Journal of Obstetrics, Gynecology and Cancer Research | ISSN: 2476-5848

Preliminary Nonlinear Regression-Based Reference Values for Fetal Biometry at 35-40 Weeks of Gestation Incorporating Maternal Height in Indonesia: A Retrospective Cross-Sectional Study

Yuni Nurwati[1*], Dewi Anggraini[2], Hardinsyah[3], Sri Anna Marliyati[3], Budi Iman Santoso[4], Ratna Candra Dewi[1], Ika Nurmaya[1], Raisya[1], Gabriel Makuei Deng Makuei[5]

1. *Department of Nutrition, Faculty of Sport and Health Sciences, Universitas Negeri Surabaya, Surabaya, Indonesia*
2. *Department of Statistics, Faculty of Mathematics and Natural Sciences, University of Lambung Mangkurat, Banjarbaru, Indonesia*
3. *Department of Community Nutrition, Faculty of Human Ecology, IPB University, Bogor, Indonesia*
4. *Department of Obstetrics and Gynecology, Faculty of Medicine, University of Indonesia, Depok, Indonesia*
5. *College of Postgraduate Studies and Scientific Research, Dr. John Garang Memorial University of Science and Technology, Bor, Jonglei State, South Sudan*

Article Info

10.24200/jogcr.12.1.49

Received: 2026/06/05
Accepted: 2026/07/16
Published Online: 01 Nov. 2026

Corresponding Information:
Yuni Nurwati,
Department of Nutrition, Faculty of Sport and Health Sciences, Universitas Negeri Surabaya, Surabaya, Indonesia

Email: yuninurwati@unesa.ac.id

ABSTRACT

Background & Objective: International fetal growth references may not adequately represent populations with distinct maternal and fetal characteristics. This study was conducted with aim to develop preliminary gestational-age-specific reference values for Estimated Fetal Weight (EFW) at 35-40 weeks by incorporating maternal height and fetal biometry among pregnant women in Ternate, North Maluku, Indonesia.

Materials & Methods: This retrospective observational study used routinely collected records from 127 women with singleton pregnancies who received antenatal care and delivered at the same hospital between 2018 and 2023. Eligible women had at least one antenatal visit in each trimester. Data was divided into two sets: training (n=102) and testing (n=25). Candidate nonlinear regression models were fitted to describe EFW according to gestational age from 35 to 40 weeks, with maternal height included as a covariate. Performance was assessed using adjusted R^2, standard error of prediction, and validation errors.

Results: The quadratic model provided the best fit, with the highest adjusted R^2 (0.973) and the lowest standard error of prediction (152.756 g) among the evaluated models. Testing-set validation also showed lower prediction errors than the comparison models.

Conclusion: The proposed model provides preliminary local reference values for EFW at 35-40 weeks and should not be interpreted as a fetal growth chart covering the entire pregnancy. These values may support near-term fetal assessment and provide locally relevant information for ultrasound-based maternal care in Indonesia.

Keywords: Estimated fetal weight, Fetal biometry, Gestational age, Indonesia, Maternal height

Copyright © 2027, This is an original open-access article distributed under the terms of the Creative Commons Attribution-noncommercial 4.0 International License which permits copy and redistribution of the material just in noncommercial usages with proper citation.

1. Introduction

Infant Mortality Rate (IMR) in Indinesia decreased from 2017 (24 deaths per 1,000 live births) to 2020 (16.85 deaths per 1,000 live births). This condition must continue to achieve the Sustainable Development Goals (SDGs) target of 12 deaths per 1,000 live births by 2030 **(1)**. As many as 54.3% of provinces in Indonesia still have infant mortality rates exceeding the national average, and one of them is North Maluku Province. It had the sixth-highest infant mortality rate in Indonesia with 28.61 deaths per 1,000 live births. Furthermore, most infant mortality rates occur during the neonatal period, and the main cause of neonatal death is Low Birth Weight (LBW) **(2)**.

