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Maternal determinants of adverse neonatal outcomes in a rural district hospital in East Africa

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Abstract: *Background*
Maternal predisposing factors to adverse birth outcomes are often times assumed to be similar in rural and urban settings. This assumption has led to many failed or failing interventions. This study investigated the maternal risk factors of adverse birth outcomes in a remote community and compared with existing literature of similar studies done in urban areas or developed settings.

Subject and methods: This was the baseline data of a prospective cohort study, carried out in Gitwe village, Rwanda, 2019. Healthy, 529 mother-singleton infant pairs were recruited consecutively from Gitwe District hospital.

Results: The burden of adverse neonatal outcomes of significance in this rural study (caesarean section delivery, low birth weight, small for gestational age and prematurity) were 38.8%, 10.6%, 21.4% and 4.9%, respectively. Significant (p<0.05) maternal characteristics associated with cesarean section delivery were obesity, high number of antenatal visits (>6), non-Christian religion, university education, entrepreneurs, positive HIV status and short stature. Unmarried mothers were likely to produce LBW and preterm babies, while primips were prone to deliver SGA babies. The magnitude of adverse birth outcomes in this rural study was unexpectedly higher than what exists in literature and their drivers were not exactly the same as in urban settings and at the national level.

Conclusion and Recommendations:
The burden of adverse birth outcomes in this study was higher than that of several countries in the world. Therefore, mothers (not neglecting their marital, HIV, parity and religion status), residing in these rural areas should be prioritized for health care interventions, in order to lower the short- and long-term effects of these adverse birth outcomes.

Key words: preterm, LBW, SGA, cesarean section, adverse birth outcomes, rural, urban.

Résumé: Arrière-plan:
On suppose souvent que les facteursmaternelsprédisposant à des issues défavorables à l'accouchementsontsimilairesen milieu rural et urbain. Cettehypothèse a conduit à de nombreuses interventions qui ontéchouéou sontentrain d'échoué. Cette étude aexaminé les facteurs de risquematernelsd'issuesdéfavorables à l'accouchement dans unecommunautééloignée et les a comparés à la littératureexistanted'étudessimilairesréalisées dans des zones urbainesou des milieux développés.

Sujet et methods: Il s'agissait des données de base d'une étude de cohorte prospective, réalisée dans le village de Gitwe, au Rwanda, en 2019. En bonne santé, 529 couples mère-enfant célibataireontétérecrutésconsécutivement à l'hôpital du district de Gitwe.

Résultats: Le fardeau des issues néonatalesindésirablessignificatives dans cette étude rurale (accouchement par césarienne, faiblepoids à la naissance, dystrophie ponderal pour l'âgegestationnel et prématurité) était de 38,8 %, 10,6 %, 21,4 % et 4,9 %, respectivement. Les caractéristiquesmaternellessignificatives (p < 0,05) associées à l'accouchement par césarienneétaientl'obésité, le nombreélevé de visitesprénatales (> 6),

Maternal determinants of adverse neonatal outcomes in a rural district hospital in East Africa
Ogah Adenike Oluwakemi et al

101

la religion non chrétienne, l'éducationuniversitaire, les entrepreneurs, la séropositivité au VIH et la petite taille. Les mèrescélibatairesétaientsusceptibles de produire des bébés de faiblepoids de naissance et prématurés, tandis que les primigestesétaientsusceptibles de donner naissance à des bébésdystrophique (SGA). L'ampleur des issues défavorables à la naissance dans cette étude ruraleétait plusélevée que ce qui existe dans la littérature et leursfacteursen cause n'étaient pas les mêmesqu'en milieu urbain et au niveau national.

Conclusion et recommandations: Le fardeau des issues défavorables à la naissance dans cette étude était plus élevé que celui de plusieurspays du monde. Par conséquent, les mères (sans négligerleurstatut matrimonial, VIH, parité et religion) résidant dans ces zones rurales devraientbénéficierenpriorité des interventions de soins de santé, afin de réduire les effets à court et à long terme de ces issues défavorables à la naissance.

Mots clés : prématuré, faiblepoids de naissance, dystrophiestaturoponderale (SGA), césarienne, issues défavorables à l'accouchement, rural, urbain.

Introduction

Adverse birth outcomes are measures of health at birth and their magnitude is dramatically decreasing in the past 40 years. However, there is still a large gap between developing and developed countries.[1] Infants with one or more adverse birth outcomes are at greater risk for mortality and a variety of health and developmental problems. Adverse birth outcomes include preterm birth, low birth weight, stillbirth, macrosomia, congenital anomaly, and infant/neonatal death.[1]These adverse birth outcomes often require cesarean section delivery and contribute to more than 75% of neonatal deaths that occur in the first weeks of life. Preterm birth is a live birth before 37 completed weeks of gestation and is the leading cause of neonatal mortality.[2] Low birthweight is an infant, who weighed less than 2500 g at birth, regardless of gestational age.[3]

