Neonates Measurements and Maternal Factors in Sudan

Abstract:

Introduction:Anthropometric measurements of neonates serve as a vital clinical tool for identifying small or large newborns. Thesemeasurements also playa crucial role in assessing the potentialoutcomes of newborns,helping to predict future risksof morbidity or mortality. The***purpose*** of this study was to determine the average anthropometric measurements representative of Sudan's newborn population and to examine the relationshipbetween these measurements and maternal factors. ***Methodology:*** This study employed a descriptive prospective design acrossthree hospitals located in Khartoum: Omdurman Maternity Hospital, Bahri Teaching Hospital, and Saad Abo Aila Hospital. The study included 794 mothers and their newbornsafter meetingthe inclusion and exclusion criteria within the first 72 hours postdelivery. Neonatalmeasurements, includingbirth weight, crownheel length, and head and chest circumference, were taken for those who met the criteria.Statistical Package for Social Science (SPSS) version 20 to present means and generate tables and figures. Chi-square test used to assess the significant of relationship between different maternal and neonatal variables. All ethical considerations were maintained. ***Results:***newborn Males made up 51.5% (409), while females represented 48.5% (385). Maternalagefalls withinthe 20 to under 31 years range, representing 52% of the total. Themost prevalent Body Mass Index (BMI) category in the sample was overweight, making up 41.7%, whereas18.9%of the mothers were classified as obese. Head circumference demonstrated a statistically significant correlation with maternal BMI (P-value= 0.017). Maternal parity showed a statistically significant correlation with both newborn weight (P-value = 0.006) and head circumference (P-value = 0.008). Pregnancy complications were identified in 14% of cases and demonstrated a statistically significant correlation with weight, length, head circumference, and chest circumference (all P-values < 0.05). The most frequent health issue encountered during pregnancy was hypertension,affecting41% of cases, followed by malaria at22% and diabetes at 13%. The occurrence of morbidities during pregnancy showed a statistically significant relationship with weight, length, head circumference, and chest circumference,withall P-values beinglessthan 0.05.***Conclusion:***The study observed thatmaternal complications in Sudan such as overweight, hypertension, malaria, and diabetes has direct negative impact inrelation toneonatal measurements, including height, weight, head circumference, and chest circumference. Urgent intervention needed at the national level.

Keywords: Anthropometric measurements, neonate, Maternal factors, Sudan.

1. Introduction:

Anthropometric measurements are noninvasive, quantitative methods usedto evaluate the physical dimensions, proportions, and composition ofthe human body(Casadei &Kiel, 2022). These include metrics such as height, weight, Body Mass Index (BMI), and skinfold thickness. Widely employed in pediatrics to monitor growth and in adults for assessing health riskslike obesity orinforming ergonomic design, these

measurements offer essential andcostefficient data for various applications (Carrión-Martínez*et al*, 2022).

Between 1997 and 2003, the World Health Organization (WHO)developed new global standards for evaluating the growth and development of children aged 0 to 5 years. This initiative includedapproximately 8,500 children from Brazil, Ghana, India, Norway, Oman, andthe United States of America (USA) who were raised under optimal conditions.The standards emphasized breastfeeding as the benchmark for healthy growth (WHO, 2026). This is what is nowadays known asMulticenter Growth Reference Study (MGRS).

A neonate, or newborn, refers to an infant during the first 28 days of life, a crucial periodmarkedby rapid physiological adjustments, thedevelopment of early bonds, and the initiation of feeding. This phaseis associatedwith heightened risks of illness and mortalityoften necessitating specialized care for preterm or medicallycompromised infants(Anthony & McKinlay, 2023). Primary concerns during this time include susceptibility toinfections, respiratory challenges, and maintaining proper temperature regulation. In 2023, around 2.3 million newborns worldwide lost their lives within the first 28 days,aperiodknown as the neonatal stage. This continues to be the most critical andfragile phase for child survival, representing 47% of all deaths among children under the age of five Cao *et al,* 2022).

