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RESEARCH ARTICLE

Regular antenatal care visits were associated with low risk of low birth weight among newborns in Rwanda: Evidence from the 2014/2015 Rwanda Demographic Health Survey (RDHS) Data [version 1; peer review: 3 approved with reservations]

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Abstract

Background: Low birth weight (LBW) remains the global unfinished agenda in most countries of the world especially in low- and middle-income countries. LBW subsequently has harmful effects on the lifestyle, psychosocial and physiological development of the child. Although it is known that antenatal care (ANC) visits are important interventions contributing to prediction of newborn birth weight, little has been conducted on effect of ANC visits on birth weight in Rwanda. This study aimed at determining the association between regular ANC visits and risk of LBW among newborns in Rwanda.

Methods: A cross-sectional study design was conducted to analyse the effects of ANC on LBW using the 2014/2015 Rwanda Demographic Health Survey. Associations of socio-demographic, socio-economic, and individual factors of the mother with LBW newborns were performed using bivariate and multiple logistic regression analyses.

Results: Prevalences of LBW and macrosomia were 5.8% and 17.6%, respectively. Newborns delivered from mothers attending fewer than four ANC visits were at almost three-times greater risk of having LBW [aOR=2.8; 95%CI (1.5–5.4), p=0.002] compared to those whose mothers attending four or more ANC visits. Residing in a rural area for pregnant women was significantly associated with LBW [aOR=1.1; 95%CI (0.7–1.6), p=0.008]. Maternal characteristics, such as anemia, predicted an increase in LBW [aOR=3.5; 95%CI (1.5–5.4), p<0.001]. Those who received no nutritional counseling [aOR=2.5; 95%CI (2–8.5), p<0.001] and who were not told about maternal complications

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[aOR=3.3; 95%CI (1.5–6.6), $p=0.003$] were more prone to deliver newborns with LBW than those who received them. Pregnant women who received iron and folic acid were less likely to have LBW newborns [aOR=0.5; 95%CI (0.3–0.9), $p=0.015$].

Conclusion: ANC visits significantly contributed to reducing the incidence of LBW. This study underscores the need for early, comprehensive, and high-quality ANC services to prevent LBW in Rwanda.

Keywords

Antenatal care; Birth weight; newborn; Maternal factors; Sustainable Development Goals; Pregnancy

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Introduction

Antenatal care (ANC) globally is an important health strategy that has been considered as an essential intervention to contribute to the health of newborns and their mothers. This health intervention reduces low birth weight (LBW) which is a foremost public health burden that weakens the development of families and nations due to its harmful effects on quality of life.¹ LBW is defined when a baby weighs less than 2.5 kilograms at birth. This health burden particularly, in low- and middle-income countries (LMICs) may cause multiple effects, such as birth asphyxia, amniotic fluid aspiration, hypoglycemia and hyponatremia.^{2–4} The estimate of 15.5% to 15.9% of LBW worldwide was reported^{5,6} and the high prevalence (95.6%) of LBW newborns occurred in LMICs.^{7,8} ANC visits were found to play a great role in the health promotion of mothers and children before, during and after delivery. It specifically contributes to the reduction of morbidity and mortality of mothers and children.^{9,10} Epidemiological studies have shown that the children weighing less than 2.5 kilograms are nearly 20-times more likely to die than those who weigh 2.5 kilograms and more.¹¹ Other studies have stated that newborns with LBW were 5–10-times more likely to die than those who weighed 2.5 kilograms and more.^{2,3} Prior studies have indicated that the newborn may develop macrosomia, defined as birth weight more than 4 kilograms. These newborns are considered to have an excessive birth weight. Its prevalence varies globally between 3 and 15% depending on the region, due to various factors where it remains higher in the developing world.^{12,13}

Prior studies indicated that maternal and environmental factors are major factors with regard to LBW.^{14,15} The number of ANC visits attended by the pregnant women and the amount of recommended packages of the interventions provided during ANC are the main factors contributing to LBW.^{14,16} A low socio-economic status and limited access to qualified health services related to pregnancy are risk factors for LBW.¹⁶ Multiple studies established that accessibility to poor food consumption behaviors, problems of health status for pregnant women, low caloric intake, hypertension, urinary infections, smoking behaviors, genital infections and psychological distress were found to be risk factors of LBW.^{4,17,18} Earlier studies conveyed that consumption of iron, birth order, and calcium supplementation reduces the risk to develop LBW.^{18–20}

ANC refers to the routine health management of presumed healthy pregnant women without the symptomatology or screening so as to diagnose and detect the diseases or complicating symptoms.^{16,21,22} The World Health Organization (WHO) recommended pregnant women attend a minimum of four ANC visits for obtaining the basic health education and interventions that promote health of babies. The more they attend ANC services, the more they receive the maximum health package that plays a crucial role in their health and the health of their newborn.²³ Prior studies have documented that two-thirds of all pregnant women worldwide attended at least one ANC service during pregnancy. They also documented that ANC is the significant predictor of birth weight where attending the required ANC increases the probability of achieving full life-saving potential and having a newborn with more than 2,500 grams.^{24–27} In ANC visits, pregnant women are offered health education, such as adequate nutrients to be consumed during and after delivery, vitamin intake, proper vaccination, changing risk behaviors such as smoking, and place of delivery.^{28,29} The package provided to pregnant women consists of many interventions like the identification and management of the obstetric complications including pre-eclampsia, tetanus toxoid immunization, de-worming, iron, folic acid, and interventions related to infectious diseases, such as malaria prevention, during pregnant period and insecticide-treated nets (ITNs). The fundamental rudiments of a focused approach to ANC are surveillance of health issues among pregnant woman and their babies, management of complications occurring in the pregnancy period, such as hypertension, treatment of underlying or concurrent illness, screening for health conditions and diseases, mental health problems and intra-partner violence or domestic violence.^{25,29,30} ANC visits are obviously the opportunities for promoting the use of skilled attendance at birth, injury prevention, adherence support for preventive interventions, healthy lifestyle safety, and healthy behaviors such as breastfeeding, early postnatal, and planning for the optimal pregnancy spacing.^{24,31,32} Pregnant women are provided supplementary nutrients for enhancing the baby's and mother's health, screening for genetic and congenital disorders, and offered folic acid supplementation to reduce the risk of neural tube defects.^{1,8,28,33,34}

Earlier researchers documented that through ANC services, pregnant women and their newborns develop physiological and psychosocial wellbeing. It also reduces risk to have a LBW newborn. ANC visits contributed to development of healthy behaviors and compromise of the emergency preparedness plan to intensify the maternal awareness, improving the newborn needs and self-care.²⁹ Other studies indicated that ANC visits contribute to weight gain and weight regulation of women. They confirmed that ANC services increase the weight of pregnant women and contribute to the growth of the fetal and maternal tissues and fluids.^{21,35} This health intervention plays a great role in the provision of information about lifestyle, pregnancy, and delivery. They prevent the potential determinants associated with morbidity and mortality of mothers and children. ANC services not only contribute to pregnant women and their fetus, but also foster a virtuous social and family cohesion and resilience. It was found that more than 80% of pregnant women who attended at least four ANC visits reported showed effectively controlled pregnancy complications.^{33,36,37} ANC services contribute to preparing women for delivery and understanding warning signs during the pregnancy and childbirth.³⁸ It was scientifically found that the ANC interventions attended early become the best opportunity for appropriate screening and medical testing for health

problems in which pregnant women are exposed to have during and after pregnancy.³⁹ ANC coverage was an important indicator for reducing the risks to neonatal, infant mortality, maternal mortality and stunting issues to the child.³⁷

Previous studies indicated that there is a substantial influence of ANC on increase of birth weight for the children and their development of a good life characterized by prevention and management of pregnancy-related or concurrent diseases and psychosocial development.^{37,40} Maternal health production function explained that early onset of ANC, prenatal care and have a minimum number of ANC and prenatal care visits.^{41,42}

The rationale of this study was to increase the accessibility to ANC services that were documented to be practiced, but there was no scientific evidence that was conducted to indicate its effect on neither LBW nor contributing determinants to the reduction of children and maternal morbidity and deaths in Rwanda. Through the findings from this research, the investigators indicated how pregnant women achieve the third goal of Sustainable Development Goal (SDG-III) related to the reduction of infant and maternal mortality and morbidity by completing four ANC visits and more. Although it is known that ANC visits are an important intervention that contributes to prediction of the newborn birth weight, little has been conducted on effect of ANC visits on birth weight in developing countries, including Rwanda. This research, therefore, aimed to determine the effect of antenatal care visits on the LBW of children in Rwanda using the secondary data analysis of Rwanda Demographic and Health Survey (RDHS) 2014-2015. We hypothesize that ANC visits result in reducing the high incidence of LBW among newborns of Rwanda.