Monitoring fetal growth during pregnancy is an integral part of quality Antenatal Care (ANC). One of the main instruments used in this monitoring is the fetal growth chart, which allows health workers to assess whether fetal growth is within normal limits or indicates a disorder such as Small-for-Gestational-Age (SGA), LBW, or Large-for-Gestational-Age (LGA) **(3,4)**. Early identification of these conditions is crucial because they are closely related to an increased risk of

perinatal morbidity and mortality, allowing for timely clinical intervention **(5)**.

Several international fetal growth charts have been developed and widely used in clinical practice, including the INTERGROWTH-21st growth chart **(6)**, the World Health Organization (WHO) Fetal Growth Chart **(7)**, and the Global Reference **(8)**. Although these charts were developed through large-scale, multicenter studies with rigorous methodology, there is ongoing debate about their ability to universally represent fetal growth patterns. General population-based charts only consider gestational age and fetal sex in calculating weight percentiles, without accounting for physiological variations stemming from maternal characteristics **(4,9)**. However, numerous studies demonstrated that maternal weight, height, parity, and ethnicity are significant determinants of fetal birth weight that cannot be ignored in accurate growth assessment **(10,11)**. Adjustment for these maternal physiological variables has been shown to improve the charts' ability to differentiate constitutionally small fetuses **(9,12)**.

Gardosi et al., introduced the concept of customized fetal growth charts "One size does not fit all" **(11)** as a response to the limitations of general population-based charts. These charts accommodate the optimal growth potential of each fetus individually by adjusting maternal characteristics such as weight, height, parity, maternal age, and ethnicity **(10,13)**. Studies in Malaysia have shown that international charts have limitations in detecting SGA infants in Southeast Asian populations, and local charts tailored to maternal characteristics have been shown to provide higher accuracy **(14,15)**. Several other studies have also shown that the integration of maternal variables such as height, BMI, pre-pregnancy weight, and parity into fetal weight estimation formulas consistently improves estimation accuracy compared to conventional formulas based solely on fetal biometry **(16-19)**. Maternal height, anemia, and pre-pregnancy BMI have specifically been identified as the most significant independent predictors of infant birth weight even after consideration of fetal biometry parameters from ultrasound **(20-22)**. This indicates that local biological, genetic, and environmental factors have a significant influence on fetal growth patterns that cannot be fully captured by universal international references **(4,23)**.

The development of growth charts in Indonesia was first carried out by Husaini et al., **(24)**, but these charts were for the adolescent growth and development. The need for local population-based fetal growth charts is increasingly urgent as the coverage of ultrasound examinations in antenatal care increases. The Indonesian government has distributed ultrasound devices to all public health centers to improve the quality of care for pregnant women throughout the region **(25)**. However, the use of ultrasound examination results for fetal growth assessment still relies heavily on international reference charts that do not necessarily match the characteristics of the local Indonesian population. Several studies have attempted to develop Indonesian population-based fetal growth references **(26-28)**.

Ternate, as one of the main cities in North Maluku Province, is a region with growing access to healthcare services but still faces limitations in the availability of local population-based clinical data. The absence of fetal growth references that consider local maternal characteristics has the potential to lead to misclassification of fetal growth status and impact the accuracy of clinical decision-making **(9,12)**. Moreover, in the final trimester, particularly between 35 and 40 weeks of gestation, monitoring fetal growth becomes even more crucial because this period is closely related to determining the timing and mode of delivery, as well as the risk of perinatal complications. This study was conducted with aim to develop a gestational age-based fetal growth chart for pregnancies at 35-40 weeks using a locally developed fetal weight estimation formula and serial ultrasound biometry data considering maternal characteristics in the population of Ternate City, North Maluku, Indonesia.

2. Materials and Methods

This single-center retrospective observational study was conducted using routinely collected maternal, ultrasound, and delivery records. The study was conducted at a private referral hospital in Ternate City, North Maluku Province, Indonesia from January 2018 to December 2023. Antenatal and ultrasound data were obtained from the records of an obstetrician and gynecologist practicing at the same hospital.