Maternal factors referto the physical, social, and genetic conditions of a pregnant individual that play acrucial role in shaping pregnancy, childbirth, and the longtermhealth of the child. Important and manageable aspects include maternal age, prepregnancy weight, existing medical conditions such as diabetes or hypertension, infections, and mental wellbeing (Muglia *et al*, 2022). Abnormal maternity conditions considerably heighten the likelihood of disabilities and developmental challenges in children (Alkazaleh*et al,* 2025).

Global maternal health and mortality,reflectedin a rate of 197 deaths per 100,000 live births in 2023, are largely influenced by stark inequities.Notably, 94% of these deaths occur in lowresource settings (Shanto*et al*, 2023).

Sudan,situated in East North Africa, is classified asa developing country (Satti *et al,* 2026: Abdalrhman *et al,* 2025). Ongoing conflict has significantly harmed the nation's healthcare system, leaving manypregnant women without access to essential maternal care services (Abdelnour *et al,* 2026: Satti *et al*, 2025). Therefore, Maternal mortality remains a significant issue in Sudan,accounting for approximately 78.7% to 80.25% of deaths between 2000 and 2019 (Taha *et al,* 2025). The primarycause is obstetrichemorrhage,responsible for 45.45% to 45.5% of fatalities, followed by hypertensive disorders at16.1%, and sepsis (Taha *et al,* 2025).In2023, the national maternal mortality ratio was estimated at 256 per 100,000 live births (Elhassan *et al,* 2025).

2. Methodology:

The study was a prospective, cross-sectional, hospital-based investigation conducted in Khartoum State across three hospitals: Omdurman Maternity Hospital, Bahri Teaching Hospital, and Saad Abo Ailla Teaching Hospital. The study population comprised Sudanese women who had recently givenbirth in these hospitals, alongwith their neonates within the first 72 hours post-delivery. A total of 794 mothersand their newborns

participated. Data forthe study were collected using astraightforward questionnaire designed to gather demographic information from the mothers. The author wasactively involved in screening all mothers and babies (n=794) and conducted clinical neonatal examinations to rule out any congenital abnormalities. Additionally, theauthor performed anthropometric measurements following standard methodologies. Themothers' body weight and height were measured using astadiometer. Neonatal anthropometric parameters were recorded with measuring tapes, pre-calibrated weighing scales, and an infantometer for length measurements. Thecollected data was summarized and presented through tables and graphs. Pearson's chi-square test was employed to evaluate the significance of the suggested relationshipsamongvarious maternal and neonatal variables. Additionally,the chi-square testandthe Statistical Package for the Social Sciences (SPSS) version 20 wereutilizedfor generating tables,figures, and processing the results. All ethical considerations been maintained.

3. Results:

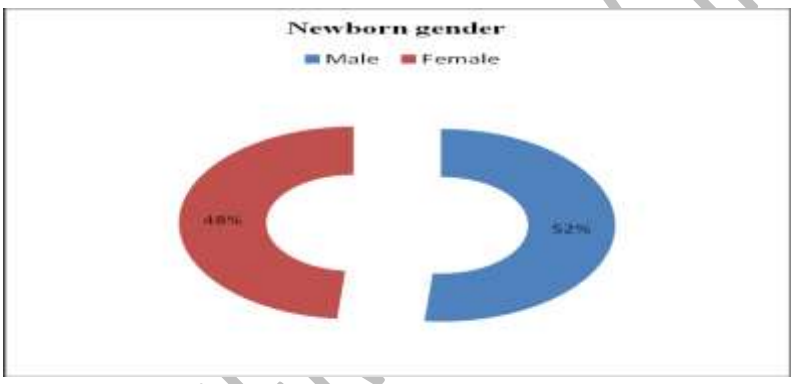

Figure 1: Gender(n=794)

Malesconstituted 51.5%(409) of the sample,while females accountedfor 48.5% (385), as illustrated in Figure 1.

