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# Disparities in health and nutrition between semi-urban and rural mothers and birth outcomes of their newborns in Bukavu, DR Congo: a baseline assessment

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**Abstract**

*Aim:* This research aimed to evaluate health and nutritional practices of mothers during pregnancy and birth outcomes of their newborns in Bukavu, Democratic Republic of the Congo (DRC), comparing semi-urban and rural areas. *Background:* Health and nutrition during pregnancy are crucial for adequate development of the fetus. Health care plays an important role but is often poor in rural areas of developing countries. *Methods:* A baseline survey of a nutritional follow-up study was conducted in two semi-urban and one rural hospital in the vicinity of Bukavu, DRC. In total, 471 mother-child pairs were recruited after delivery. Data collection included socio-demographic parameters, nutrition and health measures during pregnancy, and anthropometric parameters. Semi-urban and rural study locations were compared and predictors of birth weight evaluated. *Findings:* Semi-urban and rural mothers differed significantly in nutrition and health practices during pregnancy, as well as birth outcomes. In the rural area, there was a higher rate of newborns with low birth weight (10.7%) and lower rates of antimalarial medication (80.8%), deworming (24.6%), consumption of nutritional supplements (81.5%), and being informed about nutrition by medical staff (32.8%) during pregnancy as well as practicing family planning (3.1%) than in the semi-urban areas (2.7%, 88.6%, 88.3%; 89.3%, 46.5%, and 17.1%, respectively). Birth weight was positively predicted by increasing maternal MUAC, age, and gestational age and negatively by rural location, being primipara, being a farmer, and female newborn sex. *Conclusion:* The findings highlight the importance of strengthening antenatal care activities especially in rural areas in order to ameliorate both maternal and infantile health and ensure appropriate development.

## Introduction

In many countries, urban-rural disparities in health and nutritional status have been found in women and children (Jones *et al.*, 2016; Quansah *et al.*, 2016; Rutstein *et al.*, 2016; Global Nutrition Report, 2020). Regarding birth weight (BW), however, a pooled analysis of data from Sub-Saharan Africa did not associate the maternal place of residence with the occurrence of low birth weight (LBW) (Tessema *et al.*, 2021). Birth outcomes, such as birth weight, reflect maternal conditions during pregnancy and depict an important basis for health and nutritional follow-up of the newborn (Class *et al.*, 2014; Chasekwa *et al.*, 2022). Good health care, in particular antenatal care (ANC), has been associated with lower risk for adverse birth outcomes (Tamirat *et al.*, 2021). According to the World Health Organization (WHO), ANC should comprise nutritional interventions such as counseling on healthy nutrition during pregnancy and supplementation with iron and folic acid, maternal assessment including diagnostics of anemia and diabetes, preventive measures, for instance anthelmintic or antimalarial treatment in endemic areas, interventions for common physiological symptoms like nausea, and interventions regarding the health systems to ensure high quality (WHO, 2016).

In many countries, utilization of health services was found to be lower in rural compared to urban areas, including ANC and skilled birth attendance (Babalola and Fatusi, 2009; Joseph *et al.*, 2016; Kebede *et al.*, 2016; Amporfu and Grépin, 2019; Ali *et al.*, 2020; Samuel *et al.*, 2021; Woldeamanuel and Belachew, 2021). In remote areas, the next health facility might be far away, contributing to lower usage (Kebede *et al.*, 2016; Dotse-Gborgbortsi *et al.*, 2020). Another important predictor of lower use of health services is lower socio-economic status (Goli *et al.*, 2018; Noh *et al.*, 2019; Samuel *et al.*, 2021). Besides access to, the quality of health services may



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vary (Afulani, 2015; Moshi and Tungaraza, 2021) which can also contribute to their utilization (Gage et al., 2018; Gao and Kelley, 2019).

In the Democratic Republic of the Congo (DRC), care provided in ANC services has been reported to be lower in rural compared to urban areas (ESPK and ICF, 2019). Malnutrition is still an urgent issue in this country. The latest Demographic Health Survey (DHS) reported a high prevalence of the triple burden of malnutrition, with 14.4% of the women aged 15–49 years underweight while 16.0% were overweight or obese, and 38.4% were anemic (MPSMRM et al., 2014). The province South Kivu (SK) in the East of the country (capital city Bukavu) is an area of ongoing conflicts further worsening the situation and deteriorating food security. In SK, the prevalence of underweight was 7.2%, overweight and obesity 26.5%, and anemia 22.7% in women of reproductive age (MPSMRM et al., 2014). LBW was reported in 7.1% of the newborns in the DRC, in both urban and rural areas, and 11.0% in SK.

To our knowledge, there are no data about health and nutritional status of newborns and infants and their lactating mothers in semi-urban and rural areas around Bukavu. This nutritional study was conducted to evaluate the nutritional status of mother-infant pairs in Bukavu and identify addressors for improvement. The baseline assessment of the long-term follow-up study aimed to (1) describe the study population; (2) compare semi-urban and rural areas in terms of their living conditions, preventive measures during pregnancy, and nutritional and health outcomes; and (3) evaluate birth outcomes and influencing factors.

## Methods

### Study design

The presented data depict the cross-sectional baseline survey of a follow-up study that was conducted among mother-infant pairs in semi-urban and rural areas of Bukavu, Democratic Republic of the Congo (DRC) from December 2017 until June 2019. The study included four data collections and an intervention period between the third and fourth assessment with a subsequent qualitative survey (Figure 1). Results of the follow-up assessments will be published elsewhere.

### Study participants and sample size

Mothers were recruited after delivery in one of three hospitals Hôpital Général de Référence (HGR) Nyantende, HGR Ciriri, and HGR Nyangezi. In total, 471 mother-infant pairs participated in this study with 51 (10.8%) mothers having delivered in HGR Nyantende, 288 (61.1%) in HGR Ciriri, and 132 (28.0%) in HGR Nyangezi. HGR Nyantende and Ciriri are located in the rural catchment area of the city Bukavu and considered semi-urban hospitals while HGR Nyangezi is around 23 km south of Bukavu city located in a rural area.

The follow-up study aimed to assess the nutritional status of mothers and infants, as well as to evaluate the impact of nutritional interventions. Due to high anemia rates among women and young children in SK (MPSMRM et al., 2014), hemoglobin concentrations were chosen as primary indicators in the follow-up and intervention study and used as basis for sample size calculation. Differences in hemoglobin concentrations at endline between groups were assumed with 0.37 g/dl, standard deviation (SD) 0.6 g/dl (adjusted to Krafft et al., 2005). Based on Allen Jr. (2011), with a type 1 error probability at 0.05, statistical power at 90%, and an assumed drop-out rate of 20%, a sample size of 420 was calculated. Birth outcomes were secondary indicators of the overall study. In this study, SD of birth weight was 465 g. With type 1 error probability at 0.05, this study had a post hoc statistical power of 98.7% to detect a difference of 200 g in birth weight between groups, that is study locations (Dupont and Plummer, 2009).

### Study setting

The DRC, situated in Central Africa, is divided into 26 provinces. The population is poor with 70.5% living on less than 1.90 $/day in 2018 (Sachs et al., 2018). In the Global Peace Index, the country was ranked 156/163 (Institute for Economics and Peace, 2018). Especially in the eastern provinces such as South Kivu (SK), there has been increased violence and rebel activity, due to political instability and high numbers of internally displaced people (OCHA, 2017; Institute for Economics and Peace, 2018).

The DRC is divided into 516 health zones with 393 HGR, further subdivided into spheres of health with health centers (ESPK and ICF, 2019). The study was conducted in three health zones of SK, Kadutu (HGR Ciriri) with a population of 380 501 (2019), Nyantende (HGR Nyantende) with 140 313 inhabitants, and Nyangezi (HGR Nyangezi) with 165 925 inhabitants. All three health zones include nutritional units treating malnourished children and maternities in HGR and health centers (MSP, 2019; Sanru, 2020a, 2020b).

### Inclusion and exclusion criteria

Mothers delivering at the maternity ward in one of the selected hospitals and planning their follow-up appointments in one of the related health centers covered by the study were eligible for the study. Inclusion criteria were being aged 18–45 years, delivering a healthy, full-term, single newborn without severe congenital abnormalities, and the intention to breastfeed the newborn. Mothers were excluded if not living in the catchment health area, even if delivering in one of the study hospitals, delivering a premature or stillborn, suffering from any immunodeficiency disease such as HIV in the last stage, experienced severe complications during pregnancy, or being severely underweight as indicated by a mid-upper-arm circumference (MUAC) below 21 cm. Inclusion occurred on condition of written informed consent.

The intervention study required three groups of underweight, two groups of overweight, and one group of normal weight mothers (see Figure 1). Nutritional status of the mothers was defined by a MUAC for underweight ($\geq 21$ and $< 25$ cm), normal weight (MUAC $\geq 25$ and $< 28$ cm), and overweight (MUAC $\geq 28$ cm). MUAC cutoffs were based on measurements in a pilot phase. As the pilot phase revealed higher numbers of normal than under- and overweight mothers, every under- and overweight mother, but only every third normal weight mother was recruited until the required sample size was reached.

### Baseline assessment

Baseline assessment included anthropometrics, socio-demographic parameters, and nutrition and health factors during pregnancy and lactation. It was conducted during the first week postpartum at the respective hospitals. One mother-infant-pair was excluded from baseline analyses as assessment was done at day 17 after delivery. Interviews and anthropometric measurements were conducted by local health personnel in Swahili. Answers to open questions were translated via French to English.