The study included women with singleton pregnancies who met the following criteria: received antenatal care and delivered at the same hospital; had a reliable estimate of gestational age based on a first-trimester ultrasound examination; had antenatal and ultrasound records available from pregnancy until delivery; had at least one eligible ultrasound examination within 35-40 weeks of gestation; and delivered between 35 and 40 weeks of gestation. A total of 127 pregnant women were included and contributed 1,001 serial ultrasound examinations from 13 weeks of gestation onwards. Participants were randomly allocated to a training dataset comprising 80% of the participants (n=102) and a testing dataset comprising 20% (n=25). For the development and validation of the fetal growth model at term, only ultrasound examinations performed between 35 and 40 weeks of gestation were eligible for analysis. Women were excluded if they had multiple pregnancies, congenital fetal anomalies detected by ultrasound, chronic maternal conditions known to affect fetal size, or incomplete or inconsistent records for the variables required in the analysis.

The fetal biometric variables obtained from ultrasound records included Biparietal Diameter

(BPD), Head Circumference (HC), Abdominal Circumference (AC), and Femur Length (FL). Maternal height was obtained from the antenatal records. Gestational age was determined from the first-trimester ultrasound examination. Gestational age in weeks was the principal explanatory variable in the model used to derive the EFW reference values. The primary EFW values were calculated using the locally developed equation incorporating maternal height and fetal biometric measurements, particularly head and abdominal circumference:

EFW(g)= 6.78891×head circumference (mm)+5.80782×abdominal circumference+6.35725×maternal height (cm)

The model-development analysis was conducted using the training dataset of 102 women. Several functional forms were evaluated to describe the relationship between EFW and gestational age. Candidate models were compared using adjusted coefficient of determination; Standard Error of Estimate (SEE) or root mean squared error; residual distribution; residual plots for nonlinearity and heteroscedasticity; and predictive performance in the testing dataset. The model with the highest adjusted R^2, lowest prediction error, and most satisfactory residual behaviour was selected. Internal performance was evaluated using the testing dataset of 25 women. All statistical tests were two-sided, with a significance level of $P<0.05$. Statistical analyses were performed using statistical software.

3. Results

Univariate analysis of the subjects showed that the average maternal age was 28 years, body height was 155 cm, initial body weight was 51.8 kg, pre-pregnancy BMI was 21.2 kg/m^2, third-trimester hemoglobin level was 11.1 g/dL, gestational age at delivery was 39 weeks, and birth weight was 3253 gr. The majority of participants were nulliparous. Most women had normal nutritional status. Information on gestational diabetes mellitus was unavailable because routine screening data were not consistently documented in the medical records; therefore, this variable was not included in this analysis.

Gestational age at delivery ranged from 35 to 40 weeks (Table 1). Most deliveries occurred during 39 weeks of gestation (n=58, 45.7%), followed by 40 weeks (n=28, 22.0%) and 38 weeks (n=24, 18.9%). Deliveries at earlier gestational ages were less frequent, comprising 7 participants (5.5%) each in 36 and 37 weeks and 3 participants (2.4%) at 35 weeks. The mean birth weight increased progressively with advancing gestational age, from 2,550 g at 35 weeks to 3,342 g at 40 weeks. Birth weight variability also increased with gestational age, with standard deviations ranging from 86.6 g at 35 weeks to 437.6 g at 38 weeks. Across all gestational age groups, birth weights ranged from 2,500 g to 4,000 g.

Ten regression models were evaluated to describe the relationship between estimated fetal weight and gestational age using the training dataset (n=102). Based on these model selection criteria, three models with the best statistical performance were identified: linear, logarithmic, and quadratic models (S3). These three models demonstrated the highest correlation coefficients, adjusted R^2, and lowest SEE compared to the other models. All evaluated models demonstrated statistical significance in the ANOVA test ($P<0.05$), indicating that gestational age was a significant predictor of estimated fetal weight in all three models. The Shapiro-Wilk residual normality test showed that the residual distributions in the three candidate models did not deviate significantly from a normal distribution ($P>0.05$); thus, meeting the regression assumptions.

