

ORIGINAL RESEARCH ARTICLE

Placental weight and neonatal outcomes among term singleton neonates in Sudan: A cross-sectional study

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Abstract

Introduction: Placental weight is an important indicator of placental growth and function and plays a significant role in fetal development and neonatal adaptation. Variations in placental weight may reflect intrauterine conditions that influence neonatal anthropometric outcomes and early neonatal morbidity.

Objectives: This study aimed to examine the association between placental weight, neonatal anthropometric measurements, and admission to the neonatal intensive care unit among term singleton neonates.

Methods: A hospital-based cross-sectional analytical study was conducted among 770 term singleton neonates delivered at Omdurman Maternity Hospital, Sudan. Data regarding placental weight, neonatal anthropometric measurements, gestational age, Apgar scores, and neonatal intensive care unit admission were collected and analyzed. Pearson correlation analysis was used to examine the relationships between placental weight and neonatal variables.

Results: Placental weight demonstrated significant positive correlations with: neonatal birth weight ($r = 0.457, p < 0.001$), head circumference ($r = 0.332, p < 0.001$), and neonatal length ($r = 0.208, p < 0.001$). No statistically significant association was observed between placental weight and gestational age ($p = 0.266$). The overall placental weight-to-birth weight ratio was 0.198. Neonates admitted to the neonatal intensive care unit demonstrated substantially lower mean placental weights (540.91 ± 213.61 g) compared with neonates in good condition, suggesting a statistically significant association between reduced placental weight and adverse early neonatal outcomes.

Conclusion: Placental weight is significantly associated with neonatal growth measurements and early neonatal outcomes in term singleton pregnancies. Routine placental assessment may support the identification of neonatal risks and contribute to improved neonatal monitoring and care.

Keywords: Placental weight; Term singleton pregnancies; Neonatal anthropometry; Birth weight; Apgar score; Placental efficiency; Neonatal intensive care unit admission

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1. Introduction

The placenta is a vital transient organ that plays a central role in fetal growth and development by facilitating the exchange of oxygen, nutrients, and metabolic waste

between the mother and the fetus.

In addition to its transport functions, the placenta reflects intrauterine conditions and maternal health status, making it an important indicator of pregnancy progression and neonatal outcomes.^{1,2} Structural and functional variations in the placenta, including changes in placental weight, have been increasingly recognized as markers of fetal development and perinatal health.³

Placental weight has been widely studied as an indicator of placental growth and function. Both low and high placental weights have been associated with adverse neonatal outcomes, including low birth weight, fetal growth restriction, macrosomia, low Apgar scores, and increased perinatal morbidity. These associations may reflect altered placental efficiency, adaptive placental responses, or underlying maternal-fetal factors that influence placental development.^{3,4}

Previous research across various populations has highlighted a noteworthy correlation between placental weight and several neonatal anthropometric measurements. These measurements encompass critical parameters such as birth weight, length, and head circumference. Furthermore, these associations also extend to early neonatal outcomes, suggesting that placental weight plays a pivotal role in determining the growth and health status of newborns during the initial stages of life.^{3,5,6}

However, placental growth and function are influenced by contextual factors such as maternal nutritional status, socioeconomic conditions, access to antenatal care, and the prevalence of maternal health disorders, which vary considerably across different geographic and healthcare settings in Sudan.⁷⁻¹⁰ Despite the growing global literature, evidence from low- and middle-income countries (LMICs) remains limited.¹⁰

In Sudan, the maternal and neonatal morbidity rates are alarmingly high, and a significant gap exists in the routine incorporation of placental characteristics into clinical assessments. Currently, there is a lack of locally generated evidence concerning placental weight and its impact on neonatal outcomes, which hampers healthcare professionals' ability to effectively integrate placental findings into holistic maternal and neonatal care planning.¹⁰⁻¹² Understanding the association between placental weight and neonatal outcomes in term singleton pregnancies is particularly important in tertiary care settings, where the early identification of at-risk neonates may improve clinical decision-making and postnatal management. From a nursing and midwifery perspective, placental assessment may enhance neonatal risk stratification and improve maternal and neonatal care.