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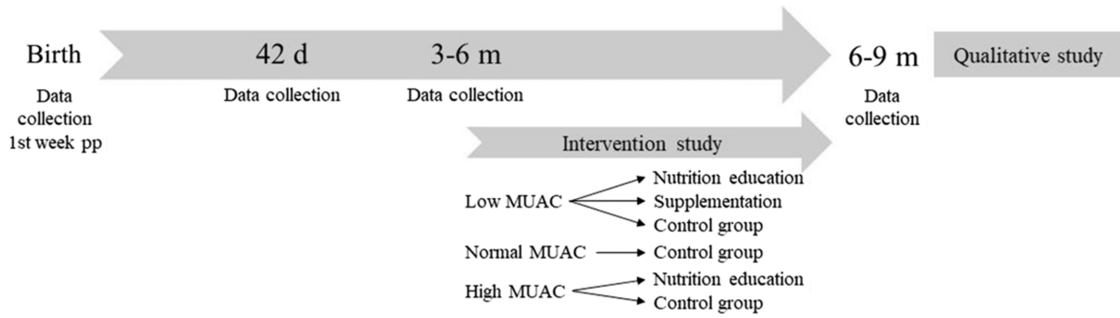


**Figure 1.** Study design

MUAC of both mother and infant and head circumference of the infant were measured by use of a non-stretchable measuring tape (seca 212) to the nearest millimeter by trained health personnel. Weight and recumbent length of the infants were measured with a digital baby scale (seca 336) and related analog measuring rod (seca 232) to the nearest 5 g and one millimeter, respectively. All measurements were taken twice, and the mean was calculated. In case of a difference of > 0.2 kg or > 0.2 cm, measurements were repeated. Birth weight (BW) was collected by mothers' and hospitals' reports. If no BW was available, it was estimated by use of the weight measured at baseline based on previous reports (Turner *et al.*, 2013; Carrara *et al.*, 2017). Details about delivery mode, time of clamping the umbilical cord, and other information linked to delivery or pregnancy were reported. Gestational age at birth was collected from hospital reports in completed weeks.

LBW was defined as BW below 2500 g according to the WHO (2015). Percentiles and *z*-scores of birth anthropometrics according to gestational age were calculated by use of the Neonatal Size Calculator based on the standards gained in the INTERGROWTH-21st Project (Villar *et al.*, 2014; INTERGROWTH-21st, 2017). Small-for-gestational age in either weight or length was defined as a *z*-score < -2. Weight-for-length *z*-score (WLZ), length-for-age *z*-score (LAZ), weight-for-age *z*-score (WAZ), body mass index (BMI), and BMI-for-age *z*-score (BAZ) were calculated using the WHO Anthro Software 3.2.2 and applying the WHO Child Growth Standards (WHO, 2006, 2010). According to WHO definitions, infant length below 38 cm was not considered and WLZ was not calculated for children with a length below 45 cm. *z*-scores outside the following ranges were excluded: LAZ –6 and +6, WAZ –6 and +5, and WLZ and BAZ –5 and +5. The same cutoffs were applied to anthropometric indicators according to gestational age. Outliers were examined but remained in the database if not part of the above-mentioned exclusions.

Socio-demographic parameters, household characteristics, health and nutritional aspects during pregnancy, issues of reproductive health, initiation of breastfeeding, planned infant feeding behavior, and nutrition during lactation were assessed by use of pre-tested structured questionnaires. Data on the lactation period will be published elsewhere. Relationships of interest between residence, socio-demographic, and health/nutrition parameters are shown in Figure 2.

## Statistics

Statistical analyses were performed using the Statistical Package for Social Sciences, version 27.0 (SPSS Inc., Chicago, IL, USA). Descriptive data are displayed as number and percentage (*n* (%)) for categorical and mean and standard deviation (mean ± SD)/ median and interquartile range (IQR) for continuous data.

Associations between maternal and/or infantile characteristics and study location (semi-urban versus rural) were investigated. To acknowledge the unequal numbers of hospitals, associations between the two semi-urban hospitals were also analyzed and are presented in the supplementary material (Tables S1-S7). Categorical data were compared by chi-square test and Fisher's exact test, at an expected cell count < 5. Effect size is reported as Cramér's V. In multiple response questions, the answers were analyzed individually. Additionally, significance of the whole question was evaluated by Bonferroni adjustment. Means were compared across groups using *t*-test or Mann-Whitney *U* test for skewed data. The effect size for t-test was Cohen's *d*; for Mann-Whitney *U* test, it was estimated by $r = z/\sqrt{N}$ (Rosenthal, 1991). Homogeneity of variances was examined with a Levene test. Normal distribution was evaluated with histograms and Kolmogorov-Smirnov and Shapiro-Wilk tests. Kendall's tau correlation was used for analysis of associations between continuous data. Simple linear regression and multiple linear regression with a backward approach were computed. Normal distribution of residuals, homoscedasticity, and multicollinearity were evaluated with histograms, P-P- and Q-Q-plots, scatterplots of standardized residuals against standardized predicted values, correlation coefficients, VIF, and tolerance, respectively.

Answers were excluded from analyses for the respective question as missing values if the mother did not know any answer (except for knowledge-related questions), did not answer, question was not applicable (for follow-up questions), or answer was missing. Anthropometric values were excluded as explained above. Total number of valid answers is given, and number of missing values and reasons for omission are given in the supplementary material (Tables S8-S14).

Simple linear regression was used to evaluate predictors of birth weight and birth weight per gestational age *z*-score (dependent variables). Categorical variables were evaluated by dummy coding in a multiple regression analysis, and answer options of multiple response questions were analyzed individually. Selection of independent variables was led by Figure 2, based on literature: socio-demographic parameters and living conditions, maternal characteristics, pregnancy-related conditions including nutrition, gestational age, and infant's sex (see Supplementary Table S15 for details). Multiple linear regression included predictors with $P < 0.100$ in simple linear regression and events being prevalent in at least 5% of the study population (for categorical variables). In case of highly correlated variables, only one was selected for multiple regression analysis. Statistical significance was set at $P < 0.05$.

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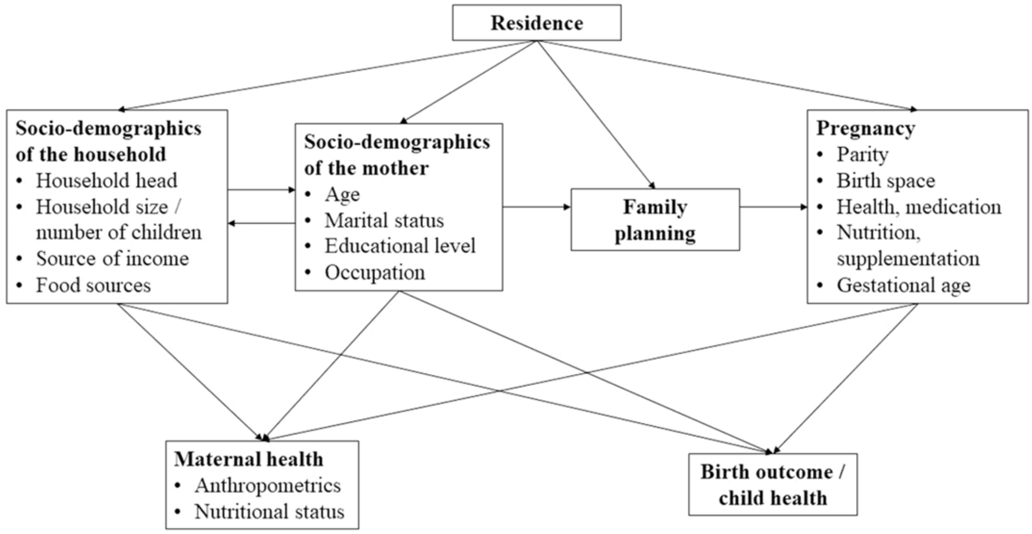


**Figure 2.** Conceptual framework on the relationship of socio-demographics and health/nutrition factors

## Results

### Socio-demographic and household characteristics

Median age of the mothers was 26 years with the majority being younger than 30 years (66.7%). Nearly all mothers were Christians (96.8%) and living with a partner (98.0%). A higher proportion of mothers delivering in the rural hospital and the semi-urban HGR Nyantende were farmers, while in the semi-urban HGR Ciriri, more mothers were without formal employment or conducting small business. Infantile participants were on average three days old at assessment. Their sex was equally distributed with 49.1% males and 50.9% females (Table 1, S1).

Concerning the households, median household size was six persons, and they were mostly led by male family members (97.7%). The main income of the households came from the husband (85.2%). However, in the rural area, the own farm contributed substantially to the family's income (36.7%). Similarly, own agricultural production was more important as a food source in the rural (61.4%), compared with the semi-urban area (14.0%), while the local markets were used by nearly all households (97.2%), but more often in the semi-urban area (Table 2). In the semi-urban area, in HGR Nyantende, the own farm as income source and own food production as food source played a more important role than in HGR Ciriri (Table S2).

### Parity and health during pregnancy and delivery

About one-fifth (19.0%) of the mothers were primipara. On average, the participating mothers had already delivered four children, including the newborn (Table 3).

Asked about family planning, nearly two-thirds (63.9%) of the mothers could mention any benefit; however, only 22.1% could name a contraceptive method, and 13.2% practiced family planning. Significantly more semi-urban than rural mothers knew about the benefits (76.0% versus 32.3%, respectively) and practiced family planning (17.1% versus 3.1%, respectively). Planning of pregnancies and health benefits for the mother were mentioned most frequently as reasons for the importance of family planning. Within the semi-urban area, there was less knowledge about contraceptive methods and specific benefits of family planning and lower practice in HGR Nyantende compared with HGR Ciriri (Table S3). Knowing any benefit of family planning was significantly associated with knowing, as well as using, contraceptive methods ($P$ = 0.000; $V = 0.368$ and $V = 0.299$, respectively). Knowledge about contraceptive methods and practicing family planning were highly associated ($P$ = 0.000; $V = 0.705$).

