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Socio-Demographic Factors Associated with Low Birth Weight in Nepal Using Imputation of Missing Determinants

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ABSTRACT

Birth weight is considered a factor that determines a baby's survival and predicts longstanding health. Hence, proper estimation of prevalence and determinants that are associated with low birth weight (LBW) is necessary for reduction of LBW. However, data on birth weight from developing countries are usually incomplete. Therefore, this study is aimed at handling missing values on determinants and identification of factors associated with LBW. The child data set from the Nepal Demographic and Health Survey (NDHS), 2011 was applied in this study. It contained information on 5240 children, but 3318 children had missing values on birth weight. Hence, in this study 1922 infants with measured birth weight were analysed. Multiple imputation was applied to handle missing values on determinants. The results revealed that only one variable was significant with LBW. Mothers residing in the Eastern and Far-Western development region were more inclined to give birth to LBW. The results obtained after handling missing values is considered less biased than assuming non-missing values or ignoring missing values. This suggests that missing values on determinants should be handled rather than ignored or assumed to be non-missing.

Keywords: Low birth weight, missing values, multiple imputation

INTRODUCTION

Weight at birth is recognised as a factor that determines infants' survival and forecasts long-term health (Barker, 2004; Wilcox, 2001). Globally, an estimate of 2.8 million infants die each year during the first 28 days of life, for which low birth weight (LBW) (< 2500 g) is a major factor (Lawn et al., 2014). LBW is also associated with morbid conditions such as stunting (Christian et al., 2013), cognitive

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delay and behavioural disorders (Arcangeli et al., 2012; Frondas-Chauty et al., 2014) in children and cardio-vascular disease, hypertension and non-insulin dependent diabetes in adults (Barker, 2004). LBW still has a significant impact on public health. the World Health Organization (WHO) targets to reduce 30% of LBW globally by 2025 (WHO, 2014).

Every year, more than 20 million births are recorded globally, out of which 15.5% are LBW. A total of 95.6% of all LBW infants are born in developing countries (UNICEF & WHO, 2004). The prevalence of LBW is highest in South Asia (28%), despite the fact that more than half of the women in this region give birth at home and are unable to provide numeric birth weight of their babies (WHO, 2014). In Nepal the prevalence of LBW is 11.5% (MOHP & New ERA, 2011). Studies conducted on LBW have identified factors like mother's age at child's birth (Reichman & Teitler, 2006), mother's education (Muula et al., 2011), consumption of iron and folic acid during pregnancy, attendance of antenatal visit (ANC) during pregnancy (Khanal, Zhao, & Sauer, 2014b; Nisar & Dibley, 2014), gender of child (Sreeramareddy et al., 2011), economic status and residence (Kayode et al., 2014). Birth weight is considered the main indicator of neonatal and infant health (Almond et al., 2002). In Nepal, neonatal mortality rate is 33 per 1000 live births, which has been constant over the past five years. Nepal is a developing country (World Bank, 2015), and correct estimation of percentage of LBW and its determinants is necessary for intervention programmes for the reduction of infant and neonatal mortality. However, data on birth weight in Nepal consist of highly missing values, because two thirds of women give birth at home (MOHP & New ERA, 2011). Studies conducted in Nepal have used either the mother's opinion on birth size as a proxy to the birth weight (Khanal, Sauer, Karkee, & Zhao, 2014b) or only a sample of complete measured birth weight (Khanal et al., 2014b). However, missing values presented on determinants were not handled in the aforementioned studies. Analysis without acknowledging missing data for determinant variables and including only complete case data tends to be more biased and has less statistical power and precision (Sterne et al., 2009), and the results from studies that ignore missing data have been proven to be different and inferior to those from studies that impute missing data (Moons et al., 2006). Thus, this study aimed to handle missing data presented on determinants and identification of factors associated with LBW.