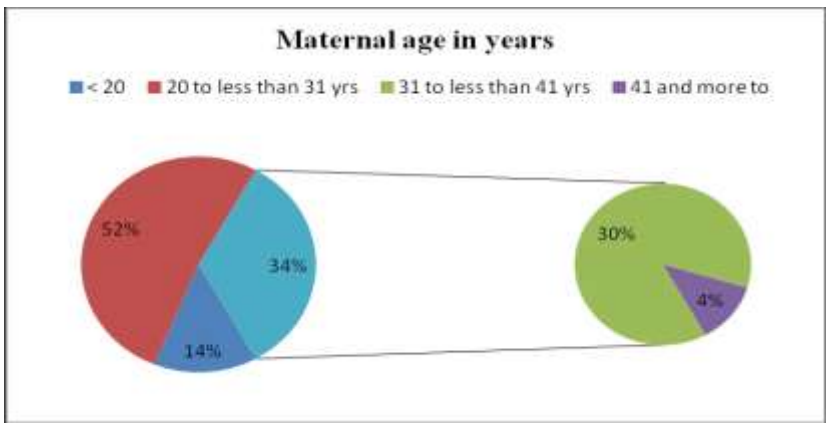

Figure 2:Age (n=794)

The maternal age group with the highest frequency,as shown in Figure 2, was between 20 andunder31 years,accounting for 52%.

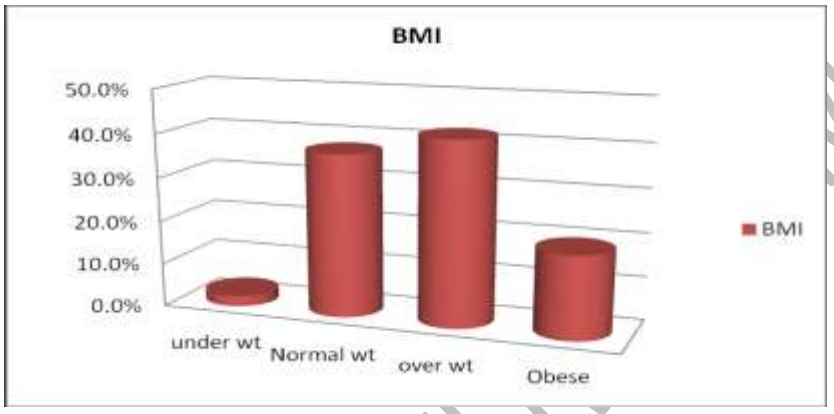

Figure 3: Maternal BMI(n=794)

The most common BMI categoryamong the sample was overweight, comprising 41.7%, while obese mothers accounted for 18.9%. On theother hand, 37%had a normal BMI, as depicted in Figure 3.

Headcircumferenceshowed a significant statistical association with maternal BMI (P-value =0.017) as presented in Table 1.

Table 1:Maternal BMI and baby anthropometric measurements

Maternal BMI	weight		length		Head circumference		Chest circumference		Total
	normal	abnormal	normal	abnormal	normal	abnormal	normal	abnormal	
Under weight	19	0	16	3	19	0	13	6	19
Normal weight	284	11	225	70	270	25	230	65	295
Over weight	319	16	281	54	304	31	264	71	335
Obese	139	6	120	25	132	13	125	20	145
Total	761	33	642	152	725	69	632	162	794

p-value	0.087	0.055	0.017	0.129

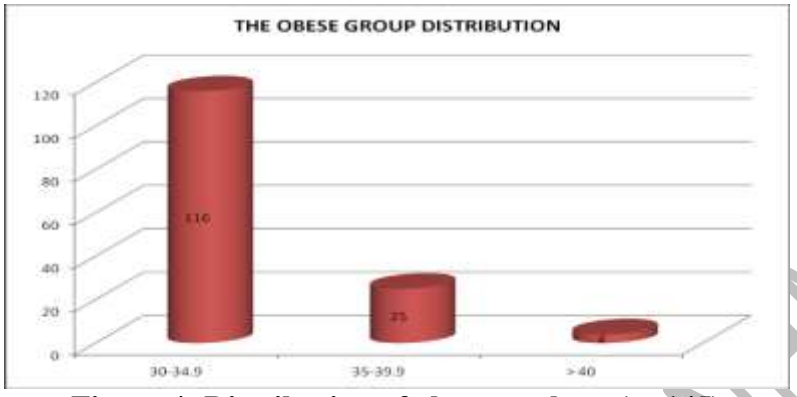

Figure 4: Distribution of obese mothers (n=145)

Atotalof 145 mothers (18.9%)werecategorizedasobese; amongthem, 116 fellunderClass 1 obesity, while 4 wereclassifiedasClass 3 with severe obesity,as illustratedin Figure 4.