Table 2 presents the results of a comparison of prediction errors between the proposed model and EFW-GA models at 35-40 weeks of gestation using a two-sample F-test (Levene) and a two-sample T-test (S1). The results of the homogeneity of variance test indicate that the comparison between proposed EFW and the linear ($P=0.106$), logarithmic ($P=0.151$), and quadratic ($P=0.137$) showed homogeneity of error variance between the models. Conversely, the comparison with the Hadlock ($P=0.005$) and Sotiriadis ($P=0.038$) models indicated a significant difference in variance. Based on the t-test, Model III showed no significant difference from the linear ($P=0.365$), logarithmic ($P=0.354$), and quadratic ($P=0.369$) models, with estimated differences of 83.8 gr, 87.7 gr, and 84.4 gr, respectively. This indicates that proposed model's predictive performance is comparable to those three models.

However, there were significant differences between proposed EFW and the Hadlock ($P<0.001$) and Sotiriadis ($P<0.001$) models. The estimated differences were also relatively large, at 479.1 gr in the Hadlock model and 672.7 gr in the Sotiriadis model. Furthermore, the lower variance ratios (<1) in both comparisons indicate that proposed EFW has less error variability than those two models. Proposed model performed comparable to linear, logarithmic, and quadratic models ($P>0.05$), but significantly differed from the Hadlock and Sotiriadis model ($P<0.05$), with a significant difference in estimates. This suggests that proposed EFW has different predictive characteristics than the commonly used standard clinical models.

Accuracy evaluation was conducted on three selected candidate models: linear, logarithmic, and quadratic models by calculating the error between the estimated fetal weight from the EFW-GA equation and the estimated fetal weight from a previously developed formula (manuscript under review). The evaluation parameters used ME, MPE, MAPE, MedAPE, and the proportion of estimates within ±5%, ±10%, and ±20% of the actual fetal weight. A complete comparison of the error values between the proposed and existing models is presented in Table 3.

The comparison results show that the quadratic model produced the smallest error value compared to the linear, logarithmic, and the three existing models. Further residual analysis of the quadratic model showed that the average residual variation in weight for all gestational ages 35-40 weeks was 9.3%, which reflects a clinically acceptable level of accuracy for fetal growth monitoring purposes **(26,27,33-34)** (S2). Based on all these statistical and clinical considerations, the quadratic model was selected as the model of choice for the construction of local fetal growth charts in this study.

Percentile curves covering P3, P5, P10, P50, P90, P95, and P97 were constructed based on the distribution of estimated fetal weight values and residual standard deviations at each gestational age. The visualization of the percentile graph is shown in Figure 1. The P50 value at 35 weeks of gestation is 3015 gr and increases to 3394 gr at 40 weeks of gestation, reflecting an average fetal weight gain of 379 gr per week over that gestational age range.

The superimposed results of the four charts are presented in Figure 2. The visual comparison shows that the percentile charts developed in this study are higher to the international charts for most gestational ages, particularly in the P50 curve. This difference reflects the unique fetal growth characteristics of the local population of Ternate, North Maluku, which are likely influenced by local maternal anthropometric characteristics, such as mean maternal, which are generally comparable to the international reference population.

The estimated fetal weight results at the 50th percentile are close to the actual infant weight at all birth weeks (37 to 40) (Figure 3). In contrast, the predicted birth weight values from existing models tend to underestimate at weeks 37 and 38, and overestimate in weeks 40. The formulas of Stirnemann et al., **(30)** and Sotiriadis et al., **(35)** produce predicted birth weight values close to the actual value only at weeks 38-39. Meanwhile, the formulas of Hadlock et al., **(36)** and Kiserud et al., **(7)** tended to produce overestimates above 38 week.