Methods

Data source

The fifth RDHS 2015 was utilized as a nationally representative sample implemented by the National Institute of Statistics of Rwanda (NISR) and Ministry of Health of Rwanda.

Study technique, participants and settings

The study design was a secondary analysis of cross-sectional survey data from RDHS 2014/2015 that was retrospectively carried out for investigating the effects of antenatal care visits on birth weight of the newborn in Rwanda. The RDHS data collection fieldwork was conducted from November 9, 2014, to April 8, 2015. The data entry, editing, and cleaning was completed by May 15, 2015, and the final survey report was completed in March 2016. A total of 8,004 pregnant women who were to receive antenatal care interventions before delivery were recruited. The interviewed women were of reproductive age (15–49 years). This study was conducted in Rwanda, a small country located in the Central and Eastern Africa bordered by the Republic Democratic of Congo to the West, Uganda to the North, Tanzania to the East and Burundi to the South. This country lies a few degrees south of the equator and is landlocked. Concerning ANC visits, accessibility to ANC services is increasing due to the improvement of the health system and health financing.¹ This health system contributes to the achievement of SDG-III those targets reducing morbidity and mortality of mothers and children worldwide specifically in LMICs. The total area of Rwanda is approximately 26,338 km², the Rwandan population density around 416 people per km² and the total population is roughly 10.8 million. The majority (43%) of the Rwandan population is aged 15 years or less. Women accounted for about 52.6% of the population, 84% of Rwandans resided in the rural setting, and 71% participant in agricultural activities.⁴³

Sampling design

RDHS was a national survey conducted to assess the birth weight of newborns. To collect the data of this household-based survey, mothers who had the youngest children, age five years or less, were interviewed to provide data related to birth weight for their children. The data for this survey were collected using a two-stage sampling strategy for enrolling participants. These stages were cluster sampling design and the sampling frame. The sampling frame was composed of the list of the enumerators' areas (EAs) that covered the entire country. All residents in selected households were eligible to be interviewed. At the first stage of this study, 492 clusters were randomly selected (113 in urban and 379 in rural areas). At the second stage of this study, the systematic sampling technique that focused on selecting the households was applied. Then, a fixed number of 26 households were selected randomly from each cluster and a total of 12,792 households were selected for the final sample for this study.

Additionally, the proportional sampling technique was used in the survey where the sample for each cluster was equal. The study included women aged 15–49 years who were permanent residents of the households or visitors who stayed in the recruited household the night before the survey. For this epidemiological research, this fifth demographic survey presented that although the weight of the newborns at birth is an important predictor of their probability of surviving, current birth weights were not available for the most children. Instead, the mothers were interviewed about the size of their children at birth because this determinant was found to be a proxy for the weight of the newborn. Therefore, 8,004 mothers with 15–49 years of reproductive age were interviewed for reporting the actual weight in kilograms using the

written information about birth weight or recalling the weight at birth for their newborns. It was found that 92% of newborns had a birth weight reported while 8% did not.

Research tools and data collection

RDHS 2014/2015 collected data at the national level using household-based survey data on birth weight retrospectively collected from the mothers. The data collection was completed by trained data collectors who used face-to-face interviews, asking mothers eligible for this study to provide a detailed birth history for children born in the preceding five years. Recruitment included stratified sampling, two stages of cluster sampling designs. The first stage was characterized by selecting the participants from the samples frame constructed from enumeration whereas the second stage involved the systematic sampling of the households. These were listed from each cluster to ensure that an adequate number of the completed individuals were obtained.⁴⁴ Participants were interviewed based on the measurement of the DHS program. Birth weight was recorded in the RDHS using metric measurement (in kilograms) for all participants from the entire stratum of the country. Data from mothers with stillbirths were excluded from this study.

Study bias

Bias refers to any tendency or deviation from the truth in study design, data collection, recruiting participants, data analysis, and results interpretation. Generally, bias may occur at any stage of the research. To manage the bias for the data from RDHS, the authors systematically did data cleaning and removed the missing variables. All authors checked several times the selected variables to include in the analysis for minimizing all possible systematic errors that could occur in the study.

Study variables

Dependent variable

The outcome variable of the current study was birth weight of the newborns. As per World Health Organization (WHO) classification, newborns weighing <2,500 grams were categorized as LBW while newborns weigh >2,500 grams were categorized as not having LBW.⁴⁵

Explanatory variables

Based on the literature review and the structure of the RDHS 2014/2015 dataset, the independent variables were found. The main explanatory variable was the number of the antenatal care visits for the pregnant women. Pregnant women who attend none or one ANC visit were considered to have inadequate number of visits, those who attended two or three ANC visits were considered to have intermediate, and those who attended four to seven were taken as adequate number of visits. As recommended by WHO, the pregnant women who attended four ANC visits were considered to have obtained extremely adequate healthcare that effectively contributes to the health of the mother and unborn.^{46–48} This study used different covariate variables selected based on the previous epidemiological studies, reviewing the suitable published demographic and epidemiological studies and the available information provided in the demographic health survey (DHS) datasets with the consideration of the potential confounders. Based on the insights from the literature and availability in the datasets, the following variables were included as potential confounders: maternal age (<19 years, 20–34 years and 35–49 years); maternal height (1: <160 cm; 2: ≥160 cm), parity (*i.e.* birth order), maternal weight (1: <80 kg; 2: 80–89 kg; and 3: ≥90 kg), body mass index (BMI), residence (0: urban; 1: rural); educational attainment (0: illiterate; 1: primary; 2: secondary and higher); household wealth status (0: poor, 1: middle and rich); place of delivery, marital status, maternal occupation, tetanus injection during the pregnancy (0: yes; 1: no), intake iron during the pregnancy (0: yes; 1: no), sex of the child (0: female; 1: male), sex of household head (0: female; 1: male), wanted pregnancy when became pregnant (0: yes; 1: no), blood pressure taken during pregnancy (0: yes; 1: no) provided anti-malaria drugs during pregnancy (0: yes; 1: no), urine sample taken during pregnancy (0: yes; 1: no), received counseling or health education related to nutrients (0: yes; 1: no).

Statistical analyses

Before analysis, the observations with missing data were dropped. Statistical analysis was performed using descriptive (such as frequency, percentage, standard deviation, and mean) and analytical analyses. In the analytical analysis, bivariate logistic regression and multiple logistic regression models were computed to determine the association between LBW and the explanatory variables. The factors that were significantly associated with LBW at 0.05 or 0.01 in bivariate logistic regression were analyzed using multiple logistic regression models for identifying the association between ANC visits and birth weight when controlling for other covariates, presenting adjusted odds ratio, 95% confidence intervals. Therefore, we adjusted sampling based on the RDHS data that were widely used and consistent data for assessing maternal and child health statistics at the national level using STATA software version 13 (RRID:SCR_012763).⁴⁹ In this cross-

sectional study design, we respected the guidelines outlined in the Strengthening the Reporting of Observational Studies in Epidemiology statement in writing the manuscript.⁵⁰

Ethical consideration

Data used were electronically accessed. To get full access, the first registration was completed on the DHS website. The permission to use the 2014/2015 RDHS data was granted by DHS using its website and the prior approval was maintained. In the prior approval, the women of reproductive age who were age 18–49 years provided oral and written informed consent forms to take part in the survey. In the cases on the minor participants (those women aged 15–17 years); the assent form was obtained from them while written informed consent were simultaneously provided by their guardians or parents who were adults.