Although the relationship between placental weight and fetal weight, as well as the fetal-placental weight ratio, is well established, most available evidence originates from high-income countries and may not be fully generalizable to low-resource settings such as Sudan. A fetal-to-placental weight ratio of approximately 6–7 at term is generally considered normal, whereas a ratio of ≥ 8 may indicate possible placental insufficiency, reflecting reduced placental efficiency and potential adverse perinatal outcomes. However, limited evidence exists regarding the correlation between placental weight and specific neonatal anthropometric outcomes and early neonatal morbidity in African populations.^{6,8,13} Therefore, the novelty of this study lies not in redefining established physiological ratios but in evaluating their clinical relevance within a Sudanese tertiary care setting. Specifically, this study examined the relationship between placental weight and neonatal anthropometric measurements and early neonatal outcomes, including neonatal intensive care unit (NICU) admission, in a resource-limited environment where placental assessment is not routinely integrated into standard obstetric practice. Accordingly, the study aimed to assess the association between placental weight and neonatal anthropometric measurements and early neonatal outcomes among term singleton deliveries in Sudan, with specific focus on birth weight, head circumference, neonatal length, and NICU admission rates.

2. Materials and methods

2.1. Study design

A hospital-based cross-sectional analytical study design was employed to examine the association between placental weight and neonatal outcomes among Sudanese women with singleton term pregnancies.

2.2. Study setting

The study was conducted at Omdurman Maternity Hospital, the largest tertiary referral and teaching maternity hospital in Sudan. As a national referral center that receives patients from all regions of the country, the hospital provides a broad and diverse clinical population representative of women who receive tertiary obstetric care in the country.

2.3. Study population and sampling

The target population comprised Sudanese women with singleton term pregnancies who delivered vaginally, along with their neonates and fresh placenta. Participants were recruited via convenience sampling from all eligible deliveries that occurred during the study period. This approach was adopted because of the continuous and

time-dependent nature of childbirth and the requirement for immediate placental examination following delivery, which necessitated the inclusion of participants as they became available for examination. Although convenience sampling was employed, Omdurman Maternity Hospital functions as a national tertiary referral center, receiving patients from diverse geographic and socioeconomic backgrounds, thereby enhancing the heterogeneity and representativeness of our study population. Data were collected over six months, from August 2022 to January 2023.

- Inclusion criteria: Women were eligible for inclusion if they were of Sudanese nationality, had a singleton pregnancy delivered vaginally at term gestation (37–42 completed weeks), and had a freshly delivered placenta available for examination. Gestational age was determined by the last menstrual period and confirmed by first-trimester ultrasonography to improve accuracy.
- Exclusion criteria: Women were excluded if they were of non-Sudanese nationality, had a multiple gestation, delivered by cesarean section, had unknown or unreliable gestational age, delivered preterm (<37 weeks) or post-term (>42 weeks), or experienced a macerated stillbirth (due to potential alterations in placental morphology and weight). Cesarean section deliveries were excluded to standardize the technique of placental separation and delivery across the study sample. Placental extraction during cesarean section is typically performed via manual removal, which has been associated with greater blood loss and a higher rate of third-stage complications than controlled cord traction following vaginal delivery.¹⁴ Because retained intra-placental blood and clot content can systematically alter measured placental weight, restricting recruitment to vaginal deliveries minimized this potential source of measurement bias and ensured a methodologically homogeneous cohort for placental weight assessment.
- Sample size: A total of 770 mother–neonate–placenta triads were included in the study. The sample size estimation was based on the single-population proportion formula (**Equation 1**):

$$n = \frac{Z^2 \times P(1-P)}{d^2} \quad (1)$$

where:

n = required sample size.

Z = Z statistics corresponding to a 95% confidence level.

P = anticipated prevalence of abnormal placental

weight, conservatively estimated at 50% to maximize the sample size.

d = margin of error (0.05).

In the absence of prior local data on the distribution of placental weight and its association with neonatal outcomes in the Sudanese population, a conservative prevalence estimate of 50% was used to maximize sample size and ensure adequate statistical precision, thereby providing sufficient power to detect clinically meaningful associations.