Table 1. Distribution of gestational age at delivery and birth weight

Gestational age (week)	Total participants (n)	Average of actual birth weight	SD	Minimum (g)	Maximum (g)
35	3	2550	86.6	2500	2550
36	7	2792	252.4	2500	3100
37	7	3185	291.1	2900	3200
38	24	3281	437.6	2500	4000
39	58	3316	335.7	2800	3900
40	28	3342	404.1	2700	4000

* SD= Standard Deviation

Table 2. Comparison of the error values between the proposed formula with proposed EFW-GA

Prediction error Proposed EFW – EFW-GA	Mean error (ME) (g)	Mean Percentage (MPE) (%)	Mean absolute percentage (MAPE) (%)	Median absoluter percentage (MEDAPE) (%)	Estimates within 5% EFW-GA (%)	Estimates within 10% EFW-GA (%)	Estimates within 20% EFW-GA (%)
Comparison of the error values between the proposed formula with proposed EFW-GA							
Linear	102	1.02	1.70	1.39	59.31	86.76	97.06
Logarithmic	106	1.09	1.56	1.22	55.88	82.35	95.59
Kuadratik	103	1.02	1.51	1.20	59.31	87.25	98.53
Comparison of the error values between the proposed EFW-GA with existing models							

Table 3. Comparison of the error values between the proposed formula with proposed EFW-GA and and existing models

Prediction error (ABW-EFW-GA)	Mean error (ME) (g)	Mean Percentage (MPE) (%)	Mean absolute percentage (MAPE) (%)	Median absolute percentage (MEDAPE) (%)	Estimates within 5% ABW (%)	Estimates within 10% ABW (%)	Estimates within 20% ABW (%)
Linear	-113,28	-1,13	2,81	2,37	87,09	87,09	100
Linear	-113,28	-1,13	2,81	2,37	87,09	87,09	100
Logarithmic	-25,57	-0,26	2,75	2,47	77,41	87,09	100
Quadratic	-45,92	-0,46	2,72	2,31	77,42	87,09	100
Existing models							
Hadlock (1991)	-140,04	-1,40	3,04	2,87	80,65	93,54	100
Sotiriadis (2018)	90,03	0,91	3,11	2,87	54,84	70,97	100