Results

Socio-demographic and economic status of mothers during pregnancy

The results indicated the average birth weight was 3846.1 grams with a standard deviation of 1840.5 grams. The results indicated that the average family size was 5.7 (SD=2). The majority [6012 (76.6%)] weighed 2,500–4,000grams. The majority (61.3%) of pregnant women were aged 35–39 years. For the occupation of the pregnant women, it was found that the majority (86.1%) were involved in agricultural activities (self-employed). About the participants' religious beliefs, the majority (96.8%) were Christians. Regarding the information about the households, the results indicated that the majority (21.6%) were the poorest. The majority of them (57.9%) were from the families consisting of four to seven family members and 77.3% resided in rural setting. 92% of the pregnant women attended ANC at health centers. Moreover, the prevalence of LBW and macrosomia was 5.8% and 17.6%, respectively, whereas 76.6% of pregnant women delivered newborns who weighed between 2.5 kg and 4 kg. The number of pregnant women who attended four or more ANC visits was 44.1%, those who attended fewer than four ANC was 55.1%, and only 0.8% attended no ANC visits. This indicated that Rwanda did not yet achieve the SDG-III. Besides, the findings showed that during pregnancy, these women are provided different health education and measurement for improving the health of the children including normalizing the birth weight for both mother and their children. Within this period, the results indicated that the majority of the pregnant women (80.5%) were provided at least one tetanus injection before birth, but 19.5% were not. Before pregnancy, the results indicated that the majority was not given any tetanus injection. This means that the tetanus injection is mostly attended by the women when they were pregnant during the ANC visits. The results indicated that more than 70.7% of the pregnant women were provided counseling and education related to nutrients. Indeed, the findings showed that 79.9% of pregnant women were given iron tablet during the pregnant period. The majority (83.4%) of pregnant women were measured blood pressure (Table 1).

In the bivariate logistic regression, we indicated how low birth weight is associated with ANC services, socio-demographic characteristics, maternal influences and behaviors. Therefore, we found that LBW is significantly associated with the ANC visits, BMI, maternal height, maternal weight, residence, place of delivery, sex of child, HWI, maternal parity, maternal, anemia for pregnant women, family size, age, maternal education, provision of tetanus injection during the pregnancy, health education about pregnant complications, provision of counseling about nutrients during pregnancy, provision of malaria drugs, use of health card, and attendance of ANC visits at health center (Table 2).

Multiple logistic regression analyses of the effects of the explanatory variables on birth weight of the newborns in Rwanda

Multiple logistic regression analyses indicated that ANC check-ups are the risk factor of LBW among the pregnant women. Mother attending fewer than four ANC visits are almost three-times more likely to give birth to LBW children [aOR=2.8; 95%CI (1.5–5.4), p=.002] when compared with mothers attending four or more ANC visits. Besides, newborns who were delivered at the health center [aOR=0.3; 95%CI (0.2–0.7), p=.002] and private health institutions [aOR=0.3; 95%CI (0.2–0.6), p<0.001] were less likely to weigh less than 2.5 kg than who were delivered in their households. The findings demonstrated that pregnant women who were not provided Coartem for malaria treatment [aOR=0.6; 95%CI (0.4–0.8), p<0.001] or who received other malaria drugs [aOR=4.1; 95%CI (1.7–10), p=0.02] were more likely to have LBW newborns. The pregnant women who attended the ANC visits at the health center [aOR=0.5; 95%CI (0.3–0.9), p=0.02] were less likely to have newborns with less than 2.5 kg. For marital status, married and cohabiting pregnant women were 1.86-times at greater risk to have LBW children [aOR=1.9; 95%CI (1.3–2.8), p=0.002] compared with single pregnant women. Mothers who were widowed, divorced and separated from their husbands were more likely to have LBW children compared with the women who were single during pregnancy. The results indicated that the widowed, separated and divorced pregnant women had 1.7-times greater risk of having LBW babies [aOR=1.7; 95%CI (1.1–2.5), p=0.015] than women who were single during pregnancy. Results found that being provided maternal iron and folic acid supplementation during pregnancy [aOR=0.5, 95%CI (0.3–0.9), p=0.015], not being given nutrients during pregnancy [aOR=2.5, 95%CI (2–8.4), p<0.001], being told about maternal complications during pregnancy [aOR=0.7,

Table 1. Distribution of the maternal characteristics in Rwanda, 2015.

Characteristics	Number	Percentage
Maternal age (years)		
15-19	120	4
20-34	2260	74.9
35-49	638	21.1
Mean (SD)	36.8(7.4)	
Maternal weight		
<80 kg	2621	33.4
80-89 kg	2922	37.2
≥90 kg	2305	29.4
Marital status		
Single	324	10.7
Married/cohabiting	2478	82.1
Widowed/separated/divorced	216	7.2
Maternal education		
Illiterate	389	12.9
Primary	2139	70.9
Secondary/higher	490	16.2
Religion		
Christian	2922	96.8
Muslim	666	2.1
Traditional	213	1.1
Smoking		
Yes	63	0.9
No	7319	99.1
Residence		
Urban	685	22.7
Rural	2333	77.3
Household wealth index		
Poor	236	51.5
Middle/rich	222	48.5
Family size (persons)		
Less than 4	282	19.3
4 to 7	843	57.9
More than 7	332	22.8
Mean (SD)	5.7(2)	
Birth weight		
<2,500grams	458	5.8
2,500-4,000grams	6012	76.6
>4000grams	1378	17.6
Mean (SD)	3846.1(1840.5)	
Parity		
1-2	13	2.2
3-4	138	23.5
≥5	436	74.3

Table 1. *Continued*

Characteristics	Number	Percentage
Injection of tetanus before birth		
No injection	1161	19.5
Yes	4792	80.5
Tetanus injection before pregnancy		
No injection	833	30.4
Yes	1858	67.7
More than 7	52	1.9
During pregnancy, was given iron tablet		
No	1198	20.1
Yes	4756	79.9
Sex of household head		
Male	729	50
Female	728	50
Places of ANC		
Homes	589	2.0
Provincial/district hospital	2166	7.2
Health center	4836	16.1
Privates and other health facilities	262	74.7
Number ANC visits		
No ANC and less than 4 ANC	3329	55.9
≥4 ANC	2622	44.1
Blood pressure taken during pregnancy		
No	53	16.6
Yes	266	83.4
Blood sample taken during pregnancy		
No	9	2.8
Yes	310	97.2
Heard about health nutrients at Community health workers (CHWs)		
No	908	42
Yes	1251	58
Heard about counseling or education on health nutrients		
No	893	29.3
Yes	2159	70.7

Notice: SD: Standard Deviaton.

95%CI (0.5–1), $p=0.05$], pregnant women with anemia [aOR=3.5, 95%CI (1.5–9), $p<0.001$] were positively associated with LBW. Through the number of the pregnant women who smoked during pregnancy, it was found that birth weight is significantly associated with smoking, as pregnant women who did not smoke were less likely [aOR=0.3; 95%CI (0.1–0.6), $p=0.002$] to deliver LBW babies (Table 3).

Discussion

This study revealed that LBW remains a public health burden at the national level and it remains higher in Rwanda. The results found that the prevalence of LBW and macrosomia was 5.8% and 17.6%, respectively; however, the newborns weighing more than 2.5kg were 94.2%. These results were coincided with the previous studies that documented an improvement of ANC services contributing to birth weight of the newborns.³⁴ Similarly, the prevalence of LBW is low compared with other counties in the same region such as Zambia, Uganda and Nigeria.^{51–53} It is also less than the

Table 2. Bivariate logistic regression for analysing the association between the independent variables and LBW.