More than half of the mothers (57.8%) answering that they were not practicing family planning ($n$ = 339) could not state any reason. The others did not yet apply family planning methods as it was their first pregnancy or they wanted to have more children (13.6%), relied on God's plans (8.6%), had no information (8.3%), or followed the decision of the family or husband (4.1%). Only a few did not want to use or had no interest in family planning methods (2.9%), had already space between births, feared the method (1.2% each), tried, but it did not work or could not do it (0.6% each), wanted to get pregnant by own wish, or stated impossibility of family planning (0.3% each).

Health problems during pregnancy were reported by almost a quarter of the mothers with the highest rate in HGR Nyantende (47.1%) and malaria being the most prominent disease (Table 4, S4). The majority of mothers (90.3%) took some medication during pregnancy with the lower share in the rural hospital (85.4%). Most common drugs were antimalarial drugs (86.4%) and deworming (69.7%). Both were given more rarely in the rural hospital, compared with the semi-urban ones, with a large discrepancy for deworming (24.6% versus 88.3%, respectively).

Anemia was rarely diagnosed during pregnancy (3.9%). Of those with diagnosed anemia, only one mother could mention her hemoglobin level (8 g/dl), three stated that it had not been measured, and others did not know their level or did not answer. Vision problems at dawn and daytime were highly correlated ($P$ = 0.000; $V = 0.833$).

Around one-tenth of the mothers had not used a mosquito net. Main reason was the lack of a bed net either as not having received it during the pre-natal care programs in the health center ($n = 10$), not owning one without stating a reason for that ($n$ = 7), not participating in the pre-natal care ($n$ = 3), having lost it due to damage or by theft, or lacking someone to install it ($n$ = 1 each). Two mothers stated that they wanted to use it after delivery and another mother said that the net is reserved for the infant. Others did not state any reason.

With regard to delivery, more than one-quarter of the infants had been delivered by Cesarean section (Table 5). Clamping of the umbilical cord was mostly done more than one minute after birth

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**Table 1.** Socio-demographic characteristics

| Variables[a] | Semi-urban $n = 339$ | Rural $n = 131$ | Total[b] $n = 470$ | *P*-value[c] | Effect size |
|---|---|---|---|---|---|
| *Socio-demographic characteristics of the mother* | | | | | |
| Age of the mothers (years) | $n = 330$ 26.0 (22.0, 32.0) | $n = 129$ 25.0 (22.0, 34.0) | $n = 459$ 26.0 (22.0, 32.0) | 0.527‡ | 0.030 |
| < 25 years | 134 (40.6) | 60 (46.5) | 194 (42.3) | 0.095 | 0.118 |
| 25 to 29 years | 89 (27.0) | 23 (17.8) | 112 (24.4) | | |
| 30 to 34 years | 53 (16.1) | 17 (13.2) | 70 (15.3) | | |
| ≥ 35 years | 54 (16.4) | 29 (22.5) | 83 (18.1) | | |
| Religion | $n = 336$ | $n = 131$ | $n = 467$ | **0.000**† | **0.393** |
| Christian: catholic | 206 (61.3) | 25 (19.1) | 231 (49.5) | | |
| Christian: protestant, revival church | 118 (35.1) | 103 (78.6) | 221 (47.3) | | |
| Other: Christian denomination, natural religion, no church | 12 (3.6) | 3 (2.3) | 15 (3.2) | | |
| Marital status | $n = 334$ | $n = 130$ | $n = 464$ | 0.652† | 0.081 |
| Married, living together with husband | 122 (36.5) | 55 (42.3) | 177 (38.1) | | |
| Married, husband living elsewhere | 3 (0.9) | 1 (0.8) | 4 (0.9) | | |
| Divorced | 4 (1.2) | 0 (0.0) | 4 (0.9) | | |
| Living with a partner without marriage | 204 (61.1) | 74 (56.9) | 278 (59.9) | | |
| Single | 1 (0.3) | 0 (0.0) | 1 (0.2) | | |
| Education level | $n = 337$ | $n = 130$ | $n = 467$ | **0.008**† | **0.169** |
| Never attended school | 30 (8.9) | 19 (14.6) | 49 (10.5) | | |
| Attended school < 3 years | 20 (5.9) | 9 (6.9) | 29 (6.2) | | |
| Elementary level (attended school 3-6 years) | 123 (36.5) | 27 (20.8) | 150 (32.1) | | |
| Secondary level (attended school 7-12 years) | 161 (47.8) | 75 (57.7) | 236 (50.5) | | |
| Higher level of education | 3 (0.9) | 0 (0.0) | 3 (0.6) | | |
| Main occupation | $n = 335$ | $n = 131$ | $n = 466$ | **0.000**† | **0.554** |
| Farmer (own farm) | 15 (4.5) | 63 (48.1) | 78 (16.7) | | |
| Farmer (farm of someone else) | 8 (2.4) | 3 (2.3) | 11 (2.4) | | |
| Small business | 99 (29.6) | 13 (9.9) | 112 (24.0) | | |
| Other job (employed/self-employed) | 27 (8.1) | 13 (9.9) | 40 (8.6) | | |
| Without employment | 184 (54.9) | 35 (26.7) | 219 (47.0) | | |
| Student | 2 (0.6) | 4 (3.1) | 6 (1.3) | | |
| *Characteristics of the index infant* | | | | | |
| Age (days) | $n = 339$ 3.0 (2.0, 4.0) | $n = 131$ 2.0 (2.0, 3.0) | $n = 470$ 3.0 (2.0, 4.0) | **0.000**‡ | −0.353 |
| Sex | $n = 339$ | $n = 131$ | $n = 470$ | 0.129 | 0.070 |
| Male | 174 (51.3) | 57 (43.5) | 231 (49.1) | | |
| Female | 165 (48.7) | 74 (56.5) | 239 (50.9) | | |

[a]Categorical variables are expressed as *n* (%) and continuous variables are expressed as mean ± SD/median (IQR).
[b]Total frequencies represent total number of participants, frequencies per variable include all respectively valid cases; lack of corresponding sum of frequencies with total sample size is due to missing data.
[c]Significantly different at *P*-value <0.05 (in bold); *P*-value was derived using t-test for continuous variables and chi-square analysis for categorical variables.
†Fisher's exact test.
‡Mann-Whitney *U* test.

as recommended by the WHO (2014). Most mothers started breastfeeding within the first hour after birth. The two mothers that had not initiated breastfeeding at time of the interview stated that there was no breast milk, yet, or the prolactin would not be active, yet. Early initiation of breastfeeding was significantly associated with mode of delivery. Of mothers with a vaginal

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**Table 2.** Household characteristics

| Variables[a] | Semi-urban $n = 339$ | Rural $n = 131$ | Total[b] $n = 470$ | P-value[c] | Effect size |
|---|---|---|---|---|---|
| Head of household | $n = 338$ | $n = 131$ | $n = 469$ | 0.735† | 0.034 |
| Male | 329 (97.3) | 129 (98.5) | 458 (97.7) | | |
| Female | 9 (2.7) | 2 (1.5) | 11 (2.3) | | |
| Number of household members | $n = 336$ 6.0 (5.0, 8.0) | $n = 131$ 6.0 (4.0, 8.0) | $n = 467$ 6.0 (4.0, 8.0) | 0.098‡ | −0.076 |
| 1-4 | 83 (24.7) | 43 (32.8) | 126 (27.0) | 0.127 | 0.094 |
| 5-9 | 197 (58.6) | 73 (55.7) | 270 (57.8) | | |
| ≥ 10 | 56 (16.7) | 15 (11.5) | 71 (15.2) | | |
| Number of children per household | $n = 336$ 4.0 (2.0, 6.0) | $n = 131$ 4.0 (2.0, 6.0) | $n = 467$ 4.0 (2.0, 6.0) | 0.153‡ | −0.066 |
| 1-2 | 86 (25.6) | 45 (34.4) | 131 (28.1) | 0.167 | 0.088 |
| 3-8 | 221 (65.8) | 76 (58.0) | 297 (63.6) | | |
| ≥ 9 | 29 (8.6) | 10 (7.6) | 39 (8.4) | | |
| Main source of income *(multiple answers possible)** | $n = 324$ | $n = 109$ | $n = 433$ | | |
| Job of the husband | 282 (87.0) | 87 (79.8) | 369 (85.2) | 0.066 | 0.088 |
| Job of the mother | 132 (40.7) | 16 (14.7) | 148 (34.2) | **0.000** | 0.238 |
| Own farm | 10 (3.1) | 40 (36.7) | 50 (11.5) | **0.000** | 0.456 |
| Job of another family member | 9 (2.8) | 0 (0.0) | 9 (2.1) | 0.120† | 0.085 |
| Other | 2 (0.6) | 0 (0.0) | 2 (0.5) | 1.000† | 0.040 |
| Food sources *(multiple answers possible)** | $n = 336$ | $n = 127$ | $n = 463$ | | |
| Local market | 332 (98.8) | 118 (92.9) | 450 (97.2) | **0.002**† | 0.159 |
| Own agricultural land | 47 (14.0) | 78 (61.4) | 125 (27.0) | **0.000** | 0.477 |
| Own vegetable garden | 77 (22.9) | 34 (26.8) | 111 (24.0) | 0.386 | 0.040 |
| Own livestock | 0 (0.0) | 4 (3.1) | 4 (0.9) | **0.005**† | 0.152 |
| Other | 1 (0.3) | 1 (0.8) | 2 (0.4) | 0.474 † | 0.033 |

[a]Categorical variables are expressed as n (%) and continuous variables are expressed as mean ± SD/median (IQR).
[b]Total frequencies represent total number of participants, frequencies per variable include all respectively valid cases; lack of corresponding sum of frequencies with total sample size is due to missing data.
[c]Significantly different at P-value <0.05 (in bold); P-value was derived using t-test for continuous variables and chi-square analysis for categorical variables.
†Fisher's exact test.
‡Mann-Whitney U test.
*Globally significant after adjustment by Bonferroni.

delivery, 93.8% breastfed within the first hour after birth, compared with 87.5% of those with a Cesarean section ($P = 0.024$; $V = 0.104$).