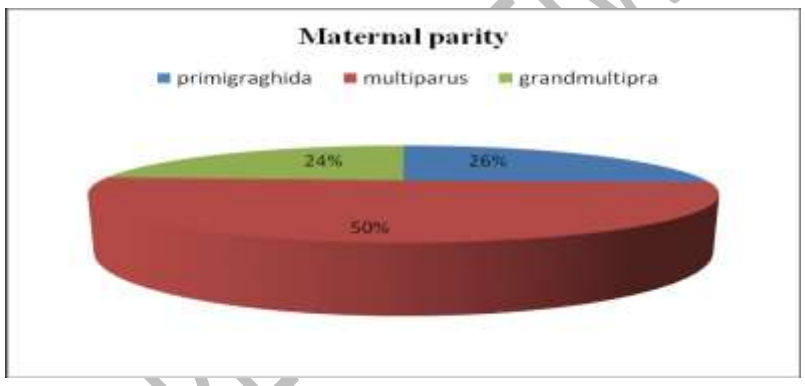

Figure 5: Maternal parity(n=794)

Figure 5 showed that 50% (400) were multiparious and 26% (240) were primigravida, and 24% (190) were grandmultipra.

Maternal parity demonstrateda statistically significant association with newborn weight (P-value =0.006) and head circumference (P-value =0.008), as inTable 2.

Table 2. Maternal parity and baby anthropometric measurements (n=794)

Maternal parity	Weight		Length		Head circumference		Total
	Normal	abnormal	Normal	abnormal	Normal	abnormal	
Primigravida	94.6%	5.4%	79.4%	20.6%	90.7%	9.3%	100% (240)

Multiparous	98%	2%	81.5%	18.5%	94%	6%	100% (400)
Grandmultipra	92.6%	7.4%	81.1%	18.9%	86.3%	13.7%	100% (190)
Total	95.8%	4.2%	80.9%	19.1%	91.3%	8.7%	100% (794)
p-value	**0.006**		**0.824**		**0.008**		

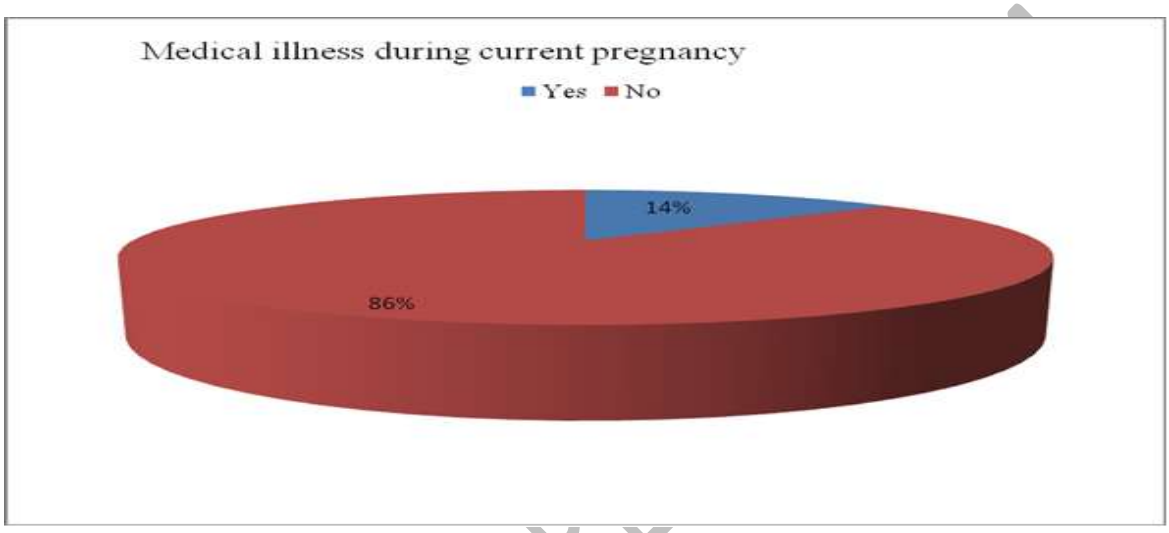

Figure 6. Medical illness during current pregnancy (n=794)

As illustratedinFigure6, 86% (683) of mothers didnot experience any medical illness during pregnancy,while 14% (111) experienced medical conditions during this period.