Characteristics	LBW, n (%)	Odds ratio	95% CI	p-value
Type of residence				
Urban	75(16.4)	1		
Rural	383(83.6)	1.3	1.1-1.7	0.031*
Body Mass index (BMI)				
≤18.5 kg/m ²	367(80.2)	1		
18.5-25.9 kg/m ²	60(13.1)	0.4	0.1-1.1	0.02*
≥25 kg/m ²	31(6.7)	1.9	1.1-3.3	0.03*
Parity				
1-2	49(10.7)	1		
3-4	338(73.8)	1.9	1.1-3.7	0.003*
≥5	71(15.5)	2.8	1.1-7.2	0.031*
Maternal height				
Less than 160 cm	187(40.8)	1		
160 cm and more	271(59.2)	2.4	1.3-4.5	0.04*
Maternal weight				
<80 kg	200(43.7)	1		
80-89 kg	133(29.1)	2.4	1.2-4.8	0.02*
≥90 kg	125(27.2)	2.8	1.3-5.9	0.0009*
Sex of child at birth				
Male	203(44.3)	1		
Female	255(55.7)	0.8	0.6-0.9	0.014*
Household Wealth index				
Poor	236(51.5)	1		
Richer/middle	222(48.5)	0.5	0.1-0.7	<0.001**
Marital status				
Single	129(28.2)	1		
Married/cohabited	263(57.4)	0.2	1.7-2.9	<0.001**
Widowed/separated/divorced	66(14.4)	0.1	0.1-0.2	<0.001**
Wanted pregnancy when became pregnant				
Wanted then	290(63.3)	1		
Wanted later	114(24.9)	1.8	0.8-1.3	0.673
Wanted no more	54(11.8)	1.1	0.8-1.5	0.405
Husband's desire children				
Both want same	279(61)	1		
Husband wants more	49(10.8)	0.8	0.6-1.1	0.211
Husband wants fewer	92(20.1)	1.1	0.8-1.4	0.610
Unaware	37(8.1)	0.99	0.8-1.2	0.956
Place of delivery				
Household	16(3.5)	1		
Public hospitals	176(38.4)	1.3	0.3-5.8	0.741
Health center	257(56.1)	0.3	0.2-0.6	<0.001**
Privates health facilities	9(2)	0.3	0.2-0.6	<0.001**

Table 2. *Continued*

Characteristics	LBW, n (%)	Odds ratio	95% CI	p-value
Maternal age				
15-19	12(2.6)	1		
20-34	342(74.7)	2.7	1.5-4.9	<0.001**
35-49	104(22.7)	14.6	7.9-27.1	<0.001**
Family size				
Less than 6	297(64.8)	1		
6 members and more	161(35.2)	0.5	0.4-0.6	<0.001**
Smoking for pregnant women				
Yes	14(3)	Ref.		
No	444(97)	0.3	0.1-0.6	0.003*
Health card				
No	57(12.5)	1		
Yes	401(87.5)	0.3	0.2-0.7	0.003*
Household head				
Male	351(76.6)	1		
Female	107(23.4)	1.2	0.7-1.02	0.074
Anemia				
Not anemic	387(84.4)	1		
Anemic	71(15.6)	4.7	2.5-9.2	<0.001**
Maternal education				
Illiterate	69(15.1)	1		
Post-primary/vocational	335(73.1)	0.5	0.3-1.3	0.105
Secondary and above	54(11.8)	0.3	0.1-0.9	0.036*
Utilization of Antenatal care services during pregnancy				
≥ 4 ANC visits	158(34.5)	1		
No and less than 4 ANC visit	300(65.5)	1.5	1.2-1.9	<0.001*
During pregnancy, Immunized with recommended dose of Tetanus and diphtheria				
No	49(10.7)	1		
Yes	409(89.3)	0.3	0.1-0.2	<0.001*
In pregnancy, provided blood pressure taken				
No	76(16.6)	1		
Yes	382(83.4)	0.8	0.6-1.1	0.193
In pregnancy, provided urine sample taken				
No	198(43.3)	1		
Yes	260(56.7)	0.87	0.1-1.1	0.130
In pregnancy, who provided blood sample taken				
Yes	13(2.8)	1		
No	445(97.2)	1.04	0.5-2.1	0.905
Told about pregnancy complications				
Yes	371(81.1)	1		
No	87(18.9)	1.1	0.8-1.5	0.0054*
In pregnancy, consumption of recommended dose of Iron and folic acid				
No	95(20.8)	1		
Yes	363(79.2)	0.4	.12-1.02	0.001**

Table 2. *Continued*

Characteristics	LBW, n (%)	Odds ratio	95% CI	p-value
During pregnancy, given coartem for malaria treatment				
No	395(86.3)	1		
Yes	63(13.7)	2	1.4-2.8	<0.001**
During pregnancy, took quinine for malaria				
No	453(98.8)	1		
Yes	5(1.2)	1.1	0.4-3	0.871
During pregnancy, took other drug for malaria				
No	449(98.1)	1		
Yes	9(1.9)	4.1	1.7-10.2	0.002*
During pregnancy, provided counseling about nutrients				
Yes	252(55)	1		
No	206(45)	6	3.5-10.7	<0.001**
Utilization of antenatal care services at health center				
No	14(3.1)	1		
Yes	444(96.9)	0.5	0.3-0.9	0.02*
During pregnancy, not provided medical drug for malaria taken				
No	76(16.5)	1		
Yes, no drug taken	382(83.5)	0.5	0.4-0.7	<0.001**

Notice: (*) Indicates the statistical significance level at 0.05; (**) Estimates the statistical significance level at 0.01; Unmarked p-values were not found to be the significant risk factors of LBW in Rwanda.

prevalence of some countries in Asia such as in China where the accessibility to ANC visits remains challenging.⁵⁴ The present prevalence of LBW is less than the previous document which was 7.1% and low access of four recommended ANC visits was 35.4%.⁵⁵ There is a significant reduction of the prevalence of LMICs compared with the prevalence (15.9%) found in developing countries.⁶ Among the women with the newborns who weigh less than 2.5kg, only 44.1% of pregnant women attended four recommended ANC visits. Within this study, a strong correlation between ANC and LBW was discovered and the results of inadequate ANC visit for pregnant women. However, almost all pregnant women (99%) attended ANC visits and only 44.1% obtained 4 recommended ANC packages, there is a need to increase attendance of ANC visits for reducing the number of newborns with LBW. These results corroborated preceding studies.^{54,56}

We observed that pregnant women who attended four and more ANC visits had less risk of having LBW children than those who attended fewer than four recommended ANC visits. This finding is consistent with previous data that indicated that the more pregnant women attend ANC visits, especially more than four, the more their children do not have LBW.^{57,58} Pregnant women who attended fewer than four ANC check-ups had 2.8-times greater odds of LBW than those who attended four and more ANC visits. These findings are relevant with the previous studies that indicated that ANC visits are significant maternal factors contributing to birth weight babies, since it normalizes the birth weight of the child and their mother due to the prevention, intervention and health education that are effectively provided in each visit.^{54,59,60} They are also relevant to prior studies conducted in central African counties that indicated that the attendance of ANC visits and being provided the recommended packages for pregnant women reduce the risk for delivering LBW outcome.^{27,61–63} Results revealed that the pregnant women who were not provided Coartem for malaria treatment were 0.6-times likely to have LBW children compared with the pregnant women who were provided Coartem for malaria treatment.^{57,64} It was found that the pregnant women who received no drug for malaria treatment had 0.3-times greater risk of having LBW children than the women who received the drugs for malaria.²¹ These results were similar to the previous studies that documented that children born to educated pregnant women and pregnant women with high wealth index who attend are less likely to weigh less than 2.5kg than other pregnant women.^{32,65} Prominently, in this research, the results are robust to adjustment for the socio-demographic characteristics of the recruited pregnant women. They revealed that marital status increased the odds of LBW. It was found that pregnant women who were married or living with the cohabitants were 1.9-times likely to have LBW compared with pregnant women who were single. They also revealed that the pregnant women who divorced or separated had 1.7-greater risks to have newborns who weigh less than 2.5 kg. These results

Table 3. Multivariate logistic regression for the risk factors associated with low birth weight.