Data were collected using a structured, interviewer-administered questionnaire developed after an extensive review of the relevant literature. The instrument comprises four standardized sections:

- The sociodemographic characteristics included maternal age, educational attainment, occupation, socioeconomic status, residence, and lifestyle habits.
- Obstetric history included gravidity, parity, number of abortions, number of stillbirths, mode of conception, and maternal medical conditions during pregnancy.
- Labor and placental characteristics included intrapartum complications, mode of delivery, placental weight, and macroscopic placental dysmorphism.
- Neonatal outcomes included gestational age, sex, Apgar score at five minutes, birth weight, length, and head circumference.

A standardized gestational age–specific weight percentile chart was used to classify neonatal weight-for-gestational-age status, ensuring uniformity and comparability with established neonatal growth standards. The study was conducted in two sequential phases to ensure methodological consistency. Administrative approval was obtained from the hospital authorities prior to initiating this study. Written informed consent was obtained from all participants after providing a comprehensive explanation of the study's objectives, procedures, and measures taken to ensure the confidentiality of the data. Data were collected by trained personnel through face-to-face interviews using standardized questionnaires; neonatal anthropometric measurements (weight, length, and head circumference) were obtained using calibrated instruments and standardized measurement techniques to minimize measurement errors. The attending clinicians recorded the Apgar scores at five minutes. Neonates were examined for gross congenital anomalies, and gestational age was calculated based on predefined criteria. Neonatal weight-for-gestational-age status was determined using a percentile chart.

Freshly delivered placentae were processed immediately. Blood clots were carefully removed, and the placentas were

weighed to the nearest gram using a calibrated infant-weighing scale. Placental weight included the membranes and umbilical cord, with the cord trimmed to approximately 5 cm from the neonatal insertion to ensure sample uniformity. This trimming protocol was applied uniformly across all study placentas to ensure internal consistency; however, placental weighing conventions (e.g., trimmed versus untrimmed cord length, inclusion or exclusion of membranes) vary across published studies, which may limit direct numerical comparability of absolute placental weight values with cohorts using different protocols. Each placenta was systematically examined for macroscopic dysmorphological abnormalities using predefined criteria. All measurements and observations were recorded using standardized data collection forms.

The face and content validity of the data collection instrument were established through expert review by a panel of five senior obstetrics and gynecology medical and nursing professors. The panel evaluated the instrument for clarity, relevance, comprehensiveness, and applicability, and minor modifications were made before the data collection.

2.4. Statistical analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS 18.0, IBM, United States). Continuous variables are presented as means $\pm$ standard deviations, while categorical variables are presented as frequencies and percentages. Pearson correlation coefficient (r) was used to evaluate the associations between placental weight and neonatal anthropometric variables. Independent comparative statistical analysis was used to compare mean placental weights according to neonatal outcomes. A p -value of <0.05 was considered statistically significant.

2.5. Ethical considerations

Ethical approval for the study was obtained from the Ethics Committee of the Sudan Medical Specialization Board (approval no. SMSB/ETH/2019/045). The approval issued on August 20, 2022, covered the study duration from August 2022 to August 2023, during which data collection was conducted. All participants voluntarily enrolled after providing written informed consent. Measures to ensure confidentiality and anonymity included the use of unique identification codes, with study data accessible only to the research team.

3. Results

3.1. Demographic characteristics of the study participants

Table 1 shows the demographic and obstetric profiles

of the 770 mother–neonate pairs, which provided the foundational context for this study. Utilizing a cross-sectional approach at Omdurman Maternity Hospital, the results indicated a predominantly young maternal cohort, with 88.5% of mothers aged 35 years or younger. Socioeconomic analysis revealed that 93.5% of participants were housewives and 82.6% were classified in the lower or middle socioeconomic tiers, highlighting the specific community-based characteristics of the sample. Additionally, grand multiparity (≥ 5 babies) was observed in 21.8% of the cases, reflecting regional obstetric trends in Sudan.

Table 1. Maternal and obstetric characteristics of the study population ($n = 770$)

Characteristic	Categories	<i>n</i>	%
Age of mothers	≤ 25 years	330	42.8
	26–35 years	352	45.7
	> 35 years	88	11.5
Educational level	$\leq$ Secondary	230	29.9
	Secondary/high secondary	358	46.4
	Graduate and above	182	23.6
Occupation	Housewife	720	93.5
	Employed/student	50	6.5
Parity	Primipara	284	36.9
	2–4 babies	314	40.8
	≥ 5 babies	172	22.3
Socioeconomic status	Poor/moderate	636	82.6
	Good/very good	134	17.4

Note: Socioeconomic status was determined using the standardized local metrics.