METHODS

This research was a cross-sectional study in which data were obtained from a survey. The study aimed to identify factors associated with LBW. All study variables were obtained from the survey data. LBW was considered as an outcome. Variables such as mother's age at child's birth, education, attendance of antenatal care and consumption of iron tablet during pregnancy, smoking, parity, women's decision for utilisation of health services, gender of child, birth interval, wealth index, ethnicity, cooking fuel, residence, ecological region and development region were included as determinants. Since the data contained missing values on determinants, multiple imputation was employed to handle missing data. Finally, logistic regression was used to identify factors associated with LBW.

Nepal Demographic and Health Survey (NDHS) data

This study utilised secondary data from NDHS 2011, a nationally representative cross-sectional household survey provided by New ERA under the aegis of the Ministry of Health and Population (MOHP). The most recent survey data of 2016 were not included in this study because they were not available at the study time. In this survey, multistage cluster sampling was used. In the first stage, probability proportionate to size was used to select wards from rural and sub-wards from urban areas. In the second stage, random sampling was done among select households. The survey interviewed 12,674 women aged 15 to 49 and 4121 men aged 15 to 59. In this study, child data set, which included information on children under five years old was used. Infant's birth weight was considered a binary outcome; that is, normal birth weight was taken as >=2500 g and LBW was taken as <2500 g. Conditions such as maternal factors, child factors and socio-demographic factors were considered exposure variables. Variables under maternal factors included age at child's birth, education, attendance of antenatal care and consumption of iron tablets during pregnancy, smoking, parity and women's decision for utilisation of health services. Child conditions included gender of child and birth interval. Determinants like wealth index, ethnicity, cooking fuel, residence, ecological region and development region were included in the socio-demographic factors. Here, all study variables were categorical and the categorisation of the study variables was based on previous studies that used similar Demographic and Health Survey (DHS) data sets conducted in Nepal (Khanal et al., 2014a, 2014b). A detailed explanation of the calculation of wealth index is given in Section 2.2 of the survey (MOHP & New ERA, 2011). The data set contained information on 5306 children. Twins, triplets and other multiple-birth children are more likely to be LBW (Gomella et al., 2004). Hence, all the 66 multiple births were excluded from this study. However, out of 5240 children, only 1922 infants' birth weight was available and was used in the present study. Out of 1922 infants, 417 (22%) infants contained missing values in at least one of the measured variables.

Data Management

Missing values were presented in the determinants of the samples numbering 1922. The frequency and percentage of missing values in each determinant is shown in Table 1.

Table 1
Frequency and percentage of missing data

Variable	Frequency of Missing Values	Percentage of Missing Values
ANC visit during pregnancy	273	14.2
Iron tablet consumption during pregnancy	274	14.3
Women's decision	148	7
Cooking fuel	17	< 1

There are three types of missing mechanism under which missing data occur i.e. missing completely at random (MCAR), missing at random (MAR) and missing not at random (MNAR) (Rubin, 1976). Statistically, Little's test can be used to identify data under MCAR mechanism, but there are no clear tests to diagnose the MAR and MNAR mechanism; these can only be reasoned or hypothesised (Schafer & Graham, 2002). Under the MCAR mechanism, missing data are handled by means of imputation methods without any bias, but this type of mechanism seldom occurs (Schafer & Graham, 2002). However, under the MNAR mechanism, there exists no appropriate method to handle missing data (Little & Rubin, 2002). Most of the missing data hold MAR assumption and under this mechanism, the multiple imputation method is considered the appropriate method to handle missing values (Schafer & Graham, 2002). Even though this study did not focus on the causes of missing determinants, determination of the missing mechanisms was considered. In the present study, missing values were presented in the determinant, ANC visit. This was probably due to the perception that most mothers, especially those who live in rural areas, usually do not open up on the ANC visit during survey interviews. The direct consequence of missing values in the ANC visit was that there were missing values in the consumption of iron tablets. In the DHS, mothers belonging to the household (*de jure*) and those who did not belong to the household (non-*de jure*) were interviewed. However, questions related to cooking fuel were collected at the household level and assigned to individuals in the individual data file. Thus, a mother who was not a member of the household, would in turn lack data on cooking fuel. It was clear that missing values on the determinants were not missing due to themselves, but were missing due to other factors. Hence, missing data held MAR assumption; thus, the multiple imputation method was applied to handle missing data.