Characteristics	Low birth weight	Adjusted odds ratio	95% CI	p-value
	Percent			
Type of residence				
Urban	16.4	1		
Rural	83.6	1.1	0.7-1.6	0.008*
Maternal education				
Illiterate	15.1	1		
Primary/vocational	73.1	1.01	0.7-1.5	<0.001**
Secondary/higher	11.8	0.99	0.6-1.8	<0.001**
Maternal age				
15-19	2.6	1		
20-34	74.7	0.8	0.4-1.5	0.428
35-49	22.7	0.8	0.4-1.5	0.467
Provided Tetanus injection during pregnancy				
Yes	89.3	1		
No	10.7	1.3	0.8-2.1	0.037*
Body Mass index (BMI)				
≤18.5 kg/m ²	80.2	1		
18.5-25.9kg/m ²	13.1	0.9	0.4-2.3	0.008*
≥25kg/m ²	6.7	0.5	0.2-1.1	0.005*
Maternal height				
Less than 160cm	40.8	1		
160cm and more	59.2	0.5	0.2-1.2	0.11
Smoking during pregnancy				
Yes	3	1		
No	97	0.3	0.1-0.6	0.002*
Maternal weight				
<80kg	43.7	1		
80-89kg	29.1	0.4	0.1-1.1	0.003*
≥90kg	27.2	1.7	0.8-3.5	0.03*
Utilization of Antenatal care services				
4 ANC and more	34.5	1		
No and less than ANC	65.5	2.8	1.5-5.4	0.002*
Parity for pregnant women				
1-2	10.7	1		
3-4	73.8	0.5	0.2-1.1	0.2
≥5	15.5	0.7	0.4-1.4	0.041
Family size				
Less than 6	64.8	1		
6 members and more	35.2	1.02	0.8-1.4	0.918
Household Wealth Index				
Poor	51.5	1		
Middle/rich	48.5	0.9	0.6-1.4	0.728

Table 3. *Continued*

Characteristics	Low birth weight	Adjusted odds ratio	95% CI	p-value
	Percent			
Anemia				
Not anemic	84.4	1		
Anemic	15.6	3.5	1.5-8.6	<.001*
Marital status				
Single	15.5	1		
Married/cohabited	75.5	1.9	1.3-2.8	0.002*
Widowed/separated/divorced	9.0	1.6	1.1-2.5	0.015*
During pregnancy, not given coartem for malaria				
No	86.3	1		
Yes	13.7	0.6	0.4-0.8	<0.001*
During pregnancy, no drug for malaria taken				
No	16.5	1		
Yes, no drug taken	83.5	0.3	0.1-0.8	0.018*
During pregnancy, provided counseling about nutrients				
Yes	55	1		
No	45	2.5	2-8.4	<0.001*
Place of delivery				
Household	3.5	1		
Public hospitals	38.4	1.03	0.2-4.8	0.969
Health center	56.1	0.3	0.2-0.7	0.002*
Privates	2	0.3	0.2-0.6	<0.001*
Sex of child at birth				
Male	44.3	1		
Female	55.7	0.8	0.62-1.16	0.293
Provided tetanus injection during pregnancy				
No	15.2	1		
Yes	84.8	0.3	0.8-2	0.337
Antenatal care visits at health center				
No	3.2	1		
Yes	96.8	1.9	0.9-4.1	0.109
In pregnancy, consumption of recommended dose of Iron and folic acid				
No	79.2	1		
Yes	20.8	0.5	0.3-0.9	0.015*
Told about complications during pregnancy				
Yes	81.1	1		
No	18.9	3.3	1.5-6.6	0.003*
Health care access				
No	12.5	1		
Yes	87.5	0.7	0.5-1	0.05*
Household head				
Male	76.6	1	1	
Female	23.4	1.1	0.8-1.6	0.519

Notice: * Indicates statistical significance at p-value <0.05; ** Indicates significance at 0.01, Unmarked p-values were not found to be the significant risk factors of LBW in Rwanda.

challenged the previous studies that indicated that pregnant women who were single had a greater risk of having LBW children than others.^{52,66,67}

Newborns whose mothers were had normal BMI (18.5–24.9 kg/m²) and mothers who were overweight (or obese;) were less likely to have new-born with LBW when compared to those mothers who were underweight. This result is consistent with the earlier research carried out in Uganda.⁶⁸ Newborns of women who smoke during pregnancy had low birth weight when compared with babies whose mothers did not smoke during pregnancies. Our findings are in congruence with the studies conducted in Tanzania.⁶⁹ Mothers from rural areas had 1.1 times greater risks of having an LBW newborn than those residing in urban settings. Mothers with secondary and higher education were less likely to have an LBW newborn than those who were illiterate. Our results concur with the earlier studies that established that the residence of pregnant women, HWI, family size, maternal age, utilization of tetanus injections and iron tablets consumption are factors of LBW.^{42,69}

Maternal anemia was identified as a risk factor, where we found that pregnant women with anemia had 3.5- times greater odds of delivering a newborn who weighed less than 2.5 kg than those who are not anemic. This result is in line with the prior studies conducted in Nigeria.⁵² The mothers who were not provided health counseling and education about nutrients were 2.5-times more likely to have LBW newborns than those who received nutritional counseling and education during ANC visits. The mothers who were not informed about maternal complications had 3.3-times greater risks of having newborns who weighed less than 2.5 kg than those who received information about health complications during pregnancy. Mothers with a weight at delivery greater than 80 kg were more likely to deliver newborn with LBW than the mothers who weighed less than 80 kg. This result is not in line with the previous studies carried out in Ethiopia.⁷⁰ The findings of this study did not reveal a significant association between maternal age, parity, HWI, sex of child, family size and LBW, however, the prior studies conducted in sub-Saharan African countries confirmed a significant association between maternal age, parity, sex of child, HWI, and LBW.^{52,70}

Strengths and limitations

The present research has numerous prominent strengths. The first strength is that the RDHS 2014/2015 used the validated and standardized tools for interviewing the eligible participants. Second, the research data about birth weight that we used were obviously verified through records and recall bias was prevented. However, several limitations also warrant discussion. First, it was limited to a study design that did not actually explore for modifiable factors of ANC visits, such as HIV status of pregnant women, maternal gestational age, prenatal depression, receiving the supplementary vitamins (like vitamin A) during the pregnant period, maternal weight gain during pregnancy, eclampsia, gestational diabetes, high blood glucose level during pregnancy, antiretroviral (ART) for HIV-positive women and reducing transmission of HIV from pregnant mother to child. Second, birth weight data was available for only babies whose weight was measured at birth. This limited us for estimating the real prevalence. Third, the selection bias resulted in the underestimation of the association between ANC and birth weight. This was because not all babies' weight was measured. The other limitation was that the qualitative aspects data from the participants was not included for exploring some factors and to triangulate the findings of the quantitative methods used. Additionally, as the methods used for measuring birth weight were not validated by the survey team, the misclassification could occur in this research. As we do not know the exact timing of the birth weight measurement, this causes misclassification.

Conclusion

In conclusion, this study found several risk factors of LBW in Rwanda that remains a national public health concern. However, ANC services for pregnant women are a fundamental intervention for reducing LBW. This integral part of primary health care, ANC services, is the population-based intervention that reduces the risk to deliver the newborn with LBW. Therefore, there is a need of a multifaceted approach for addressing the factors of LBW through reinforcing ANC coverage and quality of ANC services for pregnant women. Information on anthropometric measurement and increased awareness of the importance of regular ANC visits is also desirable. Attending four or more ANC visits is a step toward improving maternal health by providing maximum required packages and this strategy reduces the risk to LBW. The policy makers and researchers should prioritize maternal education and families with low socio-economic status for preventing LBW in Rwanda.

