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Hemoglobin level, anemia, and obesity among pregnant women in Kigali, Rwanda: a hospital-based cross-sectional study

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Abstract

Background Globally, there is an increasing trend of obesity in pregnant women, and Sub-Saharan Africa is not an exception. Recently, hemoglobin and anemia have received more attention as predictors of maternal obesity. No such study exists in Rwanda. Thus, the current study aimed to investigate the prevalence and the factors associated with obesity, including hemoglobin and anemia, among pregnant women in Kigali, Rwanda.

Methods A cross-sectional study was conducted in two hospitals in Kigali, Rwanda, from June to August 2024. A questionnaire was used to collect sociodemographic data. Weight, height, and hemoglobin were measured using standard procedures. Multinomial logistic regression analysis was performed.

Results A total of 445 pregnant women were recruited. The median (interquartile range [IQR]) age and parity were 30.0 (26.0–35.0) years and 1 (0–3), respectively. Of the 445 women, 143 (32.1%), 249 (56.0%), and 53 (11.9%) were of normal weight, overweight, and obese, respectively. One hundred and seven (24.0%) pregnant women had anemia. In multivariate multinomial regression, no significant association was found between age, parity, residency, education, maternal occupation, hemoglobin level, anemia, and overweight status. Being from rural areas (adjusted odds ratio [AOR] = 2.54, 95% confidence interval [CI] 1.16–5.56) and being a housewife (AOR = 4.34, 95% 1.42–13.26) were significantly associated with obesity. While an increase in hemoglobin level was associated with obesity (AOR = 1.28, 95% CI 1.02–1.60), anemia was inversely negatively associated with obesity (AOR = 0.33, 95% CI 0.12–0.93).

Conclusion This study indicates that 12% of the pregnant women in Rwanda were obese. Hemoglobin and anemia are associated with maternal obesity in Rwanda. There is a need for more efforts in nutritional programs targeting pregnant women to combat maternal obesity in Rwanda. Future research is recommended to explore the impact of maternal obesity on maternal and perinatal health.

Keywords Pregnant women, Overweight, Obese, Age, Hemoglobin

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Introduction

Globally, there is an increasing trend in the prevalence of maternal obesity; few comprehensive studies exist in Africa where poor maternal and perinatal occur [1, 2]. Maternal obesity is increasingly recognized as a significant public health challenge, particularly in low- and middle-income countries (LMICs) such as Rwanda [1, 3–6]. High prevalence of maternal obesity was reported in Nigeria 10.7% [6], and Sudan (25.1%) [7]. Onubi et al., in their systematic review and meta-analysis, reported that the prevalence of maternal obesity across Africa ranged from 6.5 to 50.7% [1]. According to the analysis of demographic and health surveys data from 24 African countries, from 1991 to 2014, obesity doubled among urban women in certain countries [5].

Several factors, such as age [1, 8], parity [1, 9], residency, and education [6, 8, 10] are associated with obesity during pregnancy. Maternal obesity is associated with various adverse health outcomes, including increased risk of cesarean delivery, postpartum hemorrhage, long-term health issues for both mothers and their children [10, 11] and maternal mortality [12]. Recently, more attention has been paid to the association between maternal obesity and hemoglobin [7, 9, 13, 14]. Both low and high maternal hemoglobin levels were found to be associated with poor maternal and perinatal outcomes, including low birth weight (LBW) and preterm birth, small-for-gestational-age (SGA), stillbirth, maternal mortality, gestational diabetes, and pre-eclampsia [15, 16].

The level and the direction of association between obesity, hemoglobin levels, and anemia are not yet settled. While some studies have reported a positive association between increasing hemoglobin levels and maternal obesity [9, 17], other studies have shown that hemoglobin levels are significantly lower in women with obesity [18], and that pregnant women with obesity are at a higher risk for anemia [4, 5].