## Anthropometric parameters of mothers and infants

The median MUAC of all mothers in this study was 25.4 cm; however, the MUAC of mothers from the rural hospital was significantly lower than that from the semi-urban ones (23.5 cm versus 26.7 cm, respectively). Similarly, mean birth weight and weight per gestational age were significantly lower in the rural area with a higher prevalence of LBW, as well as SGA in weight. On the other hand, length per gestational age z-score and centile were higher in the rural area. The same trends were found in the z-scores at baseline assessment in the first week postpartum except WAZ (Table 6). In HGR Nyantende, there was a higher prevalence of SGA and lower WLZ at baseline compared with HGR Ciriri, while there was no significant difference for the other anthropometric parameters (Table S6).

Maternal MUAC was significantly correlated with BW ($P = 0.000$, $\tau = 0.169$), weight per gestational age z-score and centile ($P = 0.000$, $\tau = 0.156$), WLZ ($P = 0.000$, $\tau = 0.154$), WAZ ($P = 0.004$, $\tau = 0.090$), BMI ($P = 0.000$, $\tau = 0.147$), and BAZ ($P = 0.000$, $\tau = 0.141$) of the infant. When evaluating the study locations separately, in the rural hospital none of these associations persisted. In the semi-urban area, there were significant correlations of maternal MUAC with BW ($P = 0.006$, $\tau = 0.102$), weight per gestational age z-score and centile ($P = 0.031$, $\tau = 0.081$), and WAZ ($P = 0.027$, $\tau = 0.081$).

## Nutritional aspects during pregnancy

Regarding diet during pregnancy, the main interest of mothers was eating a diet that leads to good health (33.3%). However, even more

**Table 3.** Parity and family planning

| Variables[a] | Semi-urban $n = 339$ | Rural $n = 131$ | Total[b] $n = 470$ | *P*-value[c] | Effect size |
|---|---|---|---|---|---|
| *Parity* | | | | | |
| Number of pregnancies (including the newborn) | $n = 333$<br>4.0 (2.0, 6.5) | $n = 127$<br>4.0 (2.0, 5.0) | $n = 460$<br>4.0 (2.0, 6.0) | 0.294‡ | −0.049 |
| Number of children born alive (including the newborn) | $n = 332$<br>3.0 (2.0, 6.0) | $n = 130$<br>3.5 (2.0, 5.0) | $n = 462$<br>3.0 (2.0, 6.0) | 0.460‡ | −0.034 |
| Birth space between the last pregnancies | $n = 335$ | $n = 122$ | $n = 457$ | 0.171† | 0.120 |
| 9-12 months | 13 (3.9) | 1 (0.8) | 14 (3.1) | | |
| 1-2 years | 137 (40.9) | 47 (38.5) | 184 (40.3) | | |
| 2-3 years | 105 (31.3) | 39 (32.0) | 144 (31.5) | | |
| > 3 years | 16 (4.8) | 12 (9.8) | 28 (6.1) | | |
| Not relevant (primipara) | 64 (19.1) | 23 (18.9) | 87 (19.0) | | |
| *Family planning* | | | | | |
| Knowing any benefit/importance of family planning | $n = 325$ | $n = 124$ | $n = 449$ | **0.000** | **0.407** |
| Yes | 247 (76.0) | 40 (32.3) | 287 (63.9) | | |
| No | 78 (24.0) | 84 (67.7) | 162 (36.1) | | |
| Importance of family planning *(multiple answers possible)** | $n = 325$ | $n = 124$ | $n = 449$ | | |
| Planned pregnancy | 156 (48.0) | 21 (16.9) | 177 (39.4) | **0.000** | **0.284** |
| Health benefits for mother | 147 (45.2) | 13 (10.5) | 160 (35.6) | **0.000** | **0.324** |
| Economically beneficial | 86 (26.5) | 3 (2.4) | 89 (19.8) | **0.000** | **0.270** |
| Fight malnutrition | 67 (20.6) | 2 (1.6) | 69 (15.4) | **0.000** | **0.236** |
| Child spacing | 23 (7.1) | 7 (5.6) | 30 (6.7) | 0.587 | 0.026 |
| Other | 6 (1.8) | 0 (0.0) | 6 (1.3) | 0.194† | 0.072 |
| Do not know | 78 (24.0) | 84 (67.7) | 162 (36.1) | **0.000** | **0.407** |
| Knowledge about contraceptive methods | $n = 330$ | $n = 126$ | $n = 456$ | 0.136 | 0.070 |
| Yes | 79 (23.9) | 22 (17.5) | 101 (22.1) | | |
| No | 251 (76.1) | 104 (82.5) | 355 (77.9) | | |
| Contraceptive methods known *(multiple answers possible)** | $n = 328$ | $n = 120$ | $n = 448$ | | |
| Observation of the cycle | 42 (12.8) | 3 (2.5) | 45 (10.0) | **0.001** | **0.152** |
| Three-month injection | 26 (7.9) | 9 (7.5) | 35 (7.8) | 0.881 | 0.007 |
| Birth control pill | 26 (7.9) | 5 (4.2) | 31 (6.9) | 0.165 | 0.066 |
| Lactational amenorrhea | 3 (0.9) | 0 (0.0) | 3 (0.7) | 0.568† | 0.050 |
| Condom | 2 (0.6) | 1 (0.8) | 3 (0.7) | 1.000† | 0.012 |
| Intrauterine device | 2 (0.6) | 0 (0.0) | 2 (0.4) | 1.000† | 0.041 |
| Implant | 1 (0.3) | 0 (0.0) | 1 (0.2) | 1.000† | 0.029 |
| Do not know | 3 (0.9) | 6 (5.0) | 9 (2.0) | **0.013†** | **0.129** |
| Practiced family planning | $n = 333$ | $n = 129$ | $n = 462$ | **0.000** | **0.186** |
| Yes | 57 (17.1) | 4 (3.1) | 61 (13.2) | | |
| No | 276 (82.9) | 125 (96.9) | 401 (86.8) | | |

[a]Categorical variables are expressed as *n* (%) and continuous variables are expressed as mean ± SD/median (IQR).
[b]Total frequencies represent total number of participants, frequencies per variable include all respectively valid cases; lack of corresponding sum of frequencies with total sample size is due to missing data.
[c]Significantly different at *P*-value <0.05 (in bold); *P*-value was derived using t-test for continuous variables and chi-square analysis for categorical variables.
†Fisher's exact test.
‡Mann-Whitney U test.
*Globally significant after adjustment by Bonferroni.

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**Table 4.** Health issues during pregnancy (self-reported)

| Variables[a] | Semi-urban $n = 339$ | Rural $n = 131$ | Total[b] $n = 470$ | *P*-value[c] | Effect size |
|---|---|---|---|---|---|
| Health problem during pregnancy | $n = 337$ | $n = 131$ | $n = 468$ | 0.395 | 0.039 |
| Yes | 75 (22.3) | 34 (26.0) | 109 (23.3) | | |
| No | 262 (77.7) | 97 (74.0) | 359 (76.7) | | |
| Health problem during pregnancy/perinatal *(multiple answers possible)* | $n = 74$ | $n = 33$ | $n = 107$ | | |
| Malaria | 30 (40.5) | 15 (45.5) | 45 (42.1) | 0.643 | 0.046 |
| Urinary/genital/uro-genital infection | 12 (16.2) | 4 (12.1) | 16 (15.0) | 0.771† | 0.053 |
| Hemorrhage | 8 (10.8) | 4 (12.1) | 12 (11.2) | 1.000† | 0.019 |
| Threat of premature delivery/abortion | 9 (12.2) | 2 (6.1) | 11 (10.3) | 0.497† | 0.093 |
| Infection (not precised) | 6 (8.1) | 1 (3.0) | 7 (6.5) | 0.433† | 0.095 |
| Nausea | 3 (4.1) | 1 (3.0) | 4 (3.7) | 1.000† | 0.025 |
| Hypertension | 1 (1.4) | 3 (9.1) | 4 (3.7) | 0.086† | 0.188 |
| Other | 11 (14.9) | 8 (24.2) | 19 (17.8) | 0.241 | 0.113 |
| Trimester of health problem during pregnancy *(multiple answers possible)** | $n = 75$ | $n = 34$ | $n = 109$ | | |
| First | 28 (37.3) | 22 (64.7) | 50 (45.9) | **0.008** | **0.254** |
| Second | 41 (54.7) | 6 (17.6) | 47 (43.1) | **0.000** | **0.346** |
| Third | 24 (32.0) | 7 (20.6) | 31 (28.4) | 0.221 | 0.117 |
| Visit of a health facility at health problem during pregnancy | $n = 74$ | $n = 34$ | $n = 108$ | 0.442 | 0.074 |
| Yes | 61 (82.4) | 30 (88.2) | 91 (84.3) | | |
| No | 13 (17.6) | 4 (11.8) | 17 (15.7) | | |
| Taking medicine at health problem during pregnancy | $n = 65$ | $n = 29$ | $n = 94$ | 1.000† | 0.098 |
| Yes | 63 (96.9) | 29 (100.0) | 92 (97.9) | | |
| No | 2 (3.1) | 0 (0.0) | 2 (2.1) | | |
| Medication during pregnancy | $n = 322$ | $n = 130$ | $n = 452$ | **0.026** | **0.105** |
| Yes | 297 (92.2) | 111 (85.4) | 408 (90.3) | | |
| No | 25 (7.8) | 19 (14.6) | 44 (9.7) | | |
| Type of medication during pregnancy *(multiple answers possible)** | $n = 316$-$320$ | $n = 130$ | $n = 446$-$450$ | | |
| Antimalarial drugs ($n = 447$) | 281 (88.6) | 105 (80.8) | 386 (86.4) | **0.028** | **0.104** |
| Deworming ($n = 446$) | 279 (88.3) | 32 (24.6) | 311 (69.7) | **0.000** | **0.630** |
| Antibiotics, antifungal ($n = 450$) | 22 (6.9) | 2 (1.5) | 24 (5.3) | **0.022** | **0.108** |
| Pain killer ($n = 448$) | 14 (4.4) | 0 (0.0) | 14 (3.1) | **0.013**† | **0.115** |
| Pregnancy-related medication ($n = 447$) | 13 (4.1) | 0 (0.0) | 13 (2.9) | **0.013**† | **0.111** |
| Vaccination ($n = 446$) | 2 (0.6) | 1 (0.8) | 3 (0.7) | 1.000† | 0.008 |
| Treatment of nausea ($n = 446$) | 2 (0.6) | 0 (0.0) | 2 (0.4) | 1.000† | 0.043 |
| Other ($n = 446$) | 6 (1.9) | 1 (0.8) | 7 (1.6) | 0.679† | 0.041 |
| Diagnosis of anemia during pregnancy | $n = 338$ | $n = 127$ | $n = 465$ | 0.592† | 0.027 |
| Yes | 12 (3.6) | 6 (4.7) | 18 (3.9) | | |
| No | 326 (96.4) | 121 (95.3) | 447 (96.1) | | |
| Vision problems at dawn during pregnancy | $n = 337$ | $n = 129$ | $n = 466$ | 0.303 | 0.048 |
| Yes | 22 (6.5) | 12 (9.3) | 34 (7.3) | | |
| No | 315 (93.5) | 117 (90.7) | 432 (92.7) | | |
| Vision problems at daytime during pregnancy | $n = 333$ | $n = 130$ | $n = 463$ | 0.771 | 0.014 |
| Yes | 23 (6.9) | 8 (6.2) | 31 (6.7) | | |
| No | 310 (93.1) | 122 (93.8) | 432 (93.3) | | |