We recommend further research be conducted on the risk factors of macrosomia in Rwanda. Additionally, further study to explore the barriers to access ANC visits effectively for pregnant women from the rural settings is recommended. In the meantime, pregnant women in Rwanda are required to attend ANC visits appropriately and regularly for benefiting from the required packages that increase the probability to attenuate the LBW among the newborns. We recommend to measure birth weight immediately after birth for reducing the recall bias and misclassification.

Data availability

Underlying data

Underlying data for 'Regular antenatal care visits were associated with low risk of low birth weight among newborn in Rwanda: Evidence from the 2014/2015 Rwanda Demographic Health Survey (RDHS) Data was owned by the DHS program that can be obtained from <https://dhsprogram.com/methodology/survey/survey-display-468.cfm>.

The electronic data is available from the DHS program under its terms of use. Before downloading the data, the main author of this study registered as DHS user for reasons laid out on the DHS program website and dataset access was only granted for legitimate purpose of this research.

Authors' contributions

EB conceptualized the study, did study design, formal analysis, wrote the protocol, requested the permission from the DHS website, drafted the manuscript and coordinated the study. SH contributed to data analysis, data curation and methodology. DR substantially contributed to the conceptualization. He also wrote the original draft preparation. He revised and reviewed the manuscript, and searched the relevant journal to which the study is submitted. HE reviewed and edited the study. All investigators approved the final manuscript. They also agreed to take responsibility and be accountable for the content of the manuscript. All of them agreed on all versions of the manuscript before submitting it in the international journal. They also agreed on the final version accepted for publication.

Ethics and consent to participate

The present study was exempt from searching the ethical approval because the RDHS 2014/15 obtained the ethical approval from the Institutional Review Board (IRB) of the Rwanda National Ethics Committee (RNEC).

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Sarmila Mazumder

Society for Applied Studies, New Delhi, India

This is an important domain and the paper reiterates the importance of antenatal care. However, this is a rather simplistic view of a complex issue. Few points to consider:

1. The focus of the manuscript is on the number of ANC visits and not on the quality, content, examination, investigations, ultrasound, or respectful care, ability to identify/manage or refer high risk pregnancies, etc. The underlying assumption is that these are optimum at the ANC sources. In that case, information on the same needs to be provided.
2. Additionally, just the number of ANC visits is not enough, gestational age when the pregnant women was first registered, the timeliness of the ANC visits going by the 4 ANC norm, that is, one in the first trimester, 1 in the second trimester and 2 in the third trimester, are equally important.
3. The ANC standard needs mention, there are women with 7 ANCs. Is the 2016 WHO ANC guideline being implemented at the study site? In that case is the rationale of 4 ANC as a cut-off based on minimum ANC visits? Need clarity.
4. Specific issues: How were the 8004 women selected? It is mentioned that those women who had documented birth weight were interviewed. The sampling method says 2 stage cluster sampling and random selection. In that case the selection of women seems purposive, this needs clarity.
5. This is a retrospective data collection, where women with youngest child less than 5 years were interviewed. It will be important to mention that all records on birth weight, number of ANC visits, measurement of BP, administration of antimalarial drug, height, weight and BMI, etc were available. Recall bias cannot be ruled out unless good documentation was available.
6. At which stage was BMI measured? Pre-pregnancy or early first trimester? This will be important to document.

7. Gestational weight gain is an essential component of ANC, this is not specified.
8. It is not clear why BP measurement and antimalarials are considered as confounders.
9. Tables do not have N (total number, denominators). Table 1 needs explanation. The sample size was 8004 women but in table 1, the numbers do not add up to 8004. it varies with each variable. There is no information on the number of births. It would be informative to know about preterms, SGA, AGA as well.
10. The information on availability of birth weight is a little confusing. 92% reported birth weight, were these documented on discharge reports or verbally reported. Additionally, the low birth weight does not seem to be a major issue, with only 5.8% low birth weight while 18% macrosomia.
11. Some information would be useful to present. 99% women attended ANC clinic but 44% had 4 ANC's. A qualitative component would have been helpful to understand the barriers to low utilization.
12. The discussion section needs strengthening, it is repetition of the previous section. Some of the findings could have been analyzed, for eg., explore further how was home delivery associated with LBW. The places of ANC, pros and cons, etc. have not been discussed.
13. Typographical error, table 2, 7th row, last column. 0.0.3.
14. The authors need to match the numbers in the tables and text.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Maternal and child health

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 10 Oct 2022

Emmanuel Biracyaza, University of Rwanda, Kigali, Rwanda

This is an important domain, and the paper reiterates the importance of antenatal care. However, this is a rather simplistic view of a complex issue. Few points to consider:

Response: Dear reviewer, thank you very much for these kind words and crucial suggestions and recommendations for improving our study that was submitted in the f1000research.com. All the point you raised so that we can improve our study have been relevant and they helped us to continue looking our further investigation. Frankly, the ANC contacts remains at a very low level (less than 1%) which represents pregnant women who attended 8 ANC contacts. This is similar to the other countries of the same region (SSA) or LMICs.

The focus of the manuscript is on the number of ANC visits and not on the quality, content, examination, investigations, ultrasound, or respectful care, ability to identify/manage or refer high risk pregnancies, etc. The underlying assumption is that these are optimum at the ANC sources. In that case, information on the same needs to be provided.

Responses: Thank you for the recommendations that are important. We totally agree with you about the focus of this work. But these variables about ultrasound, respectful care and risk pregnancies etc. were not found in the RDHS and we cannot change the dataset. But we recommend that the further studies can investigate and include such variables. In our data analysis, we included socio-demographic, nutritional variables, maternal and individual variables. But we did not find that the information about ultrasound or respectful care etc., however, we know how they are important in the ANC contacts.

Additionally, just the number of ANC visits is not enough, gestational age when the pregnant women was first registered, the timeliness of the ANC visits going by the 4 ANC norm, that is, one in the first trimester, 1 in the second trimester and 2 in the third trimester, are equally important.

Responses: We thank you for this essential observation and suggestion. We have checked and corrected according to the suggestions provided. Variables such as gestational age were added. But about the ANC visits, we found that majority of the attended 4-7 ANC while only 1% attended 8 recommended ANC contacts by the 2016 WHO but we have recommended the decision makers to encourage the pregnant women to attend the ANC visits as recommended by WHO. The main challenge was that the utilisation of 8 ANC visits is at low level and this could limit us in the data analysis.

The ANC standard needs mention, there are women with 7 ANC. Is the 2016 WHO ANC guideline being implemented at the study site? In that case is the rationale of 4 ANC as a

cut-off based on minimum ANC visits? Need clarity.

Responses: The cut-off of used is the 4 ANC visits as recommended by the WHO due to the evidence provided above. We wrote an unintentional in our previous version and this created the mismatch in the first version. We notice that the attendance of the ANC as required remains a public health concern in Rwanda as one of SSA countries which remain with such concern that has to be solved through multidisciplinary team. Specific issues: How were the 8004 women selected? It is mentioned that that women who had documented birth weight were interviewed. The sampling method says 2 stage cluster sampling and random selection. In that case the selection of women seems purposive, this needs clarity.

Responses: Thank you as the study used secondary study (dataset from DHS), we did not conduct the data collection with direct contact with the women. But the RDHS indicates that the women were interviewed. The sample size was clearly indicated (7381 women who fit the inclusion criteria). We only included the women who provided information about the birth weight (they were only 7381) while 8004 was for the women who gave birth. Of course, if we take 8004-7381, we directly find the number of those who did not provide birth weight for their babies.

This is a retrospective data collection, where women with youngest child less than 5 years were interviewed. It will be important to mention that all records on birth weight, number of ANC visits, measurement of BP, administration of antimalarial drug, height, weight and BMI, etc were available. Recall bias cannot be ruled out unless good documentation was available.

Response: Thank you for this recommendation that has helped us to improve our study. We included your recommendations and clarified the above-mentioned part.

At which stage was BMI measured? Pre-pregnancy or early first trimester? This will be important to document.

