this study detected a rapidly change in birth weight due to change in food intake and energy expenditure, not only as a respond to conditions during the last few months of pregnancy, but also to existing conditions just prior to delivery.

Weaknesses and strengths of the study

The data of this study was conducted almost during a whole year and represent the population of this area relatively well. In addition, since 2011 all deliveries at OCH have been free of charge, this may have increased the amount of poor women who come to the hospital to give birth. Still there are many women who give birth at home, and these are more likely the poorest ones.

There are a lot of weaknesses in this study, which are already mentioned in the discussion. This includes high probability of inaccurate measurements and incomplete data. Maternal weight before pregnancy and gestational weight gain would most likely be of importance of the results, but were impossible to measure in this situation. Several other variables would also have been interesting to investigate, e.g. differences in birth weight according to ethnical group, socio-economic status, geographical domicile and the mother's food intake.

6. Conclusion

Pregnant BMI and height were found to be the most important factors explaining birth weight. Significant standardized coefficients was respectively 0.398 and 0.273 in the multivariate linear regression analysis. MUAC and sex of birth showed a weak correlation to birth weight. Season of birth and age of mother did not appear to have any influence of importance.

Actions which can improve mother- and child health at OCH

OCH have already established several actions to improve mother- and child health. Birth weight is routinely measured in all newborns. This study reveals that the measurements can be done more precisely, according to the high amount of newborns who weighed "exactly" 2500 g and also women who measured "exactly" 150 cm. A digital weighing scale can be a helpful tool to achieve a precise birth weight. Particularly during periods of research regarding anthropometric measurements, it is important to train the staff in how to measure correctly and make the staff understand that it is important to measure *all* the women to get a valid result.

Other existing actions at OCH which is important to the mother-and-child health is the new system of free birth care, the waiting home for pregnant women and the nutrition rehabilitation centre (NRC). The waiting home helps women who travel from distant areas to stay at the hospital before delivery. Every afternoon there is teaching about labour, breastfeeding, post-natal period, nutrition and vaccination. The ward do also arrange courses about ethics, how to handle a complicated family situation and violence at home. The women are supposed to carry on the knowledge to their local women groups in their village. Staff from the local women groups do also pay a visit to the mothers who have delivered at OCH. All this is important actions to improve nutritional status of the infant and mother and to prevent the prevalence of LBW of the next child.

These actions, however, is only made for the women who deliver at OCH. It is important to work on increasing the number of women who come to hospital to give birth so more women attain this knowledge.

There are also birth centres in the villages where pregnant women can deliver. This increase the number of women who give birth with assistance of trained staff, but may also prevent women in need to come to the hospital to give birth.

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