(*Continued*)

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**Table 4.** (*Continued*)

| Variables[a] | Semi-urban $n = 339$ | Rural $n = 131$ | Total[b] $n = 470$ | *P*-value[c] | Effect size |
|---|---|---|---|---|---|
| Use of mosquito net during pregnancy | $n = 338$ | $n = 131$ | $n = 469$ | 0.659 | 0.020 |
| Yes | 304 (89.9) | 116 (88.5) | 420 (89.6) | | |
| No | 34 (10.1) | 15 (11.5) | 49 (10.4) | | |

[a]Categorical variables are expressed as *n* (%).
[b]Total frequencies represent total number of participants, frequencies per variable include all respectively valid cases; lack of corresponding sum of frequencies with total sample size is due to missing data.
[c]Significantly different at *P*-value <0.05 (in bold); *P*-value was derived using chi-square analysis for categorical variables.
†Fisher's exact test.
*Globally significant after adjustment by Bonferroni.

**Table 5.** Modalities of delivery and initiation of breastfeeding

| Variables[a] | Semi-urban $n = 339$ | Rural $n = 131$ | Total[b] $n = 470$ | *P*-value[c] | Effect size |
|---|---|---|---|---|---|
| Mode of delivery | $n = 339$ | $n = 131$ | $n = 470$ | 0.591 | 0.025 |
| Vaginal | 249 (73.5) | 93 (71.0) | 342 (72.8) | | |
| Cesarean section | 90 (26.5) | 38 (29.0) | 128 (27.2) | | |
| Time of cord clamping | $n = 337$ | $n = 112$ | $n = 449$ | **0.009**† | **0.114** |
| Early cord clamping (≤ 1 min after birth) | 17 (5.0) | 0 (0.0) | 17 (3.8) | | |
| Late cord clamping (≥ 2 min after birth, recommended) | 320 (95.0) | 112 (100.0) | 432 (96.2) | | |
| Initiation of breastfeeding | $n = 337$ | $n = 131$ | $n = 468$ | **0.008**† | **0.174** |
| 1st hour after birth | 316 (93.8) | 115 (87.8) | 431 (92.1) | | |
| 2-6 hours after birth | 20 (5.9) | 10 (7.6) | 30 (6.4) | | |
| 7-12 hours after birth | 1 (0.3) | 1 (0.8) | 2 (0.4) | | |
| 13-24 hours after birth | 0 (0.0) | 1 (0.8) | 1 (0.2) | | |
| 2-3 days after birth | 0 (0.0) | 2 (1.5) | 2 (0.4) | | |
| Not yet | 0 (0.0) | 2 (1.5) | 2 (0.4) | | |

[a]Categorical variables are expressed as *n* (%).
[b]Total frequencies represent total number of participants, frequencies per variable include all respectively valid cases; lack of corresponding sum of frequencies with total sample size is due to missing data.
[c]Significantly different at *P*-value <0.05 (in bold); *P*-value was derived using chi-square analysis for categorical variables.
†Fisher's exact test.

mothers (41.5%) reported to not know or not have a special interest in food issues, especially in the rural hospital. Medical staff was the most important source of nutritional knowledge (42.9%), with this being higher in semi-urban hospitals. However, more than half of the mothers stated that no-one informed them about nutrition during pregnancy. Mother and mother-in-law played a minor role as nutrition advisors and were not mentioned at all in the rural area (Table 7). Within the semi-urban area, mothers in HGR Ciriri had less often anyone giving nutritional advice during pregnancy ($P = 0.050$); however, their interest in diet was higher (Table S7).

Intake of nutritional supplements was common, with most mothers taking Fefol® (iron + folic acid, $n = 381$). A few took iron ($n = 7$), multivitamin/vitamin ($n = 3$), unspecified syrup, vitamin B6, or anything else ($n = 1$ each). More mothers from the semi-urban area were taking supplements compared to their rural counterparts.

Around one-tenth of the mothers had omitted any food items during pregnancy, while this practice was less common in the semi-urban locations. Avoided foods were any types of starchy staples, pulses, animal foods, different vegetables, snacks, and oil (Table 8). In most cases, these foods had been omitted due to side effects of pregnancy, especially nausea and vomiting.

Food taboos taught for pregnancy were rarely mentioned ($n = 13$), with dairy being the most common taboo ($n = 6$). The mentioned foods should be avoided as they were believed to adversely affect the health of a pregnant or lactating women or the baby itself, compromise the cervix or breast milk, or provoke fetal macrosomia. Most of these food taboos were learned by a friend ($n = 9$) or the mother ($n = 8$), some by the mother-in-law, elder sister, medical staff, or a passenger ($n = 1$ each).

## Predictors of birth weight

In simple linear regression analyses, the following factors were found to be significant predictors of birth weight and birth weight *z*-scores: Location of the hospital, household size, number of children in the household, food sources including own production (only *z*-score), maternal occupation (farmer, student versus no occupation), maternal age, number of pregnancies and births, parity (primipara versus multipara), maternal MUAC, reporting an uro-genital

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**Table 6.** Anthropometrics

| Variables[a] | Semi-urban n = 339 | Rural n = 131 | Total[b] n = 470 | P-value[c] | Effect size |
|---|---|---|---|---|---|
| *Mothers' nutritional status (first week postpartum)* | | | | | |
| MUAC (cm) | n = 339<br>26.7<br>(24.6, 29.0) | n = 131<br>23.5<br>(22.2, 25.0) | n = 470<br>25.4<br>(23.7, 28.3) | **0.000‡** | **-0.470** |
| *Index infants' nutritional status at birth* | | | | | |
| Birth weight (g) | n = 339<br>3263 ± 444 | n = 131<br>3005 ± 468 | n = 470<br>3191 ± 465 | **0.000** | **0.573** |
| Low birth weight* | n = 339 | n = 131 | n = 470 | | |
| Yes | 9 (2.7) | 14 (10.7) | 23 (4.9) | **0.000** | **0.167** |
| No | 330 (97.3) | 117 (89.3) | 447 (95.1) | | |
| Weight per gestational age z-score | n = 323<br>0.1 ±1.1 | n = 129<br>−0.6 ± 1.2 | n = 452<br>−0.1 ± 1.1 | **0.000** | **0.602** |
| Weight per gestational age centile | n = 323<br>55.7<br>(24.2, 79.2) | n = 129<br>24.6<br>(9.2, 61.2) | n = 452<br>46.9<br>(16.9, 75.0) | **0.000‡** | **-0.261** |
| Length per gestational age z-score | n = 323<br>0.0<br>(−0.8, 0.7) | n = 124<br>0.5<br>(−0.2, 1.2) | n = 447<br>0.2<br>(−0.6, 0.9) | **0.000‡** | **0.216** |
| Length per gestational age centile | n = 323<br>51.7<br>(21.8, 77.2) | n = 124<br>69.1<br>(43.3, 89.1) | n = 447<br>57.2<br>(28.2, 80.4) | **0.000‡** | **0.216** |
| Small-for-gestational age* in weight | n = 323 | n = 129 | n = 452 | | |
| Yes | 10 (3.1) | 12 (9.3) | 22 (4.9) | **0.006** | **0.130** |
| No | 313 (96.9) | 117 (90.7) | 430 (95.1) | | |
| Small-for-gestational age* in length | n = 323 | n = 124 | n = 447 | | |
| Yes | 15 (4.6) | 2 (1.6) | 17 (3.8) | 0.172† | 0.071 |
| No | 308 (95.4) | 122 (98.4) | 430 (96.2) | | |
| *Index infants' nutritional status (first week postpartum)* | | | | | |
| Weight-for-Length z-score (WLZ) | n = 338<br>−0.2 ±1.0 | n = 121<br>−1.0 ±1.2 | n = 459<br>−0.4 ±1.1 | **0.000** | **0.773** |
| Length-for-Age z-score (LAZ) | n = 339<br>−0.5 ±1.0 | n = 126<br>0.0 ±1.0 | n = 465<br>−0.4 ±1.0 | **0.000** | **-0.592** |
| Weight-for-Age z-score (WAZ) | n = 339<br>−0.4 ±0.9 | n = 130<br>−0.5 ±1.0 | n = 469<br>−0.4 ±0.9 | 0.264 | 0.115 |
| Body Mass Index (BMI) | n = 339<br>12.9<br>(12.2, 13.6) | n = 126<br>12.3<br>(11.2, 12.9) | n = 465<br>12.7<br>(12.0, 13.5) | **0.000‡** | **-0.251** |
| BMI-for-Age z-score (BAZ) | n = 339<br>−0.3<br>(−0.9, 0.3) | n = 124<br>−0.9<br>(−1.7, −0.3) | n = 463<br>−0.5<br>(−1.1, 0.2) | **0.000‡** | **-0.249** |