Response: This was documented in the study. BMI as an important anthropometric indicator for pregnant women and can have a crucial effect on weight of child was measured at early first trimester (when the pregnant women attended the 1st ANC contact).

Gestational weight gain is an essential component of ANC, this is not specified.

Responses: Thank you. The gestational age was added in the analysis; however, gestational diabetes was not included because of having several missing information.

It is not clear why BP measurement and antimalarials are considered as confounders.

Responses: We have corrected according to your recommendations. By analysing the multicollinearity, we found that the variables such as variables related to malaria and BP inflated with the birth weight. As results, we removed them from the analysis and we remained with the good variables that presented the variables, which seemed to be equal (near to 1). But the removed ones had more than 3 values of VIF.

Tables do not have N (total number, denominators). Table 1 needs explanation. The sample size was 8004 women but in table 1, the numbers do not add up to 8004. it varies with each

variable. There is no information on the number of births. It would be informative to know about preterms, SGA, AGA as well.

Responses: All the tables were appropriately corrected. The mismatching was because we shared the wrong table. This impact in the interpretations. About the above variables such as AGA, preterms, and SGA; they had several missing variables. So, that is why we did not include them in the analysis.

The information on availability of birth weight is a little confusing. 92% reported birth weight, were these documented on discharge reports or verbally reported. Additionally, the low birth weight does not seem to be a major issue, with only 5.8% low birth weight while 18% macrosomia.

Responses: Thank you very much for this but for the developing country like Rwanda, the prevalence of about 6% for LBW may be a public health burden if the further strategies to promote health for the pregnant woman and the newborns.

Some information would be useful to present. 99% women attended ANC clinic but 44% had 4 ANC's. A qualitative component would have been helpful to understand the barriers to low utilization.

Responses: Thank you for these important recommendations. The qualitative study design was recommended based on our results. This can be found in the strengths and further directions.

The discussion section needs strengthening, it is repetition of the previous section. Some of the findings could have been analyzed, for e.g., explore further how was home delivery associated with LBW. The places of ANC, pros and cons, etc. have not been discussed.

Responses: The discussion was also modified and of course improved due to your recommendations.

Typographical error, table 2, 7th row, last column. 0.0.3.

Responses: This typo error and grammatical errors were corrected.

The authors need to match the numbers in the tables and text.

Responses: We kindly thank you for these recommendations. We have matched the results from the tables and texts.

Thank you very much.

Competing Interests: No conflict of interest

Reviewer Report 04 August 2022

<https://doi.org/10.5256/f1000research.55185.r144427>

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Manoja Kumar Das

The INCLEN Trust International, New Delhi, Delhi, India

The article presents the prevalence of LBW and the risk factors for the same in Rwanda using the RDHS 2014/15 data.

The manuscript needs attention in some sections:

1. Methods

1.1 Macrosomia definitions should be mentioned

2. Results

2.1 The following statements need review and clarification.

"For marital status, married and cohabiting pregnant women were 1.86-times at greater risk to have LBW children [aOR=1.9; 95%CI (1.3–2.8), p=0.002] compared with single pregnant women."

"The results indicated that the widowed, separated and divorced pregnant women had 1.7-times greater risk of having LBW babies [aOR=1.7; 95%CI (1.1–2.5), p=0.015] than women who were single during pregnancy."

The two statements are in conflict. Please check.

2.2. The statement "Results found that being provided maternal iron and folic acid supplementation during pregnancy [aOR=0.5, 95%CI (0.3–0.9), p=0.015], not being given nutrients during pregnancy [aOR=2.5, 95%CI (2–8.4), p<0.001], being told about maternal complications during pregnancy [aOR=0.7...."

How was the nutrient given assessed?

3. Discussion

3.1. Please check the statements and discuss

"They revealed that marital status increased the odds of LBW. It was found that pregnant women who were married or living with the cohabitants were 1.9-times likely to have LBW compared with pregnant women who were single. They also revealed that the pregnant women who divorced or separated had 1.7-greater risks to have new-borns who weigh less than 2.5 kg."

This statement needs to be examined carefully, whether the factor responsible was crowding, low SES and undernutrition or hunger.

4. Limitations

4.1 The limitations should mention the qualitative nature of the risk factors captured in the RDHS, like iron intake and duration, nutrition intake, maternal anemia and malnutrition status, which influence the birth weight.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Child health, public health

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 10 Oct 2022

Emmanuel Biracyaza, University of Rwanda, Kigali, Rwanda

Reviewer 2

First of all, I thank you for the valuable points you raised for us. They have of course and prominently helped us to strengthen our study.

The article presents the prevalence of LBW and the risk factors for the same in Rwanda using the RDHS 2014/15 data.

Response: Thank you very much for this appreciation.

The manuscript needs attention in some sections:

1. Methods

1.1 Macrosomia definitions should be mentioned

Responses: Thank you very much for the recommendations. The concept macrosomia was also defined in the first paragraph of the background of the study. It was defined as when a baby is born with more than 4 kilograms (or 4000 grams).

2. Results

2.1 The following statements need review and clarification.

"For marital status, married and cohabiting pregnant women were 1.86-times at greater risk to have LBW children [aOR=1.9; 95%CI (1.3–2.8), p=0.002] compared with single pregnant women."

Response: This sentence was rephrased and improved.

"The results indicated that the widowed, separated and divorced pregnant women had 1.7-times greater risk of having LBW babies [aOR=1.7; 95%CI (1.1–2.5), p=0.015] than women who were single during pregnancy."

The two statements are in conflict. Please check.

Responses: This sentence was rephrased and improved

2.2. The statement "Results found that being provided maternal iron and folic acid

supplementation during pregnancy [aOR=0.5, 95%CI (0.3–0.9), p=0.015], not being given nutrients during pregnancy [aOR=2.5, 95%CI (2–8.4), p<0.001], being told about maternal complications during pregnancy [aOR=0.7...."

How was the nutrient given assessed?

Responses: This statement was also improved after adjusting some analyses due to the required analysis from the other reviewers.

3. Discussion

3.1. Please check the statements and discuss

"They revealed that marital status increased the odds of LBW. It was found that pregnant women who were married or living with the cohabitants were 1.9-times likely to have LBW compared with pregnant women who were single. They also revealed that the pregnant women who divorced or separated had 1.7-greater risks to have new-borns who weigh less than 2.5 kg."

Responses: In discussion section, we improved this part, and we changed the statement as recommended by the reviewer.

This statement needs to be examined carefully, whether the factor responsible was crowding, low SES and undernutrition or hunger.

Responses: Thank you very much the factors such as SES and undernutrition (based on wasting, underweight, stunting and obesity) were also explored.

4. Limitations

4.1 The limitations should mention the qualitative nature of the risk factors captured in the RDHS, like iron intake and duration, nutrition intake, maternal anemia and malnutrition status, which influence the birth weight.

Responses: Thank you very much for these recommendations; and we included the recommendation that further studies could also be conducted using qualitative methods for exploring the perspectives from the pregnant women about the factors that influence their attendance of ANC and the benefits from attending ANC services on child weight at birth. So, we believe that the women can be experts in this qualitative exploration.

Thank you very much for your prominent recommendations that have helped us to improve our study.

Competing Interests: No competing interest.

Reviewer Report 22 November 2021

<https://doi.org/10.5256/f1000research.55185.r98487>

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M. Mazharul Islam

Department of Statistics, College of Science, Sultan Qaboos University, Muscat, Oman

The paper addressed a very important issue of public health. The findings of the paper are likely to contribute in literature of the impact of antenatal care on birth weight. However, I have some observations, which are given below.