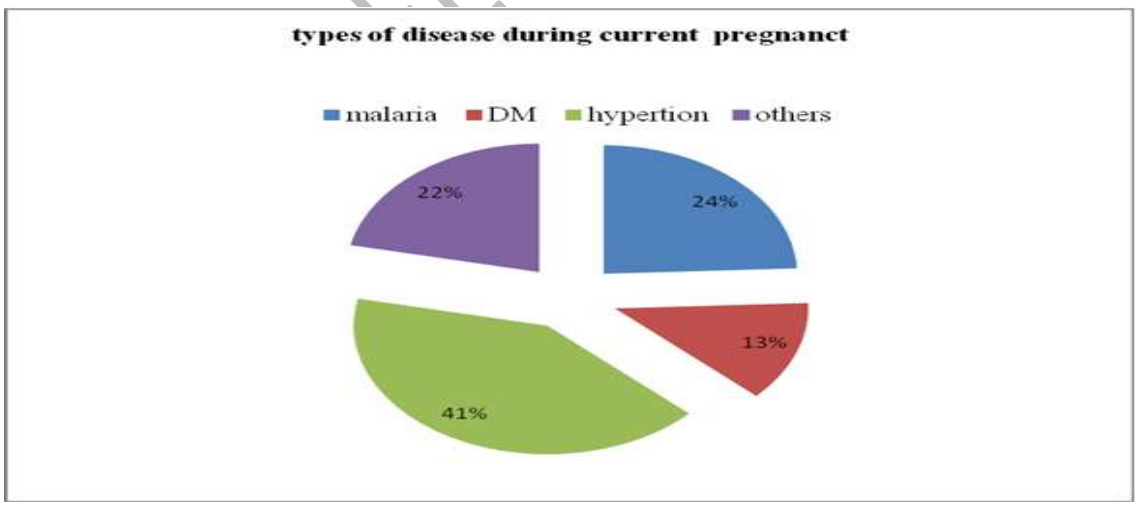

Figure 7. Types of disease during current pregnancy (n=111)

The most common health issue during pregnancy was hypertension (41%), followed by malaria (22%) and diabetes (13%) as in Figure 7.

The prevalence of morbidities during pregnancy had statistically significant association with weight, length, head circumference, and chest circumference (all P-values< 0.05), as detailed in Table 3.

Table 3. Maternal diseases during current pregnancy and baby anthropometric measurements (n=111)

Maternal diseases during current pregnancy	weight		length		Head circumference		Chest circumference	
	mean	SD	mean	SD	mean	SD	mean	SD
Malaria	2.93	0.41	46.16	2.46	34.39	1.25	31.39	1.82
DM	3.47	0.40	47.82	1.95	35.32	1.07	33.43	1.87
Hypertension	2.82	0.58	46.22	2.79	33.91	1.76	30.48	2.85
Others	3.05	0.38	47.45	1.87	31.70	1.37	31.40	1.53
p-value	**0.000**		**0.045**		**0.013**		**0.001**	

4. Discussion:

There are a significant gender differences exist in the prevalence and incidence of conditions affecting newborns. Male infants are moreprone to preterm birth, higher mortality rates, infections, sepsis, and congenital abnormalities (Gebremeskel *et al*, 2022). This study revealed no significant differences concerning the gender of the newborns.

In this study, the most common maternalagefalls within 20 to 31 years old. This age is aligned to the common maternalage worldwide and in the USA (Brown *et al,* 2025).