Statistical Analysis

It is suggested that the number of imputation should be at least equal or greater than the percentage of missing (White et al., 2011). Hence, multiple imputation was carried out 15 times because the highest percentage of missing data was 14.3%. All data management and analyses were carried out in R version 3.1.1 (R Core Team, 2015). For the iterations, the MICE package (van Buuren & Groothuis-oudshoorn, 2011) was deployed and for combining each imputed data set MiTools was used (Lumley, 2015). After imputation, a survey package (Lumley, 2010) was applied to each imputed data set to adjust for a complex sample design and sampling method. Survey logistic regression was carried out to identify determinants associated with LBW. The overall *p*-value for each variable was calculated using the Likelihood ratio test and the *p*-value for each subgroup was calculated using the Wald test.

Ethics

Ethical approval for conducting the NDHS survey was obtained by the Nepal Health Research Council, Nepal and the ICF Macro International Review Board in Calverton, Maryland, USA and the data analysis protocol was approved by the Curtin University Human Research Ethics Committee.

RESULTS

Preliminary Results

The overall and subgroup estimation of LBW prevalence and their 95-percent confidence intervals (95% CI) was calculated, and is presented in Table 2. The prevalence of LBW was found to be 11.5% (95% CI=10-13%). The prevalence of LBW was different in each category of factors except for the determinants such as mother's age at child's birth, consumption of iron tablets during pregnancy, gender of child, cooking fuel, ethnicity, wealth index, residence and ecological region, which were almost equal in each subgroup. The percentage of giving birth to LBW infants was highest among mothers who had primary education (14.6%) compared with the other two categories. The prevalence of having LBW infants among mothers who had attended one or more ANC visits (12.1%) and four or more ANC visits (11.4%) was close and higher than for mothers with no ANC visit (9.7%). The prevalence of giving birth to LBW babies was greater among smoker mothers (11.5%) than among non-smoking mothers (9.6%). For the variables such as parity and birth interval, the pattern of percentage of LBW in each subgroup was similar. The greatest percentage of LBW was found among the mothers who gave birth to two to three children (13%) within an interval of less than 24 months (13.1%). For the development region, the highest prevalence of having LBW infants was noticed among mothers residing in the Eastern development region (15%) and Far-Western development region (14.2%) compared with the other subgroups.

Table 2
Overall and subgroup prevalences of LBW after imputation

Variables	Birth Weight (Mean)	95% CI
Overall	11.5	9.6, 13.4
Maternal Factors		
Age at Child's Birth (Years)		
15-19	12.3	8.5, 16.0
20-24	11.4	8.7, 14.0
25-29	11.6	7.7, 15.4
≥30	10.6	5.7, 15.4
Education		
No Education	9.0	6.2, 12.1
Primary Education	14.6	10.6, 18.7
Secondary/Higher Education	11.6	8.5, 14.6
Body Mass Index (BMI)		
<18.5 (Underweight)	13.5	7.9, 18.8
18.5-23.0 (Normal)	12.3	8.5, 14.7
>23.0 (Overweight)	9.0	6.0, 11.7
ANC Visit During Pregnancy		
No Visit	9.7	1.0, 19.2
One-Three Visits	12.1	8.0, 16.0

Table 2 (*continue*)