[a]Categorical variables are expressed as n (%) and continuous variables are expressed as mean ± SD/median (IQR).
[b]Total frequencies represent total number of participants, frequencies per variable include all respectively valid cases; lack of corresponding sum of frequencies with total sample size is due to values out of range for calculating scores.
[c]Significantly different at P-value <0.05 (in bold); P-value was derived using t-test for continuous variables and chi-square analysis for categorical variables.
†Fisher's exact test.
‡Mann-Whitney U test.
*Low birth weight: < 2500 g; Small-for-gestational age in weight/length: < −2 z-score.

infection during pregnancy, taking deworming medication during pregnancy, taking antibiotics/antifungal medication during pregnancy (only z-score, $P < 0.100$), taking medication against nausea during pregnancy ($P < 0.100$), taking other medication during pregnancy (only z-score, $P < 0.100$), having any interest regarding diet during pregnancy, being informed about any food taboo for pregnancy, being advised by the mother about nutrition during pregnancy (only z-score; $P < 0.100$ for BW), being advised by the mother-in-law, practicing family planning ($P < 0.100$), gestational age, and sex of the child (both only BW).

**Table 7.** Nutritional aspects during pregnancy (retrospective assessment)

| Variables[a] | Semi-urban $n = 339$ | Rural $n = 131$ | Total[b] $n = 470$ | *P*-value[c] | Effect size |
|---|---|---|---|---|---|
| Main interest regarding diet during pregnancy *(multiple answers possible)** | $n = 251$ | $n = 120$ | $n = 420$ | | |
| Good health, strength, energy | 132 (44.0) | 8 (6.7) | 140 (33.3) | **0.000** | **0.358** |
| Quality | 60 (20.0) | 2 (1.7) | 62 (14.8) | **0.000** | **0.233** |
| Quantity | 6 (2.0) | 8 (6.7) | 14 (3.3) | **0.030†** | **0.117** |
| Good health, weight, growth of the fetus | 11 (3.7) | 2 (1.7) | 13 (3.1) | 0.365† | 0.052 |
| Increasing weight | 9 (3.0) | 1 (0.8) | 10 (2.4) | 0.294† | 0.064 |
| Easy delivery | 1 (0.3) | 1 (0.8) | 2 (0.5) | 0.490† | 0.033 |
| Appetite | 2 (0.7) | 0 (0.0) | 2 (0.5) | 1.000† | 0.044 |
| Other (had no appetite, requirement of means, not precised) | 5 (1.7) | 1 (0.8) | 6 (1.4) | 0.679† | 0.032 |
| No interest | 21 (7.0) | 25 (20.8) | 46 (11.0) | **0.000** | **0.200** |
| Do not know | 56 (18.7) | 72 (60.0) | 128 (30.5) | **0.000** | **0.406** |
| Teacher about nutrition during pregnancy *(multiple answers possible)** | $n = 329$ | $n = 119$ | $n = 448$ | | |
| Nurse/nutritionist/doctor | 153 (46.5) | 39 (32.8) | 192 (42.9) | **0.009** | **0.123** |
| Friend | 28 (8.5) | 1 (0.8) | 29 (6.5) | **0.004** | **0.138** |
| Mother | 28 (8.5) | 0 (0.0) | 28 (6.3) | **0.001** | **0.155** |
| Mother-in-law | 6 (1.8) | 0 (0.0) | 6 (1.3) | 0.349† | 0.070 |
| Media | 1 (0.3) | 0 (0.0) | 1 (0.2) | 1.000† | 0.028 |
| Other (family member, student, passenger) | 4 (1.2) | 2 (1.7) | 6 (1.3) | 0.659† | 0.018 |
| No-one | 167 (50.8) | 71 (59.7) | 238 (53.1) | 0.095 | 0.079 |
| Do not know | 0 (0.0) | 6 (5.0) | 6 (1.3) | **0.000†** | **0.194** |
| Omitted foods during pregnancy | $n = 338$ | $n = 130$ | $n = 468$ | **0.000** | **0.233** |
| Yes | 24 (7.1) | 31 (23.8) | 55 (11.8) | | |
| No | 314 (92.9) | 99 (76.2) | 413 (88.2) | | |
| Food taboo for pregnancy | $n = 337$ | $n = 131$ | $n = 468$ | 0.531† | 0.047 |
| Yes | 11 (3.3) | 2 (1.5) | 13 (2.8) | | |
| No | 326 (96.7)) | 129 (98.5) | 455 (97.2) | | |
| Supplement intake during pregnancy | $n = 319$ | $n = 130$ | $n = 449$ | **0.025** | **0.106** |
| Yes | 285 (89.3) | 106 (81.5) | 391 (87.1) | | |
| No | 34 (10.7) | 24 (18.5) | 58 (12.9) | | |

[a]Categorical variables are expressed as *n* (%).
[b]Total frequencies represent total number of participants, frequencies per variable include all respectively valid cases; lack of corresponding sum of frequencies with total sample size is due to missing data.
[c]Significantly different at *P*-value <0.05 (in bold); *P*-value was derived using chi-square analysis for categorical variables.
†Fisher's exact test.
*Globally significant after adjustment by Bonferroni.

Multiple regression revealed infantile sex and gestational age as significant predictors of BW. Maternal MUAC and age contributed to both BW and BW *z*-scores according to gestational age and sex. Location of the hospital was a significant predictor for *z*-scores and contributed non-significantly to the model for BW. Being a farmer and parity were further non-significant predictors of BW. Lower BW was predicted for children of rural, farmer, and primiparous mothers and female infants, and higher BW with increasing maternal MUAC and age, and gestational age (Table 9).

## Discussion

### *LBW*

This study revealed a considerable difference in the number of LBW and small-for-gestational age among infants born in semi-urban (2.7%; 3.1%) and rural hospitals (10.7%; 9.3%). With a total of 4.9%, it is approximately half of the prevalence of LBW in SK (11.0%) reported in the last DHS (MPSMRM *et al.*, 2014). However, only 92.6% of live births in the province have been reported to take place in a health facility including hospitals and

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**Table 8.** Omitted foods and food taboos in pregnancy

| Food group | *n* | Foods | Reason |
|---|---|---|---|
| *Omitted foods (multiple answers possible) (n = 56)* | | | |
| Starchy staples | 17 | Bread, fufu (different types), maize, manioc, rice, sweet potato | Vomiting; disgust; lack of appetite; feeling bad; gastritis; stomach; pyrosis |
| Pulses | 4 | Beans, soy | Lack of appetite; vomiting |
| Dairy | 5 | Milk | Nausea; vomiting; pregnancy (pyrosis) |
| Meat, poultry, fish | 21 | Meat (different types), sausage, fish (fresh, salted), small fish | Vomiting; disgust; lack of appetite; caprices of pregnancy; hypersalivation; due to pregnancy; nausea; for good health |
| Eggs | 1 | Eggs | Vomiting |
| Dark green leafy vegetables | 16 | Amaranth, bean leaves, black nightshade leaves, manioc leaves, green leafy vegetables | Vomiting; nausea; lack of appetite; upset stomach; gastritis |
| Other vegetables | 9 | African eggplant, cabbage | Vomiting; lack of appetite; disgust; due to pregnancy; missing |
| Snacks | 2 | Beignets, sugarcane | Vomiting |
| Oil | 1 | Oil | Vomiting |
| *Food taboo (multiple answers possible) (n = 13)* | | | |
| Starchy staples | 1 | Rice | The cervix becomes hard and stays closed.[a] |
| Dairy | 6 | Milk | To avoid a great baby.<br>Bad for health of a pregnant woman.<br>Bad for a lactating woman.<br>The cervix becomes hard and stays closed.[a] |
| | | Yogurt | Do not know. |
| Meat, poultry, fish | 2 | Red hard meat | This prolongs pregnancy. |
| | | Cowhide | The baby will have a circular cord. |
| Eggs | 2 | Eggs | – |
| Dark green leafy vegetables | 1 | Black nightshade | Bad for a pregnant woman |
| Other vegetables | 3 | African eggplant | The child will have skin rash. |
| | | Cabbage | Alleviates the milk (milk like water). |
| Other fruits | 4 | Avocado | The baby will grow (fetal macrosomia).<br>The cervix will get spastic.[a] |
| | | Fruits | Bad for health of a pregnant woman.<br>Bad for a lactating woman. |
| Spices | 1 | Chili | This goes through breast milk. |
| | 1 | Food with spices | For health of the baby. |

[a]The answers regarding cervix were all given by the same mother.

health centers (MPSMRM *et al.*, 2014). Not delivering in a health facility is often related to remote areas and poverty (Adde *et al.*, 2020), which in turn can be associated with malnutrition and, thus, poorer birth outcomes. Therefore, recruitment of mother-infant pairs after delivery in a hospital may have resulted in underestimation of the LBW rate.