3.2. Neonatal outcomes and clinical physical assessment:

Table 2 shows 86.8% of neonates were delivered in good condition. While the majority (90.9%) were appropriate for gestational age (AGA), 13.0% of newborns exhibited some degree of Apgar score depression at 5 minutes. These clinical findings are consistent with the NICU admission rate of 12.7%, suggesting that while term singleton births are generally stable, a significant minority requires specialized neonatal support. The occurrence of fresh stillbirths was limited to 0.5% of the total births.

Table 2. Neonatal outcomes and clinical physical assessment (*n* = 770)

Characteristic	Categories	<i>n</i>	%
Sex	Male	410	53.3
	Female	360	46.8
Gestational age-specific weight	Large for GA	48	6.2
	Average for GA	700	90.9
	Small for GA	22	2.9
	7–10 (no depression)	670	87.0
Apgar score at 5 min	4–6 (mild depression)	86	11.2
	0–3 (severe depression)	14	1.8
Neonatal outcomes	NICU admission	98	12.7
	Fresh stillbirth	4	0.5
	Good condition	668	86.8

Note: Good condition denotes neonates who do not require resuscitation or specialized care.

Abbreviations: GA: Gestational age; NICU: Neonatal intensive care unit.

3.3. Distribution of placental weight and neonatal anthropometric measurements among term singleton deliveries

Table 3 shows that placental weight across the cohort averaged 635.81 ± 136.55 g, with a higher mean weight in male neonates (644.89 g) than in females (628.02 g). A pivotal metric examined was the placental weight-to-birth weight ratio, which was 0.198. The corresponding fetal-to-placental weight ratio of 5.05 is substantially lower than the global term norm of 6–7. This increased placental mass relative to fetal weight indicates a specific efficiency profile in the studied population, potentially reflecting adaptive responses to the intrauterine environment.

3.4. Comparison of placental weight across neonatal clinical outcomes

Table 4 shows that placental weight is a sensitive indicator of early neonatal stability. Neonates admitted to the NICU had substantially lower placental weights (540.91 ± 213.61 g) than those born in good condition. This difference underscores the correlation between reduced placental mass and adverse neonatal outcomes. While the small number of fresh stillbirths (*n* = 4) limits generalizability for that group, the overall trend underscores the predictive potential of placental morphometrics.

3.5. Pearson correlation analysis of placental weight and neonatal anthropometric characteristics

Table 5 presents the correlation analysis of placental weight with neonatal growth markers. A significant moderate

positive correlation was found with birth weight ($r = 0.457$, $p < 0.001$), followed by head circumference ($r = 0.332$) and neonatal length ($r = 0.208$). These results confirm that placental weight is a robust determinant of physical development at term. Notably, the lack of correlation with gestational age ($p = 0.266$) suggests that variations in placental weight in this cohort are driven more by biological factors than by the duration of the terminal stage of pregnancy.

Table 3. Distribution of placental weight and neonatal anthropometric measurements among term singleton deliveries (*n* = 770)

Category	<i>n</i>	Mean $\pm$ SD (g)	Min	Max
Overall	770	635.81 ± 136.55	350	1,190
Male neonates	410	644.89 ± 151.03	350	1,190
Female neonates	360	628.02 ± 122.43	350	1,150
Placental weight-to-birth weight ratio ^a				
Male		0.198		
Female		0.198		
Overall		0.198		
Placental coefficient				0.198

Notes: ^aPlacental weight divided by birth weight; The calculated fetal/placental ratio (~5.05) is lower than internationally reported norms.

Abbreviation: SD: Standard deviation.

Table 4. Comparison of placental weight across neonatal clinical outcomes (*n* = 770)

Outcome	<i>n</i>	Percent	Mean placental weight $\pm$ SD (min–max)
NICU admission	98	12.7	540.91 ± 213.61 (350–1,150)
Fresh stillbirth	4	0.5	650.00 ± 150.00 (450–900)
Good condition	668	86.8	649.65 ± 136.55 (580–1,190)
Total	770	100	635.81 ± 136.55 (350–1,190)

Abbreviations: NICU: Neonatal intensive care unit; SD: Standard deviation.