According to the Rwanda Demographic and Health Survey (RDHS) 2010, the prevalence of overweight and obesity among women of reproductive age has increased dramatically, with estimates indicating that nearly 30% of women are now classified as overweight or obese in Kigali city [10]. Also, the RDHS indicates that urbanization, economic development, and shifts in cultural practices are contributing to increased rates of women's obesity [10]. Similar to other African countries, the prevalence of obesity among pregnant women in Rwanda reflects a growing public health concern. Nkubitoet al., [19] in their study included 1000 Rwandan pregnant women; 26.1% and 6.7% were overweight and obese, respectively. The rising prevalence of obesity among African pregnant women, including Rwandan ones, poses serious risks to maternal, neonatal, and child health outcomes, including gestational diabetes, hypertension, and complications during delivery such as macrosomia and cesarean section. This trend of increasing maternal obesity necessitates a deeper understanding of its contributory factors to maternal obesity in Rwanda, as well as its implications for hemoglobin levels and overall maternal health. In addition to obesity, in Rwanda, studies reported a high prevalence of anemia in pregnancy, ranging from 24.6% [20] to 29.4% [21].

Although nutritional status during childbearing age has been studied in several studies in Rwanda, less is known about nutritional status during pregnancy [20, 21], and no comprehensive research has explored the association between obesity and hemoglobin levels. Nevertheless, Nuwabaine et al. reported that pregnant women with normal body mass index (BMI) were three times at risk of being anemic [20]. In addition, a high prevalence of anemia was reported among pregnant women in African contexts, including Rwanda [6, 22–24]. Although Niyitegeka et al. reported low Knowledge regarding overweight and obesity prevention among women attending Kibagabaga Hospital, Rwanda, the prevalence and the possible associated factors with maternal overweight and obesity were not assessed [22]. Such predictive factors need to be investigated among other African contexts. The rising prevalence of maternal obesity and anemia in Rwanda are pressing public health issues that warrant immediate attention. Understanding the multifaceted factors that contribute to this trend, including socioeconomic conditions, dietary patterns, cultural beliefs, and lifestyle choices, is crucial for developing effective interventions. Furthermore, the few existing data about the relationship between maternal obesity and hemoglobin levels highlight the need for comprehensive health strategies that address both these public health problems (obesity and anemia). Therefore, the current study aimed to investigate the prevalence and the factors associated with obesity, including hemoglobin and anemia, among pregnant women in Kigali, Rwanda.

Methods

Study area

This hospital-based cross-sectional study was conducted from June to August 2024 at Kacyiru and Kibagabaga Hospitals, Kigali, Rwanda. These are the main two tertiary maternity hospitals in Kigali.

Study design and population

This study adhered to strengthening the reporting of observational studies in epidemiology (STROBE) guidelines [25]. The investigators trained three female medical officers, through workshops and piloting, in data collection methods to standardize the data collection procedure. All pregnant women who attending the delivery room for labour at the two hospitals were approached to participate in the study. Initially, one in every three consecutive attendees was selected to participate. However, specific inclusion criteria were followed, including obtaining informed consent and carrying a singleton pregnancy. Women who refused to give consent and/or had multiple pregnancies, as well as those with diseases such as hypertensive disorders of pregnancy and sickle cell disease, were excluded from this study.

Sample size calculation

The sample size of 445 pregnant women was computed using the OpenEpi software. We assumed that 30% of pregnant women would be overweight or obese, and this assumption was based on the prevalence (30.0%) of obesity among women of relative age in Kigali City, Rwanda [10]. We assumed that 30.0% of women with normal weight and 18.0% of obese women would have anemia, and this assumption was based on the prevalence of anemia among pregnant women in Rwanda [20, 21]. This sample size of 445 pregnant women was determined to detect a 5% difference at $\alpha = 0.05$ with 80% power.

Study variables and measures

The questionnaire was developed from previous similar studies [1, 6, 8, 9, 11]. The questionnaire included data on sociodemographic characteristics: women's age, residency (urban or rural), and educational level of the woman and her husband (more than secondary level or secondary level and below), maternal occupational status (housewife or employed); obstetrical data such as parity, history of miscarriage (yes or no), number of antenatal care visits and latter categorized into adequate antenatal care (eight visits and more) or inadequate antenatal care (less than eight visits); anthropometric measurements such as maternal weight and height and later expressed as BMI. A blood sample was collected from each pregnant woman to determine her hemoglobin level.