The overall prevalence of adverse birth outcomes is 25.7% in rural India,[4] 15.61% in Zimbabwe,[5] and 10.8% in rural Uganda.[6]Historically, rural areas have had more healthcare problems than urban areas, most likely due to lower healthcare provision and utilization.[7]
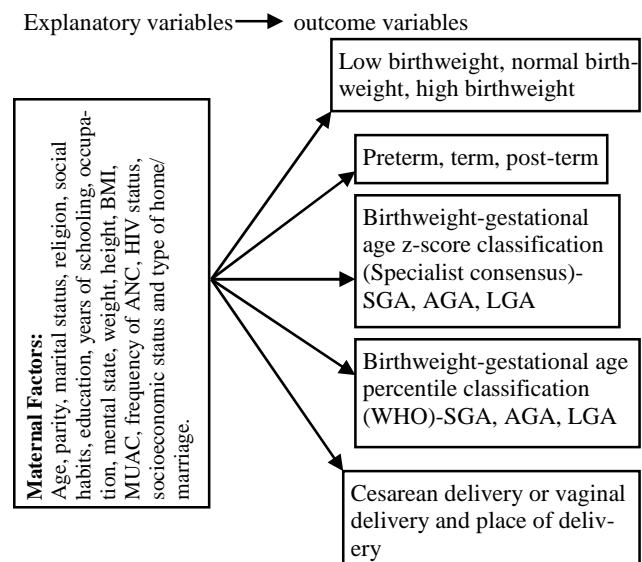
Maternal factors associated with neonatal mortality, which is the extreme of adverse birth outcomes in the same study site (Gitwe District Hospital, Southern Province of Rwanda), as observed by Ndayisenga et al? (2014) included grandmultigravida, positive HIV status, infrequent antenatal clinic visits and home delivery.[8]Kibe et al (2022) noted that cesarean section deliveries were disproportionately high among women of high socioeconomic groups, with residence in Kigali city and attended at least four antenatal care visits.Butcesarean section was significantly lower among multiparous mothers.[9]In an hospital-based unmatched prospective case-control study, in Western Ethiopia, a predominantly rural region, the odds of developing adverse birth outcomes were 3.92 times higher in mothers, who had one-time ante-natal visit (ANC) attendance than mothers who attended four and above times (2020).[10] Vahid et al. (2023) observed in a retrospective study of 8888 pregnant mothers in Iran, those living in rural areas had a higher risk of developing anemia, preterm birth, post-term pregnancies, LBW, need for neonatal resuscitation, and NICU admission, but a lower risk of cesarean section, compared to those living in urban areas.[11]

Similarly, cesarean section rate was higher in urban (10.4%) than rural areas (3.8%) in a study by Ahinkorah et al. (2022), a multi-country study in sub-Saharan Africa. Wealth index (39.2%), antenatal care attendance (13.4%), parity (12.8%), mother's educational level (3.5%), and health insurance subscription (3.1%) explained approximately 72% of the rural–urban disparities in caesarean deliveries. After conducting secondary analysis of the demographic and health surveys of 28 nations, these authors postulated that, if the child and maternal characteristics were levelled, more than half of the rural–urban inequality in adverse birth outcomes would be reduced.[12]For effective attenuation of adverse birth outcomes, data pertaining to determinants of adverse birth outcomes are important. The findings of this study will assist the health care policy makers and providers, in planning tailored interventions to improve the wellbeing of children and women in the rural areas.

Concept of the study

Figure 1, shows the maternal determinants of adverse birth outcomes, that were investigated in this study.

Fig 1: Concept of the study

Explanatory variables ⟶ outcome variables

Maternal Factors:
Age, parity, marital status, religion, social habits, education, years of schooling, occupation, mental state, weight, height, BMI, MUAC, frequency of ANC, HIV status, socioeconomic status and type of home/ marriage.

- Low birthweight, normal birthweight, high birthweight
- Preterm, term, post-term
- Birthweight-gestational age z-score classification (Specialist consensus)- SGA, AGA, LGA
- Birthweight-gestational age percentile classification (WHO)-SGA, AGA, LGA
- Cesarean delivery or vaginal delivery and place of delivery

Maternal determinants of adverse neonatal outcomes in a rural district hospital in East Africa
Ogah Adenike Oluwakemi et al

102

Materials and methods

The methods employed in carrying out this study is discussed in this section.

Study setting

Rwanda is a landlocked country located in the central-eastern part of Africa. It is a low-income country with a population of about 13 million people. The country's health system is a 'pyramid' with the top of the pyramid being the Ministry of health responsible for sector coordination and oversight and setting health policies and strategies. Currently, Rwanda has 567public health facilities including 504 Health centers, 7 Medicalized Health Centers, 40 District, 4 Provincial, 4 Specialized and 8 Referral hospitals. Health posts are entities working at the lowest level and operating under public-private partnership models; there are 1222 Health Posts in Rwanda.[13]

Non-availability of regular supplies of clean and safe water, has been a longstanding problem in Rwanda, as a whole, probably because of its landlocked and hilly terrains, making construction and supply of piped water, a major challenge. The public piped water flows infrequently and the taps and pipes may be rusted and breached in some places, especially in the rural areas, further leading to contamination of household water. Many families store rain water in big tanks for use in their homes and this may become polluted (in the writer's opinion) because of difficulties of cleaning these storage tanks. A few non-profit organizations, such as USAID and Water-for-life have sunk bore holes in strategic locations in a few villages in the country, with the aim of alleviating this water problem.[13]