Variables	Birth Weight (Mean)	95% CI
Four or More Visits	11.4	9.0, 13.7
Consumption of Iron Tablets During Pregnancy		
No	11.0	4.1, 18.3
Yes	11.5	9.8, 13.5
Women and Husbands Together	11.8	9.0, 14.5
Husband or Others	13.4	10.3, 16.5
Child Factors		
Birth Interval		
No Interval	12.3	10.0, 14.7
<24 months	13.1	7.1, 19.0
≥24 months	10.2	7.6, 12.7
Gender of baby		
Male	10.7	8.3, 13.1
Female	12.4	9.3, 15.4
Socio-Demographic Factors		
Cooking Fuel		
Low Polluting Fuel	10.8	7.7, 14.0
High Polluting Fuel	11.9	9.4, 14.3
Wealth Index		
Poor	11.8	8.6, 15.0
Middle	10.8	7.4, 14.3
Rich	11.6	8.8, 14.5
Ethnicity		
Relatively Advantaged	12.2	9.5, 15.0
Relatively Disadvantaged (Janjati)	10.2	7.4, 13.0
Relatively Disadvantaged (Dalit)	10.9	6.8, 15.0
Residence		
Rural	11.6	9.0, 13.2
Urban	11.4	9.2, 14.0
Ecological region		
Mountain	12.6	8.2, 14.4
Hill	11.9	8.9, 15.0
Terai	11.2	8.6, 13.8
Development Region		
Eastern	8.6	6.2, 11.1
Central	15.0	10.2, 19.7
Western	9.0	4.6, 14.1
Mid-Western	12.3	8.1, 16.5
Far-Western	14.2	9.7, 18.8

Factors Associated with LBW

Simple survey logistic regression was applied to all the studied variables as univariate analysis. The results obtained from this analysis are shown in Table 3. Even though the *p*-value calculated from Wald's test for women's decision for utilisation of health services was significant in Wald's test (*p*-value=0.032), the overall *p*-value calculated from the Likelihood ratio test was 0.105. Hence, only the development region was considered statistically significantly. Mothers residing in the Eastern development region (odds ratio [OR 1.86, 95% CI=1.12, 3.01]) and the Far-Western development region (OR 1.75, 95% CI= 1.08, 2.84) were more likely to have LBW infants. However, determinants such as mother's age at child's birth, mother's education, ANC visit and consumption of iron tablets during pregnancy, smoking, parity, birth interval, child's gender, wealth index, ethnicity, cooking fuel, residence and ecological region were insignificant.

Table 3
Unadjusted odds ratio and 95% CI of study variables

Variables	Unadjusted OR	95% CI	*p*-value
Maternal Factors			
Age at Child's Birth (Years)			*0.950*
≥30	1.00		
25-29	1.10	0.56, 2.18	0.774
20-24	1.08	0.61, 1.92	0.791
15-19	1.18	0.66, 2.10	0.579
Education			*0.105*
Secondary/Higher Education	1.00		
Primary Education	1.31	0.81, 2.12	0.267
No Education	0.77	0.49, 1.23	0.280
ANC Visit During Pregnancy			*0.894*
Four or More Visits	1.00		
One-Three Visits	1.07	0.70, 1.65	0.826
No Visit	0.82	0.27, 2.46	0.869
Consumption of Iron Tablets During Pregnancy			*0.940*
Yes	1.00		
No	0.94	0.44, 1.99	0.984
Smoke			*0.687*
No	1.00		
Yes	0.81	0.30, 2.21	0.687
Parity			*0.107*
Four and Above	1.00		
Two-Three	1.67	0.96, 2.89	0.070
One	1.33	0.72, 2.46	0.365

Table 3 (*continue*)

Variables	Unadjusted OR	95% CI	*p*-value
Women's Decision For Health Service Utilisation			*0.105*
Women	1.00		
Women and Husbands Together	1.46	0.92, 2.31	0.106
Husband or Others	1.68	1.04, 2.72	0.032*
Child Factors			
Birth Interval			*0.373*
No Interval	1.00		
<24 months	1.07	0.64, 1.82	0.790
≥ 24 months	0.81	0.58, 1.12	0.205
Gender of Baby			0.401
Male	1.00		
Female	1.18	0.80, 1.72	0.401
Socio-Demographic Factors			
Wealth Index			*0.921*
Rich	1.00		
Middle	0.92	0.58, 1.47	0.740
Poor	1.02	0.69, 1.51	0.930
Ethnicity			*0.576*
Relatively Advantaged	1.00		
Relatively Disadvantaged (Janjati)	0.82	0.55, 1.21	0.310
Relatively Disadvantaged (Dalit)	0.88	0.54, 1.42	0.599
Cooking Fuel			*0.668*
Low Polluting Fuel	1.00		
High Polluting Fuel	1.11	0.73, 1.68	0.668
Residence			*0.941*
Urban	1.00		
Rural	0.99	0.70, 1.38	0.941
Ecological Region			*0.846*
Terai	1.00		
Hill	1.07	0.73, 1.58	0.727
Mountain	1.15	0.71, 1.86	0.579
Development region			*0.039*
Central	1.00		
Eastern	1.86	1.12, 3.01	0.013*
Western	1.09	0.57, 2.07	0.794
Mid-Western	1.49	0.90, 2.44	0.119
Far-Western	1.75	1.08, 2.84	0.024*