After the pregnant women agreed to participate and signed an informed consent form, the selected women were approached by the medical officers. The selected women were informed about the aims and all necessary information, including the voluntary participation in the study and their right to withdraw from the study at any time without giving any reason/s, and the preventive measures taken to ensure the privacy, confidentiality, and safety of the participants, such as excluding personal identifiers during data collection. The sociodemographic, obstetrical, and hematological parameters, including hemoglobin levels, were considered secondary outcomes, while overweight and obesity were considered primary outcomes.

Weight and height measurements

The weights of pregnant women were measured in kilograms (kg) using standard procedures, which involved well-calibrated scales adjusted to zero before each measurement. Weight was measured to the nearest 100 g (g). The women stood with minimal movement, with their hands by their sides. In addition, shoes and excess clothing were removed. Height was measured to the nearest 0.1 centimeter (cm), with the women standing straight with their backs against the wall and their feet together. The BMI was calculated using the following equation: weight in kg divided by height in meters squared (kg/m²), based on the maternal weight and height obtained. According to the WHO's standards, the BMI was classified as underweight (BMI < 18.5 kg/m^2), normal weight (BMI 18.5–24.9 kg/m^2), overweight (BMI 25–29.9 kg/m^2), and obese (BMI ≥ 30 kg/m^2) [26].

Blood samples processing

Each pregnant woman was requested to provide three to five ml of blood drawn in a plain tube under aseptic conditions. Hemoglobin was performed per the manufacturer's instructions (Sysmex KX-21, Japan) [27].Then, anemia was defined based on the obtained maternal hemoglobin levels; pregnant women were categorized as anemic when their hemoglobin level was less than 11 g/dl and non-anemic when their hemoglobin level was 11 g/dl or more [28].

Statistical analysis

The collected data were entered into IBM Statistical Product and Service Solutions (SPSS) for Windows (version 22.0; SPSS Inc., New York, NY) for analysis. Missing data (2.5%) were handled using regression-based imputation. Continuous data, such as age, parity, and hemoglobin, were evaluated for normality using the Kolmogorov–Smirnov test and were found to be non-normally distributed. Consequently, they were expressed as median (interquartile range [IQR]). The hemoglobin levels were compared between the different BMI groups using non-parametric tests (Kruskal–Wallis H). Furthermore, significant variables (p-value < 0.05) in the Kruskal–Wallis H test were analyzed using a post-hoc test to identify differences between the different BMI groups (adjusted p-value). Normal weight, overweight, and obese were used as dependent variables for univariate multinomial analysis. The socio-demographic data, including the women's age and residency, the educational level of the women and their husbands, and obstetrical variables such as parity, antenatal care, history of miscarriage, and hemoglobin levels and anemia, were used as independent variables for all analyses. Thereafter, variables with $p < 0.05$ in the Kruskal–Wallis H and/or univariate analysis were included in a multinomial regression analysis to control for potential confounding factors. The results of adjusted odds ratios (AORs) and a 95% confidence interval (CI) were calculated, and a p-value of $P<0.05$ was considered significant.

Results

General characteristics

In this study, 445 pregnant women were recruited. The median (IQR) age and parity were 30.0(26.0−35.0) years and 1(0 −3), respectively. The median (IQR) BMI was 25.9 (24.6–27.7) kg/m^2. The median (IQR) hemoglobin was 12.0 (11.0–13.0) g/dl (Table 1).

Of the total, 445,312 (70.1%) resided in urban areas, while the rest, 176, lived in rural areas. Of the total, 445, 101 (22.7%) had more than a secondary education level, 109 (24.5%) were employed, and 55 (12.4%) had a history of miscarriage. Ten women (2.2%) received adequate antenatal care, defined as eight or more visits. One hundred and seven (24.0%) pregnant women had anemia (Table 1). Of the 445 recruited pregnant women, 143 (32.1%), 249 (56.0%), and 53 (11.9%) were normal, overweight, and obese, respectively; no one was underweight. The median (IQR) hemoglobin levels for BMI groups for normal weight, overweight, and obese were 12.8(12.0−13.7) g/dl, 13.1(12.4−13.7) g/dl, and 13.2(12.4−14.2) g/dl, respectively.