Themost mothers BMI category in this study was overweight. Mothers who are overweight or obese are more likely to give birth to infants with higher birth weights,which are also associated with newborn measurements suchas head circumference which clearly identified in this study.The prevalence of overweight and obesity among pregnant women in Sudan is rising at a concerning pace, especially in urban regions, posing a notable public health challenge (Eltayeb& Khalifa,2021).Researchreveals a strikingly high occurrence, with one studyreporting that over 35% of pregnant women are overweight and almost 20% are obese (Eltayeb & Khalifa, 2021).

In additional, this study showed correlation between pregnancy complications and newborn measures regarding weight, length, head circumference, and chest circumference.Pregnancy complications like diabetes and hypertension considerably heighten the likelihood of unfavorable outcomesfor newborns, including issues with birth weight. Such complications frequently result in respiratory difficulties and developmental challenges (Sokou*et al,* 2025). On the same issue, the most frequent health issue encountered during pregnancy in this study was hypertension, malaria, and diabetes. In Sudan, Hypertension during pregnancy is a significantcontributor to maternal morbidity

and mortality in Sudan, responsible for around 16.1% of maternal fatalities (Elhassan *et al,* 2025). Regarding malaria, Prevalence rates are significant, with studies reporting pregnant women infection rates up to 38.5% in some areas (Sulaiman*et al*, 2021). Furthermore, the prevalence of diabetes is notablyhigh among the Sudanese population (Abdelnour *et al,* 2025). Some studies attribute this to the fact that sugar is one of Sudan's primary products (Abdelnour *et al,* 2023). Therefore, Effectivemanagement of malaria, diabetes, and hypertension among pregnant women in Sudan necessitates a comprehensive approach to antenatal care (Adam *et al,* 2011).This involves promoting the use of insecticidetreated nets, ensuringtimely malaria treatment with Artemisinin Based Combination Therapies, and closely monitoringandcontrolling blood pressure and blood sugarlevels (Ali*et al,* 2011).

The occurrence of morbidities during pregnancy in this study showed significant relationship with weight, length, head circumference, and chest circumference.It is well documented in the literature that Maternal health issues, such as obesity and diabetes, have adirect impact on neonatal outcomes specifically towards weights, head circumferences, and chest circumferences (Shoji *et al,* 2022).

Finally, enhancing maternal and neonatal health in Sudan demands immediate, multi-dimensional efforts aimedat rebuilding health systems affectedby conflict (Elhassan *et al,* 2025:Olaleye*et al,* 2023).This involves establishing wellequipped neonatal intensive care units and reinforcing primary healthcare services (Elhassan *et al,* 2025). Priorityactions include providing midwives with emergency care training,expanding antenatal care coverage, ensuring access to critical medical supplies, and raising communityawarenessabout safe childbirth practices (Olaleye *et al,* 2023).

5. Conclusion:

The study emphasized that maternal healthissues in Sudansuch as overweight, hypertension, malaria, and diabetessignificantly affect neonatal measurements, including height, weight, head circumference, and chest circumference. Thisunderscores the pressing need for nationwide interventionsaimedat enhancing primary healthcare services to improve the health of both mothers and newborns.

References:

1. Abdalrhman, S., Elyas, U., Abdelnour, H., Abdulmagid, T., Almalty, T., Adam, M. (2025). Medical Staff and Physiotherapy Role in Total Knee Replacement. *Archives of Physiotherapy and Rehabilitation*, 8 (4), 27-32.https://cdn.fortunejournals.com/articles/medical-staff-and-physiotherapy-role-in-total-knee-replacement-6469.pdf
2. Abdelnour, H., Satti, L., Yousif, T., Ahmed, S., Eldin, A. S., & Abdelrahim, A. (2026). A Cross-Sectional Study of Knowledge, Perception, and Utilization of Physiotherapy Services Among Pregnant Women. *Journal of Life Science and Public Health, 2*(1), 31-35. https://doi.org/10.69739/jlsph.v2i1.1537
3. Abdelnour, H., Bleedy, N., Alkazaleh, H., Ahmed, A., Hawari, N., Mortada, O., & Abbas, A. (2025). Amputation Patient and Physiotherapy Education in Sudan. *Cuestiones de Fisioterapia*, *54*(5), 706-717.https://doi.org/10.48047/7s5g8y02