* ABW=Actual Birth Weight

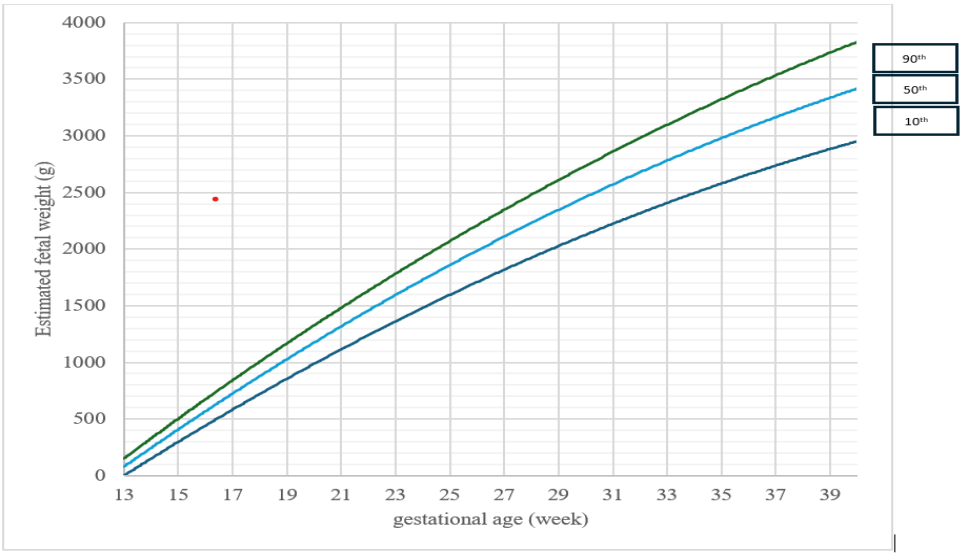


Figure 1. Visualization of the percentile growth chart

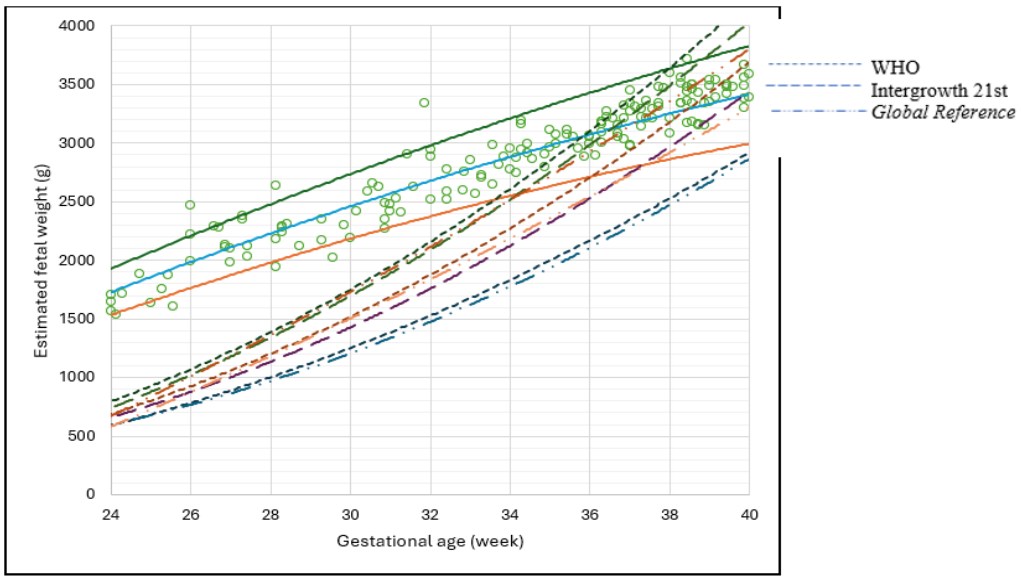


Figure 2. **Visual comparison between proposed growth chart and existing growth charts**

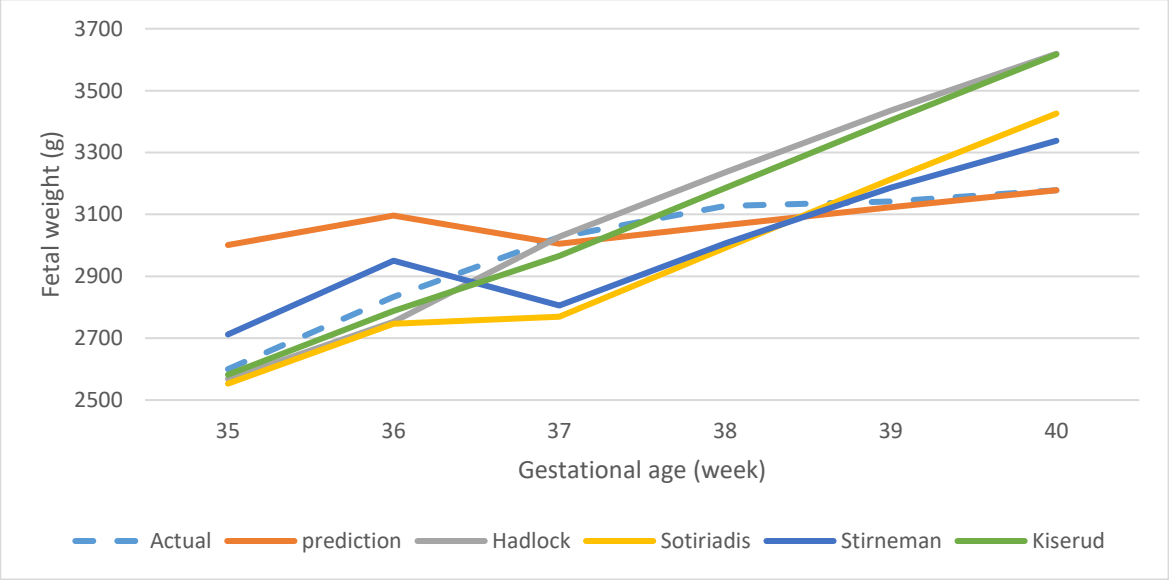


Figure 3. **Comparison actual birth weight with predicted fetal weight in proposed and existing models**