Gitwe village is located at a high altitude of 1,674 meters above sea level, in the southern province, 240km from Kigali, which is the capital city of Rwanda. Gitwe General hospital was set up in 1995, immediately after the genocide, for the purposes of providing medical services and later training, for this isolated community. The hospital has been fully supported by the government since the year 2020. The maximum number of deliveries at the hospital per month is about 200. Some of the challenges in the hospital include poor specialist coverage and few trained health workers, poor supply of equipment, water, electricity, laboratory services and medicines. Challenging cases are referred to the University Teaching hospital in Butare or Kigali. Gitwe village was selected for this study, because there was no published birth data from this poorly researched, remote community. In 2019, birth, feeding and growth data on 529 healthy mother-singleton newborn pairs were compiled in this village, over a period of 12months for this study, which was carried out in the delivery and post natal wards of Gitwe General hospital and at its annex, the maternal and child health clinic.

Data source and sample

This was a prospective cohort study design. Mother-newborn pairs were recruited consecutively, on first-come-first-serve basis. Maternal file review and newborn anthropometry [weight (kg), length (cm) and head circumference (cm) measurements, recorded to the nearest decimals] were carried out, soon after birth. Maternal sociodemographic, antenatal and nutritional data were obtained using questionnaires, which were read to the mothers and filled by the research assistants. Maternal anthropometry was measured at 6 weeks postpartum and recorded and their BMI and MUAC were computed. Four approaches were used to classify the newborn: gestational age, birthweight, birthweight-gestational age percentile (WHO), and birthweight-gestational age z-score (Specialists consensus). Newborn gestational age was determined using the maternal last menstrual period (LMP), fetal ultrasound gestational age dating (preferably done at first trimester) and/or expanded new Ballard criteria and were classified into preterm, term and post-term. Birthweight regardless of gestational age, with cut-off points of 2.5-3.9kg for normal birth weight. Birthweight-gestational age newborn classification (globally recommended) into small-for-gestational age (SGA), appropriate-for-gestational age (AGA) and large-for-gestational age (LGA) was done: according to WHO using 10th-90th percentiles cut-off points for AGA and according to Specialists consensus using ±2 z-score cut-off points for AGA. It is worth noting that newborn classification is rarely done routinely in the study site. Newborn place and mode of delivery were also recorded.

To ensure the quality of data collected, 2 registered nurses were trained as research assistants at Gitwe Hospital for 2 days on the over-all procedure of mother and newborn anthropometry and data collection by the investigator. The questionnaires were pre-tested before the actual data collection period, on 10 mother-infant pair participants (2% of the total sample). The investigator closely followed the day-to-day data collection process and ensured completeness and consistency of the questionnaires administered each day, before data entry.

Statistical analysis

Data clean up, cross-checking and coding were done before analysis. These data were entered into Microsoft Excel statistical software for storage and then exported to SPSS version-26 for further analysis. Both descriptive and analytical statistical procedures were utilized. Participants' categorical characteristics were summarised in frequencies and percentages. A multivariate, multinomial and binary logistic regression models and Chi test were created to examine the relationships between the antenatal maternal independent variables (age, parity, marital status, religion, social habits, education, years of schooling, occupation, mental state, weight, height, BMI, MUAC, frequency of ANC, HIV status, socioeconomic status and type of home/marriage) and dependent

variables [gestational age, birthweight classification, birthweight-gestational age z-score classification (Specialists' consensus), birthweight-gestational age percentile classification (WHO), place and mode of delivery] and to generate the odds ratio. Factors with p-values <0.1 were included in the regression models. Odds ratio (OR), with a 95% confidence interval (CI) were computed to assess the strength of association between independent and dependent variables. Significant environmental factors determining birth outcomes were cross-tabulated. For all, statistical significance was declared at p-value < 0.05. The reporting in this study were guided by the STROBE guidelines for observational studies.