The Kruskal-Wallis H test revealed that BMI groups were significantly associated with age, parity, and hemoglobin levels. Post-hoc tests showed a significant association between hemoglobin level, overweight, and obesity (Table 2). Residency, educational level of the pregnant women and husbands, and anemia were significantly associated with the BMI groups (Table 2).

In univariate multinomial lgistic regression analysis, age, parity, and hemoglobin level were associated with obesity. While being from rural areas, less educated women and husbands were positively associated with obesity, anemia was negatively associated with obesity. However, a history of miscarriage and antenatal care were not associated with obesity (Table o3).

In univariate and multivariate multinomial logistic regression, there was no association between age, parity, residency, education, maternal occupation, hemoglobin, or anemia in the overweight group compared to the normal weight group (Tables 3 and 4). In multivariate multinomial regression, being from rural areas (AOR = 2.54, 95% CI 1.16−5.56) and housewives (AOR = 4.34, 95% CI 1.42−13.26) were significantly associated with obesity. While increasing hemoglobin levels were associated with obesity (AOR = 1.28, 95% CI 1.02−1.60), anemia was negatively associated with obesity (AOR = 0.33, 95% CI 0.12−0.93) (Table 4).

Table 1 Sociodemographic characteristics of the studied pregnant women in Rwanda, 2024 (*n* = 445)

Variable		Total (*n* = 445)	
		Median	**Inter quartile range**
Age, years		30.0	26.0–35.0
Parity		1.0	0.0–2.0
Body mass index kg/m^2		25.9	24.6–27.7
Haemoglobin g/dl		12.0	11.0–13.0
		Frequency	Percentage
Residency	Urban	176	39.6
	Rural	269	60.4
Parity	Primipara	133	29.9
	Parous	312	70.1
Maternal education school level	> Secondary	101	22.7
	≤secondary	344	77.3
Husband education school level	> Secondary	205	46.1
	≤secondary	240	53.9
Maternal occupation	Housewife	336	75.5
	Employed	109	24.5
History of miscarriage	No	390	87.6
	Yes	55	12.4
Adequate antenatal care visits (≥ 8 visits)	Yes	10	2.2
	No	435	97.8
Anemia	No	338	76.0
	Yes	107	24.0
Body mass index groups	Normal weight	143	32.1
	Overweight	249	56.0
	Obese	53	11.9

Discussion

The primary findings of the present study were that 11.9% of the studied pregnant women were obese in Rwanda; both hemoglobin levels and anemia have shown positive and negative associations with maternal obesity, respectively. In addition, being a housewife and residing in rural areas were associated with maternal obesity. This high prevalence was aligned with previous reports in African countries, including Nigeria,10.7% [6]. In contrast, this prevalence of maternal obesity (11.9%) was lower than reported in Sudan (25.1%) [7], Cameroon (42.3%) [24], and Morocco, 41.0% [11]. On the other hand, this prevalence was higher than reported (6.7%) by Nkubito et al. in 2019 [19], indicating an increasing pattern of maternal obesity over the years.

Onubi et al., in their systematic review and meta-analysis, reported that the prevalence of maternal obesity across Africa ranged from 6.5 to 50.7%, with older and multiparous mothers more likely to be obese; there was a remarkably increased risk of adverse labor, child and maternal outcomes among African obese mothers [1].

On the other hand, increasing hemoglobin levels were positively associated with obesity in pregnant women. Likewise, other studies, including those in Sudan and Saudi Arabia, found a positive association between

Table 2 Sociodemographic and clinical characteristics of women in Kigali, Rwanda, by body mass index groups,2024 (*n* = 445)