4. Discussion

As the results of the present study showed, the average residual variation in body weight of 9.3% across the gestational age range indicates a clinically acceptable level of accuracy, in line with the accuracy criteria used in limited population-based fetal growth chart development studies in developing countries **(27,30)**. A key finding in this study is the position of the Ternate local chart percentile curve, which is consistently above the third percentile curve of the international charts, namely INTERGROWTH-21st, WHO, and Global Reference across the entire gestational age range evaluated. This difference cannot be explained solely by maternal height, considering that the mean maternal height in this study population (155.6±3.6 cm) is in a comparable range to the WHO reference population. This indicates that the observed difference stems from two main interrelated factors **(16-20)**. First, the EFW formula used in this study integrates maternal characteristics and fetal biometry simultaneously **(16,18,37)**. Second, these differences may also reflect the actual fetal growth characteristics of the Ternate population, which has a different demographic and anthropometric profile from the

multicenter population underlying the development of the international charts **(6,7)**.

Grantz et al., **(38)** in their study emphasizes that adjustment for maternal physiological variables, weight, height, parity, and ethnicity, is a more accurate approach in defining the optimal growth potential of each fetus individually. The findings of these chart differences are also consistent with similar studies in Southeast Asia and Indonesia. Saw et al., **(39)** in a study on the Malaysian population reported that international charts have limitations in detecting SGA infants, and local charts developed based on the local population provide higher accuracy. Fattah et al., **(26)** from Jakarta reported that local Indonesian fetal weight standards have a better ability to predict low Apgar scores in SGA neonates compared to the Hadlock reference. Comparison with Anggraini et al., **(27)** charts developed based on the Indonesian population shows a more comparable pattern than the international charts, indicating similarities in fetal growth characteristics across local Indonesian populations despite geographical and demographic differences. This further strengthens that fetal growth characteristics in the Indonesian population have their own uniqueness which cannot be fully captured by international references developed from populations with different characteristics **(6,7,28)**. The approach used in this study, which developed a local population-based EFW formula before constructing the percentile chart, is methodologically more appropriate than simply adopting a conventional formula with coefficients from a different population **(38,40)**. Visual comparison analysis between actual and estimated fetal weights from the proposed model and the three existing models showed that the proposed model produced estimates that were closer to actual fetal weights at 37-40 weeks gestation than the international charts used for comparison.

This study had several limitations that should be considered when interpreting the findings. First, the retrospective cross-sectional design of the study limits the ability to establish longitudinal fetal growth trajectories. Second, the sample size (n=127, with an internal validation subset of n=25) is relatively small for establishing population-level reference standards. Gestational diabetes mellitus could not be evaluated because complete screening data were not available in the retrospective medical records. Consequently, its potential influence on fetal growth cannot be assessed.

5. Conclusion

This study developed the first internally validated a fetal growth reference for Ternate City, North Maluku, covering the gestational age range of 35–40 weeks incorporating maternal height and fetal biometry. The model demonstrated good predictive performance within the study population. However, since the study was conducted at a single private hospital with a relatively small sample size, external validation in larger and more diverse population is required.

6. Declarations

Acknowledgments

The authors acknowledge obstetrician-gynecologist, midwife, and all hospital staff who helped to conduct this research.