Ethics

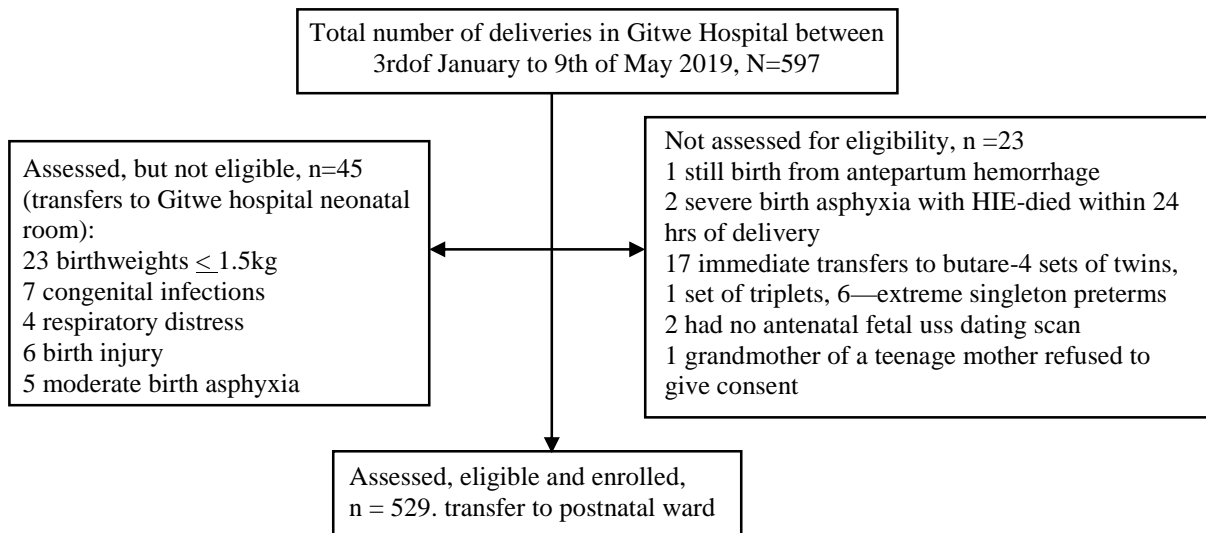Ethical approval from the Health Sciences Research Ethics Committee of the University of the Free State in South Africa (Ethical Clearance Number: UFS-HSD2018/1493/2901) was obtained. Written permission to collect data was obtained from the Director of Gitwe Hospital and the eligible mothers gave their verbal informed consent before enrolment. The participants were given research identity numbers and the principal investigator was responsible for the safe keeping of the completed questionnaires and collected data, to ensure anonymity and confidentiality of the participants.

Results

The following are the results obtained from the study.
Participants
Five hundred and ninety-seven (597) babies were delivered at Gitwe Hospital, Rwanda, between 3rdJanuary 2019 and 9thMay 2019, out of which, eligible 529 mother-newborn pairs were enrolled into the study, Figure 2.

Fig 2: Flow of participants from admission to recruitment into study

Total number of deliveries in Gitwe Hospital between 3rdof January to 9th of May 2019, N=597

Assessed, but not eligible, n=45 (transfers to Gitwe hospital neonatal room):
23 birthweights $\leq$ 1.5kg
7 congenital infections
4 respiratory distress
6 birth injury
5 moderate birth asphyxia

Not assessed for eligibility, n =23
1 still birth from antepartum hemorrhage
2 severe birth asphyxia with HIE-died within 24 hrs of delivery
17 immediate transfers to butare-4 sets of twins, 1 set of triplets, 6—extreme singleton preterms
2 had no antenatal fetal uss dating scan
1 grandmother of a teenage mother refused to give consent

Assessed, eligible and enrolled, n = 529. transfer to postnatal ward

Newborn characteristics

Prevalence rates of small for gestational age (SGA), appropriate for gestational age (AGA) and large for gestational age (LGA) babies, were 21.4%, 71.6% and 7.0%, respectively, according to WHO percentile classification, Table 1. According to Specialists' consensus z-score classification, there were SGA (5.3%), AGA (91.5%) and LGA (3.2%). Spearman rho correlation coefficient between the 2 classifications was fairly strong at 0.539. The majority were male (53.5%) and term babies (57.5%). Cesarean section delivery rate was 38.8% and 2 babies (0.4%) were not delivered in any health facility.

Maternal characteristics (independent variables)

The median values for age, parity, duration of schooling, weight, height and BMI of the mothers were 28 years, 2.0, 6years, 62.0kg, 159cm and 24.7kg/m^2, respectively, Table 2.

The highest percentage of the mothers in the study, were young in age (43.9%), of primary school education (65.8%), unemployed/unskilled (58.8%), married (90.7%), Christians (97.5%), middle class (75.0%), and of moderate parity (51.4%). Three (0.6%) mothers did not attend antenatal care clinic, and the majority (56.9%) had insufficient ANC visits (1-3). HIV positivity rate amongst the mothers was 5.1%. Majority of the mothers had good BMI (99.2%) and MUAC (95.3%), Table 3.

Maternal determinants of adverse neonatal outcomes in a rural district hospital in East Africa
Ogah Adenike Oluwakemi et al
104

Table 1: Newborn characteristics (outcome variables) in the study

Characteristics	Frequency	Percent
Weight-for-gestational age (WHO, 1995)		
Small-for-gestational age (<10th percentile)	113	21.4
Appropriate-for-gestational age (10th -90th percentile)	379	71.6
Large-for-gestational age (>90th percentile)	37	7.0
Birth weight (grams)		
Low birthweight (<2500)	56	10.6
Normal birthweight (2500-3999)	461	87.1
High birthweight (>3999)	12	2.3
Mode of delivery		
Cesarean section	205	38.8
Vaginal delivery	324	61.2
Place of delivery		
Outside health facility	2	0.4
Inside health facility	527	99.6
Gender		
Female	246	46.5
Male	283	53.5
Gestational age		
Preterm	26	4.9
Term	304	57.5
Post-term	199	37.6
Total	529	100.0