Variable		Normal (*n* = 143)	overweight (*n* = 249)	Obese (*n* = 53)	*P* value	Body mass index groups	Adjusted *P* value
		Median interquartile range					
Age, years		14.9(13.1–16.4)	14.2(12.7–15.8)	14.9(13.8–16.4)	0.007	Overweight vs. normal	0.415
						Overweight vs. obese	0.007
						Normal vs. obese	0.170
Parity		2.50(2.50–3.06)	2.50(2.50–3.06)	2.50(2.50–3.07)	0.036	Overweight vs. normal	0.999
						Overweight vs. obese	0.031
						Normal vs. obese	0.197
Haemoglobin g/dl		12.8(12.0–13.7)	13.1(12.4–13.7)	13.2(12.4–14.2)	0.033	Overweight vs. normal	0.999
						Overweight vs. obese	0.032
						Normal vs. obese	0.059
		Frequency (percentage)					
Residency	Urban	67(46.9)	97(39.0)	12(22.6)	0.008		
	Rural	76(53.1)	152(61.0)	41(77.4)			
Parity	Primipara	98(68.5)	172(69.1)	42(79.2)	0.300		
	Parous	45(31.5)	77(30.9)	11(20.8)			
Maternal education at school level	> Secondary	28(19.6)	54(21.7)	19(35.8)	0.046		
	≤secondary	115(80.4)	195(78.3)	34(64.2)			
Husband education	> Secondary	62(43.4)	109(43.8)	34(64.2)	0.019		
	≤secondary	81(56.6)	140(56.2)	19(35.8)			
Maternal occupation	Housewife	102(71.3)	185(74.3)	49(92.5)	0.008		
	Employed	41(28.7)	64(25.7)	4(7.5)			
History of miscarriage	No	124(86.7)	220(88.4)	46(86.8)	0.876		
	Yes	19(13.3)	29(11.6)	7(13.2)			
Adequate antenatal care visits (≥ 8 visits)	Adequate	2(1.4)	7(2.8)	1(1.9)	0.650		
	Inadequate	141(98.6)	242(97.2)	52(98.1)			
Anemia	No	104(72.7)	186(74.7)	48(90.6)	0.027		
	Yes	39(27.3)	63(25.3)	5(9.4)			

hemoglobin and maternal obesity [7, 9, 13, 14]. For example, a previous study that included 586 Sudanese pregnant women showed that increasing BMI and obesity were significantly associated with decreased ORs of anemia and positively associated with hemoglobin level [7]. Likewise, such association was not confined to pregnant women as other studies found an association between hemoglobin and high BMI in children and adolescents [29, 30].

The association between maternal obesity and increased hemoglobin levels is a complex and multifaceted topic that has been the topic of extensive research. While evidence suggests an association between these two factors, the underlying mechanisms and broader implications of this association are poorly understood. Higher hemoglobin levels indicate various conditions, including anemia, dehydration, or respiratory or cardiovascular disorders. A high maternal hemoglobin level has been recently associated with several maternal and perinatal outcomes, as mentioned above [15, 16]. However, in maternal obesity, the increase in hemoglobin levels may be attributed to several explanations. One potential explanation is the impact of maternal obesity on the body's oxygen demand and utilization. Obesity is often associated with increased inflammatory processes, decreased physical activity, and impaired respiratory function, all of which can contribute to a state of relative hypoxia (low oxygen levels) in the body [31, 32]. In response, the body may increase the production of hemoglobin to facilitate more efficient oxygen delivery to tissues, resulting in higher hemoglobin levels. Moreover, maternal obesity has been linked to altered placental function and changes in maternal blood flow, both of which can impact the fetal environment and contribute to increased hemoglobin levels [33]. The placenta plays a crucial role in regulating the exchange of nutrients, gases, and waste products between the mother and the fetus; disruptions to this system can have profound consequences. Furthermore, obesity is often accompanied by chronic inflammation, which can also influence hemoglobin levels. Inflammatory cytokines, such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), have

Table 3 Univariate multinomial logistic regression analysis of factors associated with overweight and obesity among pregnant women in Kigali, Rwanda, 2024 ($n=445$)