4. Discussion

This study demonstrated a consistent positive association between placental weight and neonatal anthropometric measurements in term singleton pregnancies, particularly birth weight, head circumference, and length. These findings agree with a large body of international literature

reporting moderate to strong correlations between placental mass and neonatal size across diverse populations, including Asian and African studies.^{4,15-18}

Table 5. Pearson correlation analysis of placental weight and neonatal anthropometric characteristics (*n* = 770)

Newborn characteristic	<i>n</i>	Pearson correlation (<i>r</i>)	<i>p</i> -value
Birth weight (g)	770	0.457**	<0.001
Head circumference (cm)	770	0.332**	<0.001
Length (cm)	770	0.208**	<0.001
Gestational age (weeks)	770	0.040	0.266

Notes: ***p* < 0.01 (2-tailed); Statistical significance was maintained across all key growth parameters, except for gestational age.

The biological plausibility of these findings has been well established. Placental weight reflects the structural and functional capacity of the placenta to support maternal-fetal exchange of oxygen and nutrients, which directly influences fetal growth. Consequently, an increased placental mass is generally associated with improved fetal growth potential, whereas reduced placental weight may indicate impaired placental development or reduced efficiency.^{4,19} In this context, fetoplacental ratios and related indices are widely used as proxy indicators of placental efficiency, although they should be interpreted cautiously because they do not directly measure the transport function.¹⁹

In the present study, the mean placental weight was higher than that reported in several published international reference ranges. However, such comparisons must be interpreted cautiously because of methodological heterogeneity across studies. Differences in placental processing (including whether membranes and cord are trimmed or included) and population characteristics, such as maternal nutrition, parity, and fetal sex, may contribute to variations in placental weight across settings.^{4,20,21}

Within this term-restricted cohort, gestational age showed minimal variability and did not significantly influence the neonatal anthropometric outcomes. This finding supports previous studies indicating that, among term pregnancies, placental weight better reflects individual fetal growth potential than gestational duration alone.^{16,22} Sex-related differences were also observed, with male neonates tending to have slightly higher placental weights and anthropometric measurements than females. This aligns with evidence suggesting fetal sex dimorphism in placental development and growth demands, although the magnitude of these differences is often small.^{21,23-}

²⁵ Maternal factors, such as parity, may have a stronger

influence on placental weight than fetal sex alone.²¹

Importantly, placental weight was lower among neonates requiring NICU admission or exhibiting adverse early clinical conditions, whereas higher placental weights were generally associated with favorable neonatal outcomes. This finding is consistent with previous studies demonstrating that abnormal placental size is associated with an increased risk of neonatal morbidity, including low Apgar scores, respiratory complications, and NICU admission.^{22,26-28} These observations suggest that deviations from normal placental growth patterns, rather than absolute values, may be clinically significant.

Although fetoplacental ratios were not the primary focus of this study, the existing literature indicates that both low and high ratios may reflect maladaptive placental responses. Importantly, the relationship between placental efficiency and neonatal outcomes appears to be non-linear, with increased risks observed at both extremes of the distribution.^{19,29}

The variability observed in placental weight and neonatal outcomes is likely influenced by unmeasured maternal determinants, including nutritional status, anemia, body mass index, and hypertensive disorders during pregnancy. These factors are well-established contributors to placental development and fetal growth restriction or overgrowth, suggesting potential residual confounding in this analysis.^{1,30-32} From a clinical perspective, these findings support the utility of routine placental weight measurement as a simple and informative marker of intrauterine conditions. While placental weight alone is not sufficient as a diagnostic tool, its integration into routine obstetric practice may enhance the early identification of at-risk neonates. When combined with neonatal anthropometry and clinical indicators, such as Apgar score, placental assessment may improve perinatal risk stratification.^{4,21,25}

Furthermore, placental weight should be interpreted within the broader clinical context of maternal health status, obstetric history, fetal sex, and underlying placental pathology. Maternal metabolic and constitutional factors influence placental growth, and studies have shown positive effects of maternal body mass index (BMI), gestational weight gain, and fasting glucose on placental weight, with some associations differing by fetal sex.³³ Large reference data also indicate that parity affects placental weight more strongly than fetal sex; therefore, crude comparisons of placental size without adjustment for maternal and pregnancy characteristics can be misleading.³⁴