4. Abdelnour, H., Mohamed, A., El Tigani, D., Abdallha, B. (2023). Physical Disabilities and Rehabilitation Services in Khartoum State, Sudan. *The International Journal of Humanities & Social Studies*, 11(9). https://doi.org/10.24940/theijhss/2023/v11/i9/HS2309-016
5. Adam, I., Elhassan, E. M., Mohmmed, A. A., Salih, M. M., &Elbashir, M. I. (2011). Malaria and pre-eclampsia in an area with unstable malaria transmission in Central Sudan. *Malaria journal*, *10*, 258. https://doi.org/10.1186/1475-2875-10-258
6. Alkazaleh, H., Habiela, S., Abdelnour, H., Zaitoon, Z., Ahmed, A. (2025). Effect Of Proprioceptive Training on Children with Spastic Diplegia. *International Journal of Environmental Sciences*, 11(19s), 3314-3320. https://doi.org/10.64252/regfe863
7. Ali, A. A., Elhassan, E. M., Magzoub, M. M., Elbashir, M. I., & Adam, I. (2011). Hypoglycaemia and severe Plasmodium falciparum malaria among pregnant Sudanese women in an area characterized by unstable malaria transmission. *Parasites & vectors*, *4*, 88. https://doi.org/10.1186/1756-3305-4-88
8. Anthony, R., & McKinlay, C. J. (2023). Adaptation for life after birth: a review of neonatal physiology. *Anaesthesia& Intensive Care Medicine*, *24*(1), 1-9. https://www.nccwebsite.org/content/documents/courses/fetal%20to%20neonatal%20transition.pdf
9. Brown, A. D., Hamilton, B. E., Kissin, D. M., & Martin, J. A. (2025). Trends in mean age of mothers in the United States, 2016 to 2023.https://dx.doi.org/10.15620/cdc/174598
10. Casadei K, Kiel J. (2022). *Anthropometric Measurement*. In: StatPearls. StatPearls Publishing, Treasure Island (FL). PMID: 30726000.https://europepmc.org/article/NBK/nbk537315
11. Cao, G., Liu, J., & Liu, M. (2025). Countdown 2030: Trends in neonatal mortality between 1990 and 2023 with projections towards sustainable development goal target 3.2 at the global, regional, and national levels. *International journal of surgery (London, England)*, *111*(12), 8849–8859. https://doi.org/10.1097/JS9.0000000000003131
12. Carrión-Martínez, A., Buckley, B. J. R., Orenes-Piñero, E., Marín, F., Lip, G. Y. H., & Rivera-Caravaca, J. M. (2022). Anthropometric Measures and Risk of Cardiovascular Disease: Is there an Opportunity for Non-Traditional Anthropometric Assessment? A Review. *Reviews in cardiovascular medicine*, *23*(12), 414. https://doi.org/10.31083/j.rcm2312414
13. Elhassan, S., Osman, M., Altaher, A., Mohamed, R. M. A., Salah, S., Elsharif, S., & Yousif, E. (2025). Adverse maternal and neonatal outcomes in Northern Sudan: the role of antenatal care and socioeconomic inequities in war. *Reproductive health*, *22*(1), 186. https://doi.org/10.1186/s12978-025-02129-4
14. Eltayeb, R. A., & Khalifa, A. A. (2021). Impact of Maternal Body Mass Index on Maternal and Neonatal Outcomes Among Sudanese Women. *Cureus*, *13*(9), e18365. https://doi.org/10.7759/cureus.18365
15. Gebremeskel, A. T., Fantaye, A. W., Faust, L., Obegu, P., & Yaya, S. (2022). Gender differences in survival among low birthweight newborns and infants in

sub-Saharan Africa: a systematic review. *International health*, *14*(2), 122–131. https://doi.org/10.1093/inthealth/ihab044