In DRC, prevalence of LBW has been reported to be similar in urban, compared to rural areas. However, stunting, wasting, and underweight in children below five years and underweight in women of reproductive age have been reported to be higher in the rural areas. (MPSMRM *et al.*, 2014) Equally, in a pooled analysis of Sub-Saharan countries, no higher risk of LBW was found in rural, compared to urban areas (Tessema *et al.*, 2021). The presented study found similar rates of LBW, but differences in SGA prevalence between the two semi-urban hospitals. This may point to the fact that even smaller regions and health zones need to be evaluated for their characteristics and health outcomes.

## Predictors of birth weight

For both birth weight and birth weight *z*-scores, higher maternal age and MUAC predicted higher BW while being primipara was a determinant for lower BW. It needs to be considered that in this study, MUAC was measured postpartum and cannot reflect maternal status throughout the pregnancy, but might give an estimate for nutritional status during the last weeks of pregnancy. Other studies confirmed maternal underweight in terms of low BMI or MUAC and/or lower parity as risk factors for LBW (Elshibly and Schmalisch, 2008; Muhihi *et al.*, 2016; Kaur *et al.*, 2019). However, results regarding the impact of maternal age varied and more factors such as maternal height and educational

**Table 9.** Multiple linear regression analyses assessing predictors of birth weight

| Predictors | B (95% CI) | SE | Standardized Beta | R Zero-Order | R Partial | *P*-value |
|---|---|---|---|---|---|---|
| Model for birth weight in g | | | | | | |
| (Constant) | −1162.289 (−3510.053, 1185.474) | 1193.400 | | | | 0.331 |
| Location (rural = 1) | −116.718 (−248.357, 14.921) | 66.914 | −0.112 | −0.223 | −0.096 | 0.082 |
| Gestation age (in completed weeks) | 96.908 (37.557, 156.259) | 30.169 | 0.163 | 0.183 | 0.175 | **0.001** |
| Sex of the infant (female = 1) | −148.340 (−241.582, −55.098) | 47.396 | −0.159 | −0.202 | −0.171 | **0.002** |
| Maternal age | 10.020 (2.114, 17.927) | 4.019 | 0.137 | 0.171 | 0.137 | **0.013** |
| Occupation (farmer = 1) | −129.042 (−275.220, 17.136) | 74.304 | −0.106 | −0.197 | −0.096 | 0.083 |
| Parity (primipara = 1) | −110.969 (−241.352, 19.414) | 66.276 | −0.092 | −0.163 | −0.092 | 0.095 |
| Maternal MUAC | 16.934 (0.582, 33.286) | 8.312 | 0.115 | 0.232 | 0.112 | **0.042** |
| Model for birth weight per gestational age z-score | | | | | | |
| (Constant) | −1.998 (−3.143, −0.853) | 0.582 | | | | **0.001** |
| Location (rural = 1) | −0.478 (−0.759, −0.197) | 0.143 | −0.194 | −0.238 | −0.182 | **0.001** |
| Maternal age | 0.030 (0.013, 0.048) | 0.009 | 0.176 | 0.167 | 0.182 | **0.001** |
| Maternal MUAC | 0.047 (0.007, 0.087) | 0.020 | 0.135 | 0.220 | 0.129 | **0.020** |

Multiple linear regression analyses with a backward approach: Location (rural = 1 versus semi-urban = 0), gestational age (in completed weeks; only for birth weight in g), sex of the infant (female = 1 versus male = 0; only for birth weight in g), maternal age (in years), maternal occupation (farmer = 1 versus other/no occupation = 0), number of births, parity (primipara = 1 versus multipara = 0), practicing family planning (yes = 1 versus no = 0), maternal MUAC (in cm), antenatal deworming (yes = 1 versus no = 0), antenatal antibiotics/antifungal medication (yes = 1 versus no = 0, only for *z*-score), stating any interest regarding diet during pregnancy (yes = 1 versus no = 0), being advised by the mother about nutrition in pregnancy (yes = 1 versus no = 0) were included as independent variables in the initial model; model for birth weight in g: $n = 333$, $R^2$: 0.173, Adjusted $R^2$: 0.155; model for birth weight per gestational *z*-score: $n = 330$, $R^2$: 0.105, Adjusted $R^2$: 0.097.

level were found to be predictors as well (Elshibly and Schmalisch, 2008; Muhihi *et al.*, 2016; Kaur *et al.*, 2019), which could not be confirmed in this study.

Our results suggest that primiparous women should receive special consideration. They received less counseling in antenatal (and postnatal) care about health and nutrition during pregnancy and postpartum, compared with their multiparous counterparts. Thus, they might lack important knowledge and support, which could increase the risk for lower BW.

In addition to these well-known risk factors, living in the rural area predicted BW to be around 117 g lower compared with the semi-urban area. Other socio-demographic and nutritional factors did not endure in multiple regression analysis except the occupation as a farmer. As farmers were more prevalent in the rural area, there might be an overlap between these two factors, resulting in inclusion of both of them as non-significant predictors. This is supported by the fact that the rural location was a negative predictor of BW *z*-scores as well. Equally, in certain regions of Ethiopia, rural residence depicted an increased risk factor for LBW (Tadese *et al.*, 2021). Ngandu *et al.* (2021) compared birth outcomes in the DRC and South Africa. They found the country to be more important than socio-economic factors. In this study, several factors related to nutrition or health services were found to be poor in the rural compared to the semi-urban area. Although the single variables did not show a significant effect in multiple regression analysis, the combined effect of limited ANC utilization and disparate living conditions might contribute to the higher share of LBW in the rural area. In addition, maternal nutritional status, that is also addressed in ANC, was poorer in the rural area.

## Discrepancies between semi-urban and rural areas and the role of health services

### Preventive measures

The provision of both antimalarial and anthelminthic drugs was lower in the rural than in the semi-urban area. More mothers received antimalarial medication than have suffered from malaria, revealing their prophylactic administration as recommended by the WHO (WHO, 2022). Likewise, for DRC, higher rates for those preventive medications were reported for urban areas, albeit the discrepancy in terms of vermifuges was less extensive than in the study area (MPSMRM *et al.*, 2014). In Tanzania, women with urban residences were found to be more likely to use deworming medication compared with their rural counterparts (Bankanie and Moshi, 2022). In total, the prevalence of preventive medication was higher in this study population compared with that reported for

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SK, with 42.4% receiving sulfadoxine-pyrimethamine (malaria) and 54.9% vermifuges (MPSMRM *et al.*, 2014). There were higher rates among women attending ANC (ESPK and ICF, 2019); thus, utilization of ANC might contribute to these discrepancies.

Malaria prevention also includes the prevention of mosquito bites as a main measure. Nearly 90% of mothers in both semi-urban and rural area used mosquito nets. This rate is higher than reported for SK (63.3%) and several other Congolese provinces with an average of 78.4% (MPSMRM *et al.*, 2014; Inungu *et al.*, 2017). However, overestimation of self-reported bed net use is common (Krezanoski *et al.*, 2018), and this study also did not assess frequency of use during pregnancy. Mothers not using a bed net mostly stated a lack of a net as reason; they relied mainly on ANC and health institutions for provision. Few mothers indicated to use it only after delivery or for the infant, emphasizing the need for increasing awareness about the importance in each life stage, especially pregnancy. Others found that knowledge about mosquitoes as transmitters of malaria or mosquito nets as preventive measure was associated with higher odds of using mosquito nets, even though that was not confirmed in all studies (Baume and Koh, 2011; Inungu *et al.*, 2017; Kanyangarara *et al.*, 2018; Moscibrodzki *et al.*, 2018; Adedokun and Uthman, 2020).

Tetanus vaccination should be provided to every pregnant woman if complete vaccination status cannot be proven (WHO, 2019). Only three mothers reported any vaccination during pregnancy. Although many study participants were multipara and might have been evaluated and vaccinated during previous pregnancies, the vaccination rate seems to be low, especially when compared to the rate of 31.6% in SK (MPSMRM *et al.*, 2014). The vaccination practices in ANC need to be evaluated to confirm the results. When asked about reception of any medication during pregnancy, mothers might have limited their answers to oral drugs and omitted reporting vaccination.

In this study, antimalarial medication was not associated with the BW of the newborn. Deworming was a significant predictor of BW in simple linear regression, but the effect did not endure in multiple regression, and could have been mediated by coincidence with the hospital location. A systematic review found a 27% risk reduction of LBW by use of antimalarial medication during pregnancy in East Africa, but this was reduced or even eradicated in areas with substantial rate of resistance to treatment (Muanda *et al.*, 2015). In the study population, mainly sulfadoxine-pyrimethamine (Fansidar®) was used (data not presented). Although the resistance level to sulfadoxine-pyrimethamine seems to be stable at 16-17% in the DRC throughout the last 20 years (Amimo *et al.*, 2020), this is of concern and may have influenced the impact on BW in this study. Further, the number of received doses and compliance had not been assessed, but can influence the effect of the treatment (Kayentao *et al.*, 2013; Bakken and Iversen, 2021). For deworming, there seem to be inconsistent results regarding the effects on LBW (Ndibazza *et al.*, 2010; Walia *et al.*, 2021). As helminth infections were associated with maternal anemia (Yatich *et al.*, 2010; Aderoba *et al.*, 2015) and maternal anemia and low intake of iron-folic acid supplements were risk factors for LBW (Deriba and Jemal, 2021), the high rate of supplementation may have masked a possible effect of anti-helminthic medication in this study.