1. In the Introduction section, page 3, the authors stated that WHO recommended four or more ANC visits during pregnancy, which is a dated recommendation. Perhaps, the authors are referencing 2001 WHO recommended schedule of 4 ANC visits (Villar *et al.*, 2001). However, in 2016 WHO revised its recommendation and prescribed 8 or more visit schedules (see WHO (2016). WHO recommendations on antenatal care for a positive pregnancy experience.
<https://apps.who.int/iris/bitstream/handle/10665/250796/9789241549912-eng.pdf>). The authors defined the main explanatory variable (no or less than 4 ANC and ≥ 4 ANC) based on the old schedule of ANC. Considering the low average frequency of ANC visits in Rwanda, I am not claiming that the analysis is wrong, but not mentioning the latest development is a clear oversight. The authors should discuss the compliance of 8 or more ANC visits in Rwanda.
2. Under sampling design, page 4, the authors wrote: "current birth weights were not available for the most children", which contradicts the last line of the paragraph stating that "It was found that 92% of newborns had a birth weight reported while 8% did not."
3. The authors should provide clear information about the total number of births considered in the study, of whom birth weights were available for how many or what proportion of births. Among the children with birth weights, what proportion of birth weights was obtained from mothers' recall and what proportion from written information. What was meant by written information? Is it birth certificates or health cards?
4. The most important information which is missing in this study is the total sample size of the study population. In one place, the authors mentioned about 8,004 mothers of reproductive age, but the distribution of the mothers provided in column 2 of Table 1 does not reflect that. What are these numbers in column 2 of Table 1 and why there is a wide variation in number across the variables?
5. In page 6, under the Results section of Multiple logistic regression analysis: There are a lot of mistakes. Most of the aORs and the 95% CIs given within parenthesis do not correspond with the results presented in Table 3.
6. The discussion section has been written very poorly, as it is mostly a repetition of the description of the findings without providing any explanations or possible implications of their findings. To validate their results, the authors just wrote "the results are consistent or similar or corroborate with findings of other study" without providing any numerical evidence how their findings are consistent with other studies.
7. There is a methodological problem in the application of multiple logistic regression analysis to the real data considered in this study. One of the basic assumptions of the regression model is that the explanatory variables are independent. However, in this study, all the selected explanatory variables are not independent. For example, maternal height and

weight are linearly dependent, and they are also related to body mass index (BMI) because $BMI = \text{weight}/\text{height}^2$. Violation of the assumption of independence creates a serious problem in statistical analysis, which is known as multicollinearity problem, resulting in biased results. While applying regression model, the researchers should be careful about multicollinearity problem. The authors did not provide any information about the goodness of fit of the model and adequacy of the fitted model. The author should redo the multiple regression analysis by removing the suspected inter-correlated variables.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 10 Oct 2022

Emmanuel Biracyaza, University of Rwanda, Kigali, Rwanda

The paper addressed a very important issue of public health. The findings of the paper are likely to contribute in literature of the impact of antenatal care on birth weight. However, I have some observations, which are given below.

In the Introduction section, page 3, the authors stated that WHO recommended four or more ANC visits during pregnancy, which is a dated recommendation. Perhaps, the authors are referencing 2001 WHO recommended schedule of 4 ANC visits (Villar et al., 2001). However, in 2016 WHO revised its recommendation and prescribed 8 or more visit schedules (see WHO (2016). WHO recommendations on antenatal care for a positive pregnancy experience.

<https://apps.who.int/iris/bitstream/handle/10665/250796/9789241549912-eng.pdf>).

Responses: Thank you very much; we found that there was an typing error since in our

study, we used expected to use the recent recommendations of the WHO that recommend 8 ANC visits for the pregnant women. But when we realised that it could not be possible to assess it because the prevalence of using 8 recommended ANC contacts was low in Rwanda (less than 1%). So, in the study limitations and conclusions we tried to mention it and then recommend the policy makers to encourage pregnant women to respect the respected ANC contacts.

The authors defined the main explanatory variable (no or less than 4 ANC and ≥ 4 ANC) based on the old schedule of ANC. Considering the low average frequency of ANC visits in Rwanda, I am not claiming that the analysis is wrong, but not mentioning the latest development is a clear oversight. The authors should discuss the compliance of 8 or more ANC visits in Rwanda.

Responses: Thank you very much. As indicated in the work, we considered the 8 ANC visits as recommended by 2016 WHO. So, the problem was in the first table where we shared the wrong table, but we effectively corrected it and then provided the appropriate table.

Notice. For the case of 2016 WHO recommendations, you can also refer to the following publications to indicate you how the ANC remains very low:

1. Sserwanja, Q., Nuwabaine, L., Gatasi, G. *et al.* Factors associated with utilization of quality antenatal care: a secondary data analysis of Rwandan Demographic Health Survey 2020. *BMC Health Serv Res* **22**, 812 (2022). <https://doi.org/10.1186/s12913-022-08169-x>
2. Rurangirwa, A.A., Mogren, I., Ntaganira, J. *et al.* Quality of antenatal care services in Rwanda: assessing practices of health care providers. *BMC Health Serv Res* **18**, 865 (2018). <https://doi.org/10.1186/s12913-018-3694-5>

Under sampling design, page 4, the authors wrote: "current birth weights were not available for the most children", which contradicts the last line of the paragraph stating that "It was found that 92% of newborns had a birth weight reported while 8% did not."

Responses: We edited the sentence after noticing that what you have observed. We decided to remove it because we found it was not necessary. Thus, the last line of the paragraph was really enough.

The authors should provide clear information about the total number of births considered in the study, of whom birth weights were available for how many or what proportion of births. Among the children with birth weights, what proportion of birth weights was obtained from mothers' recall and what proportion from written information. What was meant by written information? Is it birth certificates or health cards?

Responses: We thank you very much for this suggestion. Normally, after we recheck our dataset and remove missing variables, we also tried to indicate the corrected number of the births and pregnant women. Please, note that we only used the data of the women who provided the number weight of their newborns at birth. the women who were of out of this major inclusion criteria were removed from the analyses (therefore, our study was conducted among 7381 women).

The most important information, which is missing in this study, is the total sample size of the study population. In one place, the authors mentioned about 8,004 mothers of

reproductive age, but the distribution of the mothers provided in column 2 of Table 1 does not reflect that. What are these numbers in column 2 of Table 1 and why there is a wide variation in number across the variables?

Responses: Thank you very much for this observation about mismatching of the totals for the table 1. We included the corrected table. In addition to that, the sample size was 7381 women who provided the weight of their babies. They were recruited from 8004 women who delivered and 30058 individuals for the participants of this dataset in which we used. In page 6, under the Results section of Multiple logistic regression analysis: There are a lot of mistakes. Most of the aORs and the 95% CIs given within parenthesis do not correspond with the results presented in Table 3.

Responses: We thank you for this observation. We have corrected the interpretations since the information provided in the table was correct. Improved interpretations of the results were also made.

The discussion section has been written very poorly, as it is mostly a repetition of the description of the findings without providing any explanations or possible implications of their findings. To validate their results, the authors just wrote "the results are consistent or similar or corroborate with findings of other study" without providing any numerical evidence how their findings are consistent with other studies.

Responses: Regarding the discussion, we have importantly made the revisions and changes based on the major results from the section results.

There is a methodological problem in the application of multiple logistic regression analysis to the real data considered in this study. One of the basic assumptions of the regression model is that the explanatory variables are independent. However, in this study, all the selected explanatory variables are not independent. For example, maternal height and weight are linearly dependent, and they are also related to body mass index (BMI) because $BMI = \text{weight}/\text{height}^2$. Violation of the assumption of independence creates a serious problem in statistical analysis, which is known as multicollinearity problem, resulting in biased results. While applying regression model, the researchers should be careful about multicollinearity problem. The authors did not provide any information about the goodness of fit of the model and adequacy of the fitted model. The author should redo the multiple regression analysis by removing the suspected inter-correlated variables.

Responses: Thank you for these recommendations. To manage the issues of methods, we did again the analysis part and we found the new results with some differences. So, we really have computed the goodness of fit for the multivariate logistical model. Multicollinearity was assessed using VIF and as a result several variables that inflated were directly removed from models for avoiding overestimation or underestimations. We really found that the removed variables negatively impacted some variables because some of the remaining variables became significantly associated while others were not. But we observed crucial improvements.

Competing Interests: No competing interests were disclosed.

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