Table 2: Numerical characteristics of mothers in the study (n=529)

	Mean	SD	95%CI	Median	IQR
Age of mother (years)	27.9	6.44	27.33, 28.43	28.0	23, 33
Parity of mother	2.5	1.72	2.35, 2.64	2.0	1, 3
Duration of schooling (years)	7.4	3.33	7.10, 7.67	6.0	6, 9
Weight (kg)	63.2	8.72	62.50, 64.00	62.0	58, 68.5
Height (cm)	159.3	5.77	158.8, 159.8	159	157,161
BMI (kg/m^2)	24.9	3.09	24.6, 25.2	24.7	22.9,26.6

Multivariate logistic regression analysis of maternal factors predicting birth outcomes

According to the Wilks' Lambda's test in the multivariate logistic regression analysis in Table 4; significant maternal factors determining birth outcomes were: number of years spent in school (p=0.049), frequency of antenatal visits (p=0.021),educational level (p=0.011),HIV status (p=0.001), occupation (p=0.001) and marital status (p=0.007).

The tests of between-subjects multivariate regression post-hoc analysis

The tests of between-subjects effects analysis, revealed that the mode of delivery was significantly determined by maternal duration of schooling in years

Table 3: Categorical characteristics of mothers in the study (n=529)

Characteristics	Frequency	Percent
Age (completed years)		
18 (Teenage mother)	23	4.3
19-25 (Very young mother)	195	36.9
26-35 (Young mother)	232	43.9
>35 (Elderly mother)	79	14.9
Education		
None/Informal	26	4.9
Primary	348	65.8
'O' level secondary	105	19.8
'A' level secondary/College	32	6.0
University	18	3.4
HIV status		
Positive	27	5.1
Negative	502	94.9
Occupation		
Unemployed/Unskilled	311	58.8
Semi-skilled/Skilled technician Shop owner	195	36.9
	13	2.5
Professional	10	1.9
Marital status		
Not married (single/separated)	49	9.3
Married	480	90.7
Religion		
Islam	13	2.5
Christian	516	97.5
MUAC (cm)		
Low (<23)	25	4.7
Not low (23)	504	95.3
BMI (kg/m^2)		
Thin (<18.5)	4	0.8
Not thin (18.5)	525	99.2
Maternal height (cm)		
Short (<150)	39	7.4
Not short (150)	490	92.6
Parity		
Primiparous (1)	196	37.1
Moderate parity (2-4)	272	51.4
Multiparous (5)	61	11.5
Socioeconomic status		
Destitute/Poor	115	21.8
Middle	397	75.0
Rich	17	3.2
Frequency of visits for antenatal care		
0 to <4	301	56.9
4	228	43.1
Total	529	100.0

(p=0.001),weight (p=0.003),height (p=0.002), BMI (p=0.012), frequency of antenatal visits (p<0.001), educational level (p<0.001), occupation (p<0.001), HIV status (p<0.001) and religion (p=0.021).
The birthweight classification was significantly determined by maternal HIV status (p=0.027) occupation (p=0.031); marital status (p=0.024) and religion (p=0.047). Gestational age was significantly determined by marital status (p=0.002). Baby's gender was signifi-

Maternal determinants of adverse neonatal outcomes in a rural district hospital in East Africa
Ogah Adenike Oluwakemi et al

105

cantly determined by maternal occupation (p=0.028).Newborn 1995 birthweight-gestational age percentile classification (WHO) was significantly determined by frequency of antenatal visits (p=0.010);while the classification using the 2007 birthweight-gestational age z-score was determined by parity (p=0.002).

Binary logistic regression analysis investigating maternal factors predicting mode of delivery and neonatal gender

In the binary logistic regression analysis investigating the relationship between significant maternal factors (identified during multivariate logistic regression analysis) and mode of delivery, maternal level of education (wald 20.1), occupation (wald 18.7) and then frequency of antenatal visits (wald 17.2) were the strongest characteristics determining mode of delivery, among other significant factors such as number of years of schooling (wald 10.3), maternal weight (wald 5.4) and height (wald 7.0), BMI (wald 4.1), religion (wald 5.4) and HIV status (wald 7.4).

The lower the number of years of schooling, the less likely the mothers will deliver by cesarean section (p=0.001; OR=0.75; 95%CI 0.63, 0.90). Independent sample T-test result showed that the mean number of years of schooling in the group of women (205 in number, 38.8%), who delivered by c-section (8.13years, SD 4.12) was significantly higher than those (324 in number, 61.2%), who delivered vaginally (6.91years, SD 2.62), p<0.001 (95% CI of the difference was 0.64, 1.79).The primary school leavers were particularly, less likely to deliver by cesarean section (p=0.019; OR=0.02; 95%CI 0.001, 0.52) compared to their counterparts.
The professional group of mothers (p=0.023; OR=16.39; 95%CI 1.47, 100) were more likely to deliver by c-section compared to the unemployed or unskilled labour mothers.There was no longer any significant relationship (wald 1.9, p=0.163) between maternal occupation and sex of the newborn after binary logistic regression analysis. However, female babies were 1.84 (95% CI 0.78, 4.32) times more commonly observed with entrepreneur or professional mothers than their counterparts, who were either unemployed or engaged in an unskilled ortechnical kind of labour. Cross-tabulation between maternal occupation and prenatal exposure to potentially harmful social habits such as alcohol, herbs, and tobacco revealed a significant relationship (p<0.001), in which, 66 (12.5%) out of the 529 mothers had prenatal exposure. Fifty-eight (87.9%) out of the 66 that were exposed were mothers that were either unemployed or engaged in unskilled labour. Eight (12.1%) of the 66 exposed, were mothers with semi-skilled or skilled technical jobs. Of note, was that, none of the entrepreneur or professional mothers were exposed. These unprescribed prenatal ingestions/exposures may have contained some sex selection drugs such as sex steroids.