Variable		Overweight ($n=249$)		Obese ($n=53$)	
		Odds Ratios (95.0% Confidence Interval)	P value	Odds Ratios (95.0% Confidence Interval)	P value
Age, years		0.98(0.95–1.01)	0.198	1.06(1.01–1.12)	0.045
Parity		0.92(0.80–1.06)	0.279	1.23(1.02–1.50)	0.035
Hemoglobin g/dl		1.03(0.91–1.16)	0.681	1.43(1.15–1.79)	0.001
Residency	Urban	Reference			
	Rural	1.38(0.91–2.09)	0.128	3.01(1.46–6.20)	0.003
Maternal education school level	> Secondary	Reference			
	≤secondary	0.88(0.53–1.47)	0.622	0.43(0.21–0.87)	0.019
Husband's education school level	> Secondary	Reference			
	≤secondary	0.98(0.65–1.48)	0.936	0.43(0.22–0.82)	0.011
Maternal occupation	Employed	Reference			
	Housewife	1.16(0.73–1.84)	0.523	4.92(1.67–14.53)	0.004
History of miscarriage	No	Reference			
	Yes	0.86(0.46–1.60)	0.634	0.99(0.39–2.52)	0.988
Adequate antenatal care visits (≥ visits)	Adequate	Reference			
	Inadequate	2.04(0.42–9.95)	0.378	1.36(0.12–15.27)	0.805
Anemia	No	Reference			
	Yes	0.90(0.57–1.44)	0.669	0.28(0.10–0.75)	0.011

Table 4 Multivariate multinomial logistic regression analysis for factors associated with overweight and obesity among pregnant women InKigali, Rwanda, 2024 ($n=445$)

Variable		Overweight* ($n=249$)		Obese* ($n=53$)	
		Odds Ratios (95.0% Confidence Interval)	P value	Odds Ratios (95.0% Confidence Interval)	P value
Age, years		0.97(0.92–1.02)	0.260	1.01(0.93–1.10)	0.869
Parity		1.01(0.82–1.25)	0.931	1.33(0.99–1.79)	0.055
Hemoglobin g/dl		1.01(0.88–1.14)	0.949	1.28(1.02–1.60)	0.037
Residency	Urban	Reference			
	Rural	1.32(0.86–2.03)	0.201	2.54(1.16–5.56)	0.019
Maternal education at school level	> Secondary	Reference			
	≤secondary	0.91(0.50–1.65)	0.759	0.80(0.34–1.89)	0.616
Husband's education school level	> Secondary	Reference			
	≤secondary	1.05(0.65–1.70)	0.838	0.48(0.21–1.06)	0.070
Maternal occupation	Employed	Reference			
	Housewife	1.05(0.65–169)	0.839	4.34(1.42–13.26)	0.010
Anemia**	No	Reference			
	Yes	0.97(0.60–1.56)	0.905	0.33(0.12–0.93)	0.036

*The reference category is normal weight

** Anemia and hemoglobin levels were entered into the model one by one

been shown to stimulate the production of hemoglobin and other red blood cell components [34]. This inflammatory response may be a compensatory mechanism to address the increased oxygen demands associated with maternal obesity. It is worth noting that the relationship between maternal obesity and increased hemoglobin is not entirely straightforward. Other factors, such as pre-existing medical conditions, gestational diabetes, and lifestyle factors, can also contribute to changes in hemoglobin levels during pregnancy [35, 36]. Additionally, the specific implications of increased hemoglobin in the context of maternal obesity are not fully understood, and further research is needed to elucidate the potential health consequences for the mother, the developing fetus, and the neonate. For example, investigating the optimal hemoglobin level that maximizes oxygen-carrying capacity could be a valuable research topic for achieving positive pregnancy outcomes. Therefore, the observed increase in hemoglobin levels associated with maternal obesity is likely a multifactorial phenomenon involving changes in oxygen demand, placental function, and inflammatory processes. While the underlying mechanisms are not yet fully elucidated, such association highlights the complex interplay between maternal health, fetal development, and the physiological adaptations during pregnancy. Continued research will improve our understanding of these critical issues and inform clinical management strategies.