### *Nutritional aspects*

In DRC, 43.4% of pregnant women and 38.4% of women of reproductive age (15–49 years) have been reported to suffer from anemia, the latter with a prevalence of 22.7% in SK (MPSMRM *et al.*, 2014). In a rural health zone of SK, 17.6% of pregnant women were found to be anemic (Bahizire *et al.*, 2017). In contrast, only 3.9% of the mothers in this study mentioned that anemia had been detected during their last pregnancy and only one mother could mention her hemoglobin level. That might suggest that hemoglobin was not routinely measured during antenatal care; thus, anemia often remained undetected. In SK, only 43% of ANC-providing health facilities have been reported to have the capacity of measuring hemoglobin (ESPK and ICF, 2019). On the other hand, intake of nutrient supplements was quite common in our study population (87.1%), usually in the form of iron and folic acid. It was slightly higher than reported intake in 2014 in SK of 78.7% (MPSMRM *et al.*, 2014) and higher in the semi-urban than rural area.

Interest for a healthy diet during pregnancy was higher in semi-urban areas, as well as being taught about nutrition by medical staff. However, in the whole study population there was a substantial number of mothers without anyone providing information about nutrition or having any specific interest in their diet. Among the women visiting ANC in SK, only 21% mentioned nutrition being taught (ESPK and ICF, 2019). Associations of nutritional knowledge with maternal dietary practices or undernutrition during pregnancy have been found in Ethiopia (Nana and Zema, 2018; Muze *et al.*, 2020). Additionally, not receiving nutritional counseling was associated with higher risk of LBW (Deriba and Jemal, 2021). This underlines the importance of increasing dietary knowledge in the study area.

### *Family planning*

Practice of family planning, knowing any contraceptive methods and knowing any benefits of family planning were significantly associated. Similar findings have been reported from other low- and middle-income countries (LMICs) (Dev *et al.*, 2019). Knowledge about benefits of family planning was the highest, with less mothers being able to name contraceptive methods and even less using them. In contrast, in SK, almost all women of reproductive age in a relationship (98.1%) have been reported to have heard about any method (MPSMRM *et al.*, 2014). Reasons for poor knowledge in this study are unclear. An interpretation of the discrepancy between knowledge about benefits and methods of family planning suggests that women may not be interested in family planning and therefore do not remember the messages provided. Misconceptions might persist as the desire for more children caused the non-use of family planning methods, even though reversible methods allow further pregnancies. Finally, the mothers might have heard about the importance of family planning in other occasions than health services, without receiving information about the respective measures.

The rate of using contraceptive methods was comparable to that previously reported in SK (13.2%) (MPSMRM *et al.*, 2014). In studies in East and West African countries, use of modern contraceptives has been found to range from 10.3% up to 73.7% (Dev *et al.*, 2019). While knowledge about contraceptive methods was comparable between semi-urban and rural areas, their use and knowledge about their importance were significantly higher among the semi-urban mothers of HGR Ciriri. Equally, in DRC, more urban than rural women have been reported to practice family planning (MPSMRM *et al.*, 2014). Information on both contraceptive methods and their benefits, rather than only practical issues, could lead to behavior change. This might have been more comprehensive in these semi-urban health facilities. Availability of contraceptives could further be limited in rural areas; however, natural methods such as observation of the cycle do not require any medication. In DRC, equal rates of urban and rural health facilities have been reported to offer family planning in terms of counseling, prescription, or provision, but among those, provision of most methods was reported to be more prominent in the urban facilities (ESPK and ICF, 2019).

The majority of the mothers in this study could not state a reason for not using contraceptive methods, while religious or family issues were only rarely mentioned. It needs to be investigated if an unmet need for contraception exists as reported from other LMICs (Dev *et al.*, 2019). Due to high sensibility of family planning, women could be shy to talk openly about this topic. Deeper investigation on health services provided as well as attention to cultural beliefs is required. Other family members, particularly the husbands, need to be addressed as well to allow joint decisions in favor of improved health of the mother and child pair. Other studies found a higher rate of family planning if the partners were involved and supported the family planning practice (Dev *et al.*, 2019).

This study did not assess if and how often ANC services and family planning programs were used. The situation regarding routine diagnostics and preventive measures during pregnancy is alarming, especially in the rural region. Both utilization and quality of ANC need to be evaluated and addressed to promote maternal and fetal health. Differences between the semi-urban hospitals mainly occurred for services related to counseling activities such as knowledge and interest about family planning and nutrition while in the rural hospital, also material-related services such as medication and supplementation were less pronounced. These findings might suggest urban-rural disparities regarding equipment, but possible discrepancies in formation or motivation of health staff regarding counseling between different health zones or facilities. Trained staff and availability of equipment and medication should form the foundation for adequate services.

### *Modalities of delivery and initiation of breastfeeding*

In all study areas, there was a high proportion of Cesarean sections with a total of 27.2%, compared with 10.0% reported in SK (MPSMRM *et al.*, 2014). However, it needs to be taken into consideration that only 92.4% of women experienced an assisted birth (medical doctor, nurse, and midwife) in SK while in this study the participants were recruited after delivery in a hospital. Nevertheless, the reasons for these high Cesarean section rates need to be evaluated.

Clamping of umbilical cord was mostly done more than one minute after birth as recommended by the WHO (2014). However, for 5% of the newborns in the semi-urban hospitals, the umbilical cord was clamped within the first minute. Awareness of medical doctors, nurses, and midwifes regarding the recommended practices of late umbilical cord clamping should be strengthened.

Most newborns (92.1%) received their first breastfeed within the first hour after birth as recommended (UNICEF and WHO, 2018), with a lower share in the rural hospital. Another study in Bukavu found lower rates of early initiation of breastfeeding (65.9%), with higher prevalence in the rural area (Kambale *et al.*, 2018). In this study, there was a lower share of early initiation of breastfeeding after a Cesarean section, which was also found by Kambale *et al.* (2018). Further, they found counseling about breastfeeding as a significant predictor for an early onset of lactation.

### *Socio-demographic factors*

Several socio-demographic characteristics differed between the areas. Educational level varied, with more mothers in the rural area who had never attended school, but also more mothers with secondary school level. Around half of the mothers in rural Nyangezi and semi-urban Nyantende worked as farmers while more than half of the semi-urban mothers in Ciriri were without formal employment. In line with that, the own agricultural land more often constituted food and income source for families in Nyangezi and Nyantende, compared to households in Ciriri. A homestead food production program has been found to be associated with higher dietary diversity (Blakstad *et al.*, 2021), while other researchers have underscored market access and purchased foods as more relevant for food security (Sibhatu and Qaim, 2017).

## Limitations

The following limitations should be taken into account when interpreting the findings of the present study: First, the study population may not be fully representative for the population in and around Bukavu due to the specific inclusion criteria. Only mothers delivering in a hospital were included, and they were selected according to their MUAC for the purpose of the following intervention study with three groups of under-, two groups of over-, and one group of normal weight mothers. However, the recruitment procedure was the same at each study site; therefore, the presented results regarding anthropometric status are still reliable. With two semi-urban and one rural hospital, there was a small number of health facilities included, limiting the meaningfulness of comparing the semi-urban and rural area. Due to lack of safety, accessibility of rural areas is very difficult in the region. Thus, we are contented for having included at least one rural hospital in our study. At the three study sites, different health personnel conducted the measurements. Despite training in all measures, this could have influenced the anthropometric data, such as MUAC and newborns' length. Conspicuously, the mean newborns' length was higher in the rural area compared with the semi-urban ones, although weight was lower. This might be an indication that some systematic measurement error occurred. The meaningfulness of the regression analysis is limited for parameters that were observed only in a small number of respondents, caused by the nature of the data. In the multiple regression, this was acknowledged by including only variables with a prevalence of at least 5%. Finally, any data about pregnancy were assessed retrospectively and by mothers' reports; thus, memory lapses are possible.

## Conclusion

Discrepancies between the study sites in terms of health care, as well as anthropometric parameters of both mothers and infants, clearly show the urgency of strengthening health care services, particularly antenatal care. Depending on the respective health facility and region, the provision of equipment and medication or motivation and formation of the health staff need to be focused on. Rural location was found to be a predictor of lower birth weight. Higher workload in agriculture and possible further factors, which were not assessed in this study, can influence maternal and child health indirectly, but are not easily modifiable. Therefore, strong preventive measures regarding health and nutrition are even more important to compensate for harder living conditions in rural areas. Maternal nutritional status, reflected by MUAC, was significantly associated with birth weight. Therefore, improving maternal nutrition and health can ameliorate not only the mother's status, but that of the fetus as well.

**Supplementary material.** To view supplementary material for this article, please visit https://doi.org/10.1017/S1463423623000518

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**Ethical standards.** The authors assert that all procedures contributing to this work comply with the Helsinki Declaration of 1975, as revised in 2008. Ethical clearance was approved by the Freiburg ethics commission international (feci; feci Code 017/1161) and the Institutional Ethics Commission of the Catholique University of Bukavu (CIE of UCB; order number UCB/CIE/NC/006/2017). The study was registered prospectively at the German Clinical Trials Register (DRKS; DRKS-ID DRKS00012842) on 27.11.2017.

Written informed consent was obtained from all participants prior enrollment in the study.

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