The lower the maternal weight, the less likely the mother will deliver via cesarean section (p=0.020; OR 0.71; 95%CI 0.53, 0.95).Independent sample T-test result showed that the mean maternal weight in the group of women (205 38.8%), who delivered by c-section (64.19kg, SD 9.83) was significantly higher than those (324 61.2%), who delivered vaginally (62.59kg, SD 7.89), p=0.050 (95% CI of the difference was 0.00, 3.20).
The taller the mother, the more likely she will deliver via cesarean section (p=0.008; OR 1.38; 95%CI 1.09, 1.76). However, it was noted that the mean weight of the mothers, who were considered short (height <150cm)in the study, were significantly (p<0.001) lighter (57.74kg, SD 10.07) than those that were considered tall (63.65kg, SD 8.46); 95%CI of the difference was -8.71, -3.10.) Independent sample T-test result showed that the mean maternal height in the group of women (205, 38.8%), who delivered by c-section (158.76cm, SD 6.70) was similar to those (324, 61.2%), who delivered vaginally (159.58cm, SD 5.07), p=0.135 (95% CI of the difference was -1.89, 0.26).
Independent sample T-test result showed that the mean number of antenatal visits in the group of women (205 38.8%), who delivered by c-section (3.86, SD 1.20) was significantly higher than those (324 61.2%), who delivered vaginally (3.19, SD 0.84), p<0.001 (95% CI of the difference was 0.48, 0.86).

The higher the maternal BMI, the more likely the mother will deliver via cesarean section (p=0.043; OR 2.11; 95%CI 1.02, 4.36). Independent sample T-test result showed that the mean maternal BMI in the group of women (205, 38.8%), who delivered by c-section (25.43, SD 3.33) was significantly higher than those (324 61.2%), who delivered vaginally (24.58, SD 2.88), p=0.002 (95% CI of the difference was 0.32, 1.39).
Mothers of Christian religion were less likely to deliver by c-section compared to the mothers of the Muslim faith, p=0.020; OR=0.07 (95%CI 0.01, 0.66). HIV negative mothers were less likely to deliver by c-section, compared to their HIV positive counterparts, p=0.007, OR=0.17 (95%CI 0.05, 0.61).

Multinomial logistic regression analysis of significant maternal factors determining neonatal birth size and gestational age

In the multinomial logistic regression analysis investigating the relationship between significant maternal factors (identified during multivariate logistic regression analysis) and neonatal birth weight, marital status (wald12.2, p<0.001) was the only characteristic that remained significant in determining neonatal birthweight, among other factors such as maternal HIV status (wald1.5, p=0.226), religion (wald0.3, p=0.577) and occupation (wald1.5, p=0.221). The odds of a single mother giving birth to a LBW baby was 3.56 times higher (95%CI 1.75, 7.27) than that of a married mother. Likewise, the odds of a single mother giving birth to a preterm baby was 6.33 times higher (wald 10.2; p=0.001; 95%CI 2.04, 19.53) than that of a married mother.

Maternal determinants of adverse neonatal outcomes in a rural district hospital in East Africa
Ogah Adenike Oluwakemi et al

106

The multiparous mother was less likely to give birth to an SGA (p=0.025, OR=0.17, 95%CI 0.04, 0.80) or to an AGA (p=0.001, OR=0.17, 95%CI 0.06, 0.46) baby, compared to a mother with lower parity. The multiparous mother was more likely to give birth to a LGA baby, (according to birthweight-gestational age z-score classification). Number of antenatal visits was no longer significant in determining birthweight-for-gestational age percentile (according to WHO classification) after multinomial regression analysis (wald 1.1, p=0.288). However, those who had insufficient number of antenatal visits were more likely to deliver an SGA baby (OR=3.09; 95% CI 0.39, 28.82), compared to those, who received adequate antenatal care.