In this study, residing in rural areas and being a housewife were found to be associated with maternal obesity. It is worth mentioning that, in this study, most women living in rural areas were housewives 213(48.0%). In this study, pregnant women living in rural areas were about three times more likely to be obese compared to their counterparts in urban areas. In contrast, RDHSs conducted in 2000, 2005, and 2010 reported that women residing in urban areas were found to be significantly associated with being overweight/obese [10]. Additionally, the 2019-20 Rwanda Demographic and Health Survey revealed that women aged 15–49 in urban areas were at nearly double the risk of being overweight or obese (42.0% vs. 22.0%) [37]. It is worth acknowledging the limited available information regarding the impact of rural residency on maternal obesity. Further research and data collection would be needed to understand better the dynamics of maternal obesity among rural pregnant women in Rwanda and develop targeted interventions to address this potential public health concern. Maternal residency has yielded varying results regarding maternal obesity; some studies have found a rural residency to be associated with maternal obesity [36], while others have shown an association with urban residency [6, 8]; however, some studies have found no association [11]. For example, our previous study included 833 pregnant women in eastern Sudan, which showed that urban residence was associated with overweight and obesity [8]. Such contradictory results regarding the association between residency and maternal obesity necessitate further socio-epidemiological research. Such a proposed study should explore the potential factors contributing to higher rates of maternal obesity in rural areas, including limited access to healthy food options, lower socioeconomic status, reduced opportunities for physical activity, and barriers to accessing antenatal care and health education. In addition, rural pregnant women may face unique challenges, such as transportation difficulties, fewer healthcare resources, and cultural/social norms that promote unhealthy behaviors. Therefore, targeted interventions and support services tailored to the needs of women in rural communities could be significant in addressing maternal obesity and improving maternal-child health outcomes.

In Rwanda, housewives were at an increased risk of maternal obesity compared to their counterparts employed. In contrast, other studies found maternal employment was a risk factor for maternal obesity [38]. Various factors could explain the higher prevalence of maternal obesity among Rwandan housewives. Many housewives have a predominantly sedentary lifestyle, with limited physical activity due to the nature of their domestic responsibilities [39]. This lack of regular exercise can lead to weight gain and, as a result, maternal obesity. The traditional Rwandan diet, often high in carbohydrates and low in animal-based proteins, fruits, and vegetables, can contribute to obesity among housewives [40]. Additionally, limited access to diverse and nutritious food options in some rural areas may exacerbate the issue [41]. Socioeconomic status can also play a role, as some Rwandan housewives from lower-income households may have limited resources to prioritize healthy eating and exercise, leading to a higher risk of obesity. To address the issue of maternal obesity among Rwandan housewives, a multifaceted approach is necessary, involving promoting awareness and education on the importance of healthy eating and physical activity during pregnancy and the postpartum period, improving access to affordable and nutritious food options in local communities; encouraging the integration of physical activity into daily routines and household tasks; providing access to antenatal and postnatal care that addresses maternal obesity and its associated risks; addressing socioeconomic factors that may contribute to the problem, such as poverty and limited access to healthcare resources. Therefore, by implementing these proposed strategies, Rwandan policymakers and healthcare providers can work to reduce the prevalence of maternal obesity among rural housewives and improve the overall health and well-being of mothers and their families.

This study did not find an association between maternal obesity and other investigated factors such as age, parity, antenatal care, and history of miscarriage. In contrast, other studies showed age [8], parity [9], antenatal care [11, 24], and history of miscarriage [11] were associated with maternal obesity as compared to counterparts of pregnant women with normal weight. The lack of preventive effect of antenatal care on maternal obesity could be explained by the quality of the provided services in an antenatal care package or late initiation of antenatal care [24] and the adopting of the new definition of the WHO for adequate antenatal care, i.e., eight visits rather than four visits [42]. In Morocco, Taoudi et al. emphasized the importance of reinforcing antenatal care to prevent maternal obesity and its associated preventable complications [11]. Similar to antennal care, the lack of power of education in decreasing maternal obesity could be due to the poor quality of education in girls compared to boys, as this discrepancy was reported in African contexts [43]. Even in this study, husbands were more than twice as educated as their wives, with 62% holding secondary education or higher, compared to 28% of their wives. Therefore, adequate antenatal care that addresses the needs of pregnant women, along with practical education tailored to the population's health needs, is highly recommended.