Note: *p*-value in italic form was calculated from Likelihood ratio test, *statistically significant at 5% level.

DISCUSSION

The overall prevalence of LBW in this study was 11.5% and this finding was similar to that of a study conducted by Khanal et al. (2014b). That study also reported a prevalence of 11.5%. This is because the above-mentioned study also excluded infants with missing birth weight from the analysis. The prevalence of LBW for determinants such as mother's age at child's birth, consumption of iron tablets during pregnancy, gender of child, wealth index, ethnicity, cooking fuel, residence and ecological region were nearly equal for each category. This finding reflected that each category had the same possibility of having LBW.

The current study revealed that mothers residing in the Eastern development region and the Far-Western development region were more prone to delivering LBW infants. This is consistent with the study by Khanal et al. (2014a, 2014b). The Far-Western development region of Nepal depicts remoteness, less development of basic infrastructure and few livelihood opportunities (United Nations Nepal Information Platform, 2012). Due to this, women living in this region are deprived of nutritious food during pregnancy and are hindered from going to health facilities. As a result, there is a higher chance of having adverse outcome pregnancy outcomes.

In this study, determinants such as ANC visit and consumption of iron tablets during pregnancy were not significantly associated with LBW. This result differs from that documented by Khanal et al. (2014a, 2014b), who found the above-mentioned variables significant. This is because the aforementioned studies presumed that missing values presented on ANC visits and consumption of iron tablet during pregnancy as 'no ANC visit' and 'no consumption', respectively. Consequently, there is a greater sample for 'no ANC visit' and 'no consumption'. Hence, ANC visit and consumption of iron tablets were found significant as a factor in LBW in the above-mentioned studies.

The current study assumed that missing data were MAR and multiple imputation was considered the best method to handle missing data when the missing data held the MAR mechanism. Therefore, missing values presented on determinants were handled using multiple imputation and were not ignored. White et al. (2011) suggested that the number of imputations should be at least equal or greater than the number of missing values. Therefore, imputation was carried out 15 times because the highest percentage of missing value was 14.3%. Although the current study and the study conducted in Nepal (Khanal et al., 2014b) analysed the same subset of the sample (1,922), the results were not consistent. In the present study, missing data on variables such as ANC visit, consumption of iron tablets during pregnancy, cooking fuel and women's decision on utilisation of health services were handled through multiple imputation rather than ignored or assumed to be missing values as non-missing. Using imputation for replacing missing values does not remove bias completely, but it does reduce bias and this is preferred to ignoring bias altogether (Lumley, 2010). Therefore, handling missing values on determinants is a better option to presuming values to be not missing or ignoring it.

The limitation of this study was that infants with missing birth weight were excluded from this study. Furthermore, this study analysed secondary data; therefore, the reason for missing values was not confirmed.

CONCLUSION

The prevalence of LBW was 11.5%, which was still high, in spite of deleting infants with missing birth weight. This finding suggested that there is a need for implementation of programmes focused on reduction of LBW in Nepal, especially targeting mothers living in the Eastern and the Far-Western development region of Nepal.

The findings revealed that assuming missing values as non-missing or ignoring missing values provide different results. Therefore, it is suggested that future researchers handle missing data and not assume values are non-missing or ignore them.

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