Cross tabulation of significant maternal factors and birth outcomes

Mothers belonging to the obese category (17 out of 26, 65.4%), mothers who frequented the antenatal clinic more than 6 times during pregnancy (8 out of 10, 80.0%), Muslim mothers (12 out of 13, 92.3%), those with university education (12 out of 18, 66.7%), entrepreneurs (10 out of 13, 76.9%), those who were HIV positive (24 out of 27, 88.9%) and those who were short (29 out of 39, 74.4%) were more likely to be delivered by c-section compared to their counterparts. Of note, the HIV positivity rate was significantly higher amongst the Muslim mothers (3 out of 13, 23.1%) compared to the Christian mothers (24 out of 516, 4.7%), p=0.003.And a higher percentage of entrepreneurs were observed among the Muslims (2 out of 13, 15.4%) compared to the Christian mothers (11 out of 516, 2.1%)

In Table 5, a higher percentage of single mothers gave birth to LBW (13 out of 49, 26.5%) and preterm babies (6 out of 49, 12.2%) compared to their married counterparts. A higher percentage of primiparous mothers gave birth to SGA (14 out of 196, 7.1%) and the multiparous mothers gave birth to LGA babies (7 out of 61, 11.5%).

Table 4: Cross tabulation of significant maternal factors and mode of delivery, n=529

	p-value	Mode of delivery C-section (%)	Vaginal Delivery (%)	Total (100.0)
Maternal BMI	0.008			
Underweight(<18.5)		1 (25.0)	3 (75.0)	4
Normal (18.5-24.9)		101 (34.1)	195 (65.9)	296
Overweight(25-29.9)		86 (42.4)	117 (57.6)	203
Obese (30)		17 (65.4)	9 (34.6)	26
Frequency of antenatal care visits	<0.001			
Low (<4)		76 (25.2)	225 (74.8)	301
Normal (4-6)		121 (55.5)	97 (44.5)	218
High (>6)		8 (80.0)	2 (20.0)	10
Religion	<0.001			
Muslim		12 (92.3)	1 (7.7)	13
Christian		193 (37.4)	32 (62.6)	516
Education	<0.001			
None/Informal education		15(57.7)	11 (42.3)	26
Primary		108 (31.0)	240 (69.0)	348
'O' level secondary		50 (47.6)	55 (52.4)	105
'A' level secondary/ College		20 (62.5)	12 (37.5)	32
University		12 (66.7)	6 (33.3)	18
Occupation	<0.001			
Unemployed/Unskilled		134 (43.1)	177 (56.9)	311
Semi-skilled/Skilled technician		55 (28.2)	140 (71.8)	195
Entrepreneurs		10 (76.9)	3 (23.1)	13
Professional		6 (60.0)	4 (40.0)	10
Maternal HIV status	<0.001			
Positive		24 (88.9)	3 (11.1)	27
Negative		181 (36.1)	321 (63.9)	502
Maternal Height	<0.001			
<150cm (short)		29 (74.4)	10 (25.6)	39
150cm (not short)		176 (35.9)	314 (64.1)	490
Total		90 (17.0)	439 (83.0)	529 (100.0)

Table 5: Cross tabulation of significant maternal factors and newborn characteristics, n=529

		Birth weight (%), p<0.001			Total
		LBW	NBW	HBW	
Marital status	Single	13 (26.5)	36 (73.5)	0 (0.0)	49 (100.0)
	Married	43 (9.0)	425 (88.5)	12 (2.5)	480 (100.0)
	Total	56 (10.6)	461 (87.1)	12 (2.3)	529 (100.0)
Birth weight-for-gestational age z-score classification (%), p<0.001					
Parity		SGA	AGA	LGA	Total
	Primiparous	14 (7.1)	182 (92.9)	0 (0.0)	196 (100.0)
	Moderate parity	11 (4.0)	251 (92.3)	10 (3.7)	272 (100.0)
	Multiparous	3 (4.9)	51 (83.6)	7 (11.5)	61 (100.0)
	Total	28 (5.3)	484 (91.5)	17 (3.2)	529 (100.0)
Gestational age classification (%), p=0.002					
Marital status		Preterm	Term	Post term	Total
	Single	6 (12.2)	34 (69.4)	9 (18.4)	49 (100.0)
	Married	20 (4.2)	270 (56.3)	190 (39.6)	480 (100.0)
	Total	26 (4.9)	304 (57.5)	199 (37.6)	529 (100.0)

Note: NBW-normal birth weight; HBW-high birth weight

Maternal determinants of adverse neonatal outcomes in a rural district hospital in East Africa
Ogah Adenike Oluwakemi et al

107

Discussion

Maternal predisposing factors to adverse neonatal outcomes are often times assumed to be similar in rural and urban settings. This assumption has led to many failed or failing interventions. According to WHO report of the 2019-2020 RDHS,[14] the national rate of cesarean section was 15%; the rate was said to be higher in the urban areas (25%) and lower in the rural areas (13%); highest in Kigali city (25%) and lowest in the Northern province of Rwanda at 12%. Nineteen percent of the mothers with four or more ANC visits were delivered via cesarean section, as compared with only 3% of births to mothers with no ANC visits. Cesarean section deliveries were most common (19%) among first-order births and decrease as birth order increases. The proportion of cesarean section deliveries increases with increasing maternal education and wealth.