In this study, obesity was associated with parity in univariate analyses but not in multivariate analyses. The lack of association between age, parity, and obesity is a positive finding, as these factors are non-modifiable. Therefore, such contradictory data (the prevalence of maternal obesity and its associated factors, including hematological parameters such as hemoglobin and anemia should be received positively by researchers as a stimulus to explore such complex associations in their countries/regions aiming to come up with precise preventive approaches to maintain a health BMI and hemoglobin level in pre-pregnancy, during pregnancy and beyond for positive pregnancy outcomes.

The findings of this study highlight the importance of enhancing women's health, as both maternal obesity and anemia are preventable and treatable conditions. Implementing preventive measures, such as promoting physical activity and encouraging healthy dietary practices, can significantly address these public health issues. Furthermore, understanding predictive factors such as hemoglobin levels can help healthcare providers identify and mitigate maternal obesity, thereby preventing its associated complications. The findings of this study highlight the importance of enhancing women's health, as both maternal obesity and anemia are preventable and treatable conditions. Implementing various preventive measures, such as promoting physical activity and encouraging healthy dietary practices, can significantly address these issues. Furthermore, understanding predictive factors such as hemoglobin levels can help healthcare providers identify and mitigate maternal obesity, thereby preventing its associated complications. This study emphasizes that maternal obesity and anemia are critical public health concerns in Rwanda that require urgent attention from all stakeholders at every level.

Strengths and limitations of the study

To the authors' knowledge, this is the first comprehensive study examining the epidemiology of maternal obesity in Rwanda, including its association with hemoglobin levels and anemia. The findings contribute valuable data to the limited literature on the prevalence and factors associated with maternal obesity in the country. However, the study has various limitations that should be acknowledged to improve future research designs. As a cross-sectional study, it cannot establish causal relationships between variables, such as the association between anemia and obesity. For example, in this study, residing in rural areas was associated with maternal obesity. There is a potential limitation related to self-reporting, including social desirability bias and recall bias. However, it is difficult to attribute this obesity to pre-pregnancy obesity or gestational weight gain (GWG) [44]. As a result, further longitudinal studies are needed to clarify the impact of maternal obesity on maternal and perinatal health and to investigate the associations between different BMI groups, including obesity and the hematological parameters studied among pregnant women. Understanding the direction of these associations is crucial, as it remains unclear at present. Additionally, this study was conducted in two hospitals in Rwanda, which limits the generalizability of the results to the entire population of pregnant women in the country, as it only includes those who attended antenatal care. Furthermore, no data were collected on dietary patterns or physical activity levels, as these have their effects on the BMI and obesity [32, 45]. Future research should address these limitations.

Conclusion

This study indicates that 12% of the pregnant women in Rwanda were obese. Hemoglobin levels and anemia can be helpful indicators for predicting maternal obesity in Rwanda. Specific interventional programs targeting rural housewives are recommended to combat maternal obesity in Rwanda. Future research is recommended to explore the impact of maternal obesity on maternal and perinatal health. A call to action is needed for policymakers and international organizations to prioritize maternal health in Rwanda and similar settings.

Abbreviations

AOR	Adjusted Odds Ratio
BMI	Body Mass Index
CI	Confidence Interval
IQR	Interquartile range
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organization

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Author contributions

MIA and IA conceived the study; MIA, AOB, AAH, and IA supervised the work, guided the analysis, and critically reviewed the manuscript; AAH and IA prepared the analysis plan, performed the data analysis, and wrote the first draft of the paper; MIA, AOB, and IA supervised data collection. All authors have reviewed and approved the final manuscript. All authors have read and agreed to the published version of the manuscript.

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Data availability

The data of the current study will be available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participants
The present study was conducted in accordance with the Declaration of Helsinki and good clinical research practices. It obtained ethics approval from the research ethical committee of the Faculty of Medicine, University of Medical Sciences and Technology, Kigali, Rwanda. All participants signed a written informed consent form. The authors followed all measures to ensure the privacy and confidentiality of the participants, including excluding personal identifiers during data collection. All methods and procedures of this study were carried out in accordance with appropriate guidelines and regulations.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Clinical trial registration
Not applicable.

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