16. Muglia, L. J., Benhalima, K., Tong, S., & Ozanne, S. (2022). Maternal factors during pregnancy influencing maternal, fetal, and childhood outcomes. *BMC medicine*, *20*(1), 418. https://doi.org/10.1186/s12916-022-02632-6
17. Olaleye, S. O., Aroyewun, T. F., & Osman, R. A. (2023). Sudan's maternal health needs urgent attention amid armed conflict. *The Lancet*, *402*(10405), 848-849.
18. Shanto, H. H., Al-Zubayer, M. A., Ahammed, B., Sarder, M. A., Keramat, S. A., Hashmi, R., Haque, R., &Alam, K. (2023). Maternal Healthcare Services Utilisation and Its Associated Risk Factors: A Pooled Study of 37 Low- and Middle-Income Countries. *International journal of public health*, *68*, 1606288. https://doi.org/10.3389/ijph.2023.1606288
19. Satti L, Abdelnour H, Alawad S, Gabrallah M, Alshiekh R. (2026). Prevalence of Stress and Neck Pain Among Accountants: A Cross-Sectional Study. *Eur J Med Health Res,* 4(1), 156-61. https://doi.org/10.59324/ejmhr.2026.4(1).22
20. Satti, L., Abdelnour, H., Yousif, B., Mustafa, O., Mohammed, R. (2025). Text Neck Syndrome Among Students at the National University in Sudan. *World Journal of Advanced Research and Reviews*, 28(03), 1501-1507. https://doi.org/10.30574/wjarr.2025.28.3.4154
21. Taha, S., Izzoddeen, A., Munywoki, A., &Wagialla, N. (2025). A decade of change: maternal mortality trends in Sudan, 2009-2019. *BMC public health*, *25*(1), 1667. https://doi.org/10.1186/s12889-025-22820-2
22. World Health Organization (WHO). 2026. *Child growth standards.*https://www.who.int/tools/child-growth-standards/who-multicentre-growth-reference study#:~:text=The%20WHO%20Multicentre%20Growth%20Reference%20Study%20(MGRS),the%20normative%20model%20for%20growth%20and%20development.
23. Suliman, M. A., Tamomh, A. G., Younis, O. Y., Magboul, A. M., Mohammed, H. Y., Hassan, I. M., & Musa, N. M. (2021). Malaria infection and associated risk factors in pregnant women attending antenatal care clinics in Al Jabalian Locality, White Nile state, Sudan. *Annals of parasitology*, *67*(3), 499–504. https://doi.org/10.17420/ap6703.363
24. Shoji, H., Murano, Y., Saitoh, Y., Ikeda, N., Ohkawa, N., Nishizaki, N., Hisata, K., Kantake, M., Obinata, K., Yoneoka, D., & Shimizu, T. (2022). Use of Head and Chest Circumference Ratio as an Index of Fetal Growth Retardation in Preterm Infants. *Nutrients*, *14*(22), 4942. https://doi.org/10.3390/nu14224942
25. Sokou, R., Lianou, A., Lampridou, M., Panagiotounakou, P., Kafalidis, G., Paliatsiou, S., Volaki, P., Tsantes, A. G., Boutsikou, T., Iliodromiti, Z., &Iacovidou, N. (2025). Neonates at Risk: Understanding the Impact of High-Risk Pregnancies on Neonatal Health. Medicina, 61(6), 1077. https://doi.org/10.3390/medicina61061077

Author profile:

1. **Dr. Wisal Ahmed:**

Assistance Professor, Pediatric Department, Faculty of Medicine, Al Neelain University (NU), Khartoum, Sudan. Pediatric Specialists, Department of Pediatric, Sultan Gabos Hospital, Dhofar, Oman. Email:wisalmohy@gmail.com. ORCID ID: https://orcid.org/0009-1041-9873-0350.

2. **Dr. ElshafieHabieballa:**

Pediatric Consultant, Pediatric Department, Military Hospital, Omdurman, Sudan. Lieutenant General,Medical Services, Sudanese Army, Khartoum, Sudan. Email: elshafie37@gmail.com

3. **Dr. Hassan Abdelnour:**

Assistance Professor, Faculty of Applied Medical Sciences, Jerash University (JU), Jerash, Jordan. School of Health Sciences, Ahfad University for Women (AUW), Omdurman, Sudan. Email: hasphysio@gmail.com. ORCID ID: https://orcid.org/0009-0001-9873-5966