In that same year of 2019, the rate of c-section was at least 38.8% (this rate could have been higher, if the very small and sick babies were included in this study) in this rural Gitwe village. This rate was even higher than the rates in Kigali city (RDHS 2020) and Namibia (16.1%), which was considered the highest in sub-Saharan Africa (sSA) according to Ahinkorah in 2022.[12] This study finding is the reverse of what exists in literature, that state that c-section was more common in the urban than rural areas. The drivers of c-section were similar in both this study and in the 2020 Rwanda Demographic Health Survey (RDHS) report, except that maternal HIV positivity, excessive BMI and non-Christian religion status were significant predictors of c-section delivery in this rural study. This was not the situation in the RDHS (2020) and Kibe et al (2022)'s reports, because these 2 reports concentrated more on larger, more accessible and more urban communities. As earlier alluded, Gitwe village has been poorly researched and has never appeared in any of the RDHS studies before this data was collected.[9] Supervised medical practice and coverage is poor in rural areas and that could be one of the reasons why maternal HIV status could have become a significant determinant of mode of delivery in such rural community.[15] The WHO has recommended an optimal c-section rate of 10–15%, above which, suggests overuse and of no benefit.[9] However, according to this study report, it appears this WHO recommendation has not been adhered to. Excessive BMI is a known risk factor for complicated pregnancy that could result in c-section delivery.[15, 16]

Preterm and LBW births were significantly associated with unmarried women in this rural study. This was contrary to the findings of Rutayisire et al's study,[17] involving 817 women in 30 health facilities in 10 districts (including urban centres) of Rwanda; where married women (54.9%) were significantly associated with preterm births, compared with single mothers (7.1%). Preterm birth rate was 13.8% in Rutayisire et al's study (2020), but was at least 4.9% in this Gitwe study. The wide disparity in the prevalence of preterm birth, may be as a result of excluding the very small and sick babies from this study and in the varying methods of determining gestational age in both studies. However, similar to Rutayisire et al's study (2020), preterm birth was more common in the rural areas (74.3%) of Rwanda, compared to urban (25.7%).

LBW rate was 7% in the 2020 RDHS report, lower than the 10.6% reported in this rural (Gitwe) study. This study's LBW rate was lower than the incidence of LBW (23.7%) reported in a tertiary hospital-based urban study in Ghana.[18] Afaya et al (2021) observed that being married has a protective effect on LBW [AOR = 0.60 (95%CI: 0.40–0.90), p = 0.013] compared to single mothers, similar to the findings in this study.[18]

The rate of SGA in a national retrospective study in Mexico (2021) was 6.7% and was noted to occur more among primiparous (aOR 1.42; 95% CI: 1.39, 1.43) mothers and mothers living in highly deprived localities (aOR 1.39; 95% CI: 1.36, 1.43).[19] This Mexico rate was at least 3 times lower than the 21.4% rate of SGA reported in this rural study. The reason for this huge difference in the rates of SGA among the Rwanda and Mexico studies could be traced to the different growth standards utilized in the 2 studies. The Mexico study used the INTERGOWTH-21st century growth standard, while the PediTool growth calculator (which was based on WHO growth standard) was used to determine the birthweight-gestational age percentiles of the babies in the Rwanda study. The rate of preterm birth was higher in this Rwanda study. Also, the characteristics of the mothers in the 2 studies were not similar. For example, the percentage of teenage pregnancies was 3times lower in this Rwanda study compared to the Mexico study; the maternal education level was lower in this Rwanda study; and a much larger sample size (2,064,507) was used in the Mexico study There was no information on SGA in the RDHS report.

Preterm, LBW and SGA births are the primary causes of perinatal illness and mortality worldwide.[20] They are the biggest healthcare challenges as they are associated with long-term disability and financial strain from the costs of care, especially in underdeveloped nations. They have also long-term adverse effects, such as poor neurodevelopment leading to learning disabilities, cerebral palsy, and vision abnormalities among others.[21]

The exclusion of very small (<1.5kg), still births, major anomalies, very sick and multiple gestation babies, from the study (as resuscitation and transfer for specialized care were prioritized in these babies), could have weakened the study power and therefore was considered a limitation. Small numbers of preterm and post-term babies and some subcategories of mothers, such as the highly educated, professionals, entrepreneurs, mothers who did not use charcoal, mothers who did not attend ANC clinic; challenged our statistical analysis, thereby necessitating merging of some sub categories in some cases, during the analysis.

Maternal determinants of adverse neonatal outcomes in a rural district hospital in East Africa
Ogah Adenike Oluwakemi et al
108

The strength of the study included the standard neonatal anthropometry and classification that were carried out for better management of these babies. This was not a routine practice in this non-specialised hospital. Birth data was generated for this remote community and made available for interested stakeholders to work with and improve the health status of mother and newborn in this community. This study also supplied additional information that was excluded in the RDHS.

residing in rural settings should be priortised on health intervention programs by healthcare providers, policy-makers, and researchers, in order to lower the short- and long-term effects of these adverse birth outcomes.

Conclusion and Recommendations

The magnitude of adverse neonatal outcomes in this rural study was unexpectedly higher than in the most recent Rwandan demographic health survey and those of several countries in the world. Therefore, mothers (not neglecting their marital, HIV, parity and religion status)

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