Placental pathology adds important interpretive value because gross weight alone cannot distinguish

normal adaptive growth from pathological enlargement or underdevelopment of the placenta. Evidence from placental pathology studies shows that the fetal/placental ratio and placental efficiency are associated with pregnancy complications and histopathological lesions, including preeclampsia, gestational diabetes, and inflammatory placental responses.³⁵ Other cohort data further show that maternal vascular malperfusion is associated with lower birth weight, shorter birth length, smaller head circumference, and greater risks of preterm delivery and small-for-gestational-age birth, supporting the need to interpret placental size alongside placental disease processes.³⁶

This integrated interpretation is particularly relevant in low-resource settings, where advanced placental imaging, biochemical assessment, and routine histopathology may not be widely available. In such settings, simple delivery room measures, such as placental weight, can still offer clinically useful contextual information when combined with neonatal anthropometry and maternal history, especially because maternal infections, inflammation, nutrition, and other exposures jointly shape the newborn size.³⁷ Reviews focused on LMICs also show that maternal undernutrition, low BMI, and poor gestational weight gain are consistent determinants of adverse fetal outcomes, reinforcing the need to interpret placental findings within the broader maternal environment.³⁸

Overall, the current study reinforces the role of placental weight as a marker of fetal growth and early neonatal adaptation in singleton pregnancies. The observed positive associations with neonatal anthropometric measurements are consistent with wider evidence showing that placental weight directly contributes to birth weight variation and mediates part of the relationship between maternal size and newborn growth.³⁹ The findings are therefore broadly aligned with the international literature, while also emphasizing that interpretation must remain context-specific in populations such as Sudan, where maternal nutritional status, parity, antenatal care, and other local determinants may shape placental and neonatal outcomes differently.^{8,40}

In conclusion, placental weight is significantly associated with neonatal anthropometric outcomes and early clinical status at birth in a term singleton pregnancy. However, its value is greatest when interpreted as part of a wider maternal–fetal assessment, rather than as an isolated indicator of placental function. Further longitudinal studies are needed to clarify the maternal determinants of placental growth and to determine whether placental measures at birth are associated with later child growth, nutrition, and developmental outcomes.

This study has several limitations that should be considered when interpreting the findings. First, its cross-sectional design precludes causal inference regarding the relationship between placental weight and neonatal outcomes. Second, the study was conducted at a single tertiary care hospital, and participants were recruited through convenience sampling during predefined data collection periods, which may limit the generalizability of the findings to other healthcare settings and populations. Third, although major maternal and neonatal variables were assessed, some potential confounding factors, including maternal nutritional status, pre-pregnancy body mass index, hemoglobin level, and pregnancy complications, were not fully controlled. Finally, only early neonatal outcomes were evaluated; therefore, the long-term clinical implications of placental weight could not be assessed. Future multicenter prospective studies using probability-based sampling are recommended to validate and extend these findings. Top of Form.

5. Conclusion

Although the relationship between placental weight and fetal growth, including the established fetal/placental weight ratio, is well documented, the novelty of this study lies in demonstrating its clinical relevance in a Sudanese tertiary care setting, where placental assessment is not routinely used for neonatal risk stratification.

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Conflict of interest

The author declares no competing interests.

Author contributions

This is a single-authored article.

Ethics approval and consent to participate

Ethical approval (approval no. SMSB/ETH/2019/045) was granted by the appropriate institutional research and ethics committees. All participants voluntarily enrolled after providing written informed consent. Measures to ensure confidentiality and anonymity included the use of unique identification codes, with study data accessible only to the research team. As this study involved retrospective

review of neonatal and placental records, all procedures were conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki. Permission to access the data was obtained from the relevant hospital authorities.

Consent for publication

Not applicable. No identifiable personal data or images are included in this manuscript.

Availability of data

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Further disclosure

The authors used an AI-assisted language editing tool exclusively for English language refinement and grammatical improvement. All scientific content, data interpretation, statistical analysis, and manuscript revisions were reviewed and verified by the authors.

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