Ethical Considerations

This research was supported by the Master's Scholarship Program to Doctorate for Outstanding Graduates (PMDSU), Directorate of Higher Education (DIKTI), Ministry of Research, Technology, and Higher Education of the Republic of Indonesia (RISTEKDIKTI), No. 077/SP2H/LT/DRPM/2021. Ethical approval was obtained from the Health Research Ethics Committee, Faculty of Medicine, Hasanuddin University (ethical code: 785/UN4.6.5.31/PP3/2022).

Authors' Contributions

Yuni Nurwati: Conceived and designed the analysis, Collected the data, contributed data or analysis tools, Performed the analysis, Wrote the paper. Dewi Anggraini: Conceived and designed the analysis, contributed data or analysis tools, Performed the analysis, Wrote the paper. Hardinsyah: Conceived and designed the analysis, contributed data or analysis tools, Performed the analysis. Sri Anna Marliyati: Conceived and designed the analysis, contributed data or analysis tools, Performed the analysis. Budi Iman Santoso: Conceived and designed the analysis, contributed data or analysis tools, Performed the analysis. Ratna Candra Dewi: Performed the analysis, Wrote the paper. Ika Nurmaya: Performed the analysis, Wrote the paper. Raisya: Performed the analysis, Wrote the paper. Gabroel Makuei Deng Makuei: Performed the analysis, Wrote the paper

Conflict of Interest

The authors declare no conflict of interest.

Fund or Financial Support

The study was funded by the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia (RISTEKDIKTI).

References

1. Badan Pusat Statistik. Profil Kesehatan Ibu dan Anak 2024 [Internet]. Jakarta: Badan Pusat Statistik; 2024. Available from: https://www.bps.go.id/id/publication/2024/12/31/a919c55a72b74e33d011b0dc/profil-kesehatan-ibu-dan-anak-2024.html
2. Badan Pusat Statistik. Hasil Long Form Sensus Penduduk 2020 [Internet]. 2023 [cited 2026 May 1]. Available from: https://www.bps.go.id/id/publication/2023/01/27/ffb5939b4393e5b1146a9b91/hasil-long-form-sensus-penduduk-2020.html
3. Salomon LJ, Alfirevic Z, Da Silva Costa F, Deter RL, Figueras F, Ghi T, et al. ISUOG practice guidelines: ultrasound assessment of fetal biometry and growth. Ultrasound Obstet Gynecol. 2019;53(6):715-23. [doi:10.1002/uog.20272]
4. Unterscheider J, Daly S, Geary MP, Kennelly MM, McAuliffe FM, O'Donoghue K, et al. Optimizing the definition of intrauterine growth restriction: the multicenter prospective PORTO Study. Am J Obstet Gynecol. 2013;208(4):290.e1-e6. [doi:10.1016/j.ajog.2013.02.007]
5. Gardosi J, Madurasinghe V, Williams M, Malik A, Francis A. Maternal and fetal risk factors for stillbirth: population based study. BMJ. 2013;346:f108. [doi:10.1136/bmj.f108]
6. Papageorghiou AT, Ohuma EO, Altman DG, Todros T, Ismail LC, Lambert A, et al. International standards for fetal growth based on serial ultrasound measurements: the Fetal Growth Longitudinal Study of the INTERGROWTH-21st Project. Lancet. 2014;384(9946):869-79. [doi:10.1016/S0140-6736(14)61490-2]
7. Kiserud T, Piaggio G, Carroli G, Widmer M, Carvalho J, Neerup Jensen L, et al. The World Health Organization fetal growth charts: a multinational longitudinal study of ultrasound biometric measurements and estimated fetal weight. PLoS Med. 2017;14(1):e1002220.. [doi:10.1371/journal.pmed.1002220]
8. Mikolajczyk RT, Zhang J, Betrán AP, Souza JP, Mori R, Gülmezoglu AM, et al. A global reference for fetal-weight and birthweight percentiles. Lancet. 2011;377(9780):1855-61. [doi:10.1016/S0140-6736(11)60364-4]
9. Carberry AE, Gordon A, Bond DM, Hyett J, Raynes-Greenow CH, Jeffery HE. Customised versus population-based growth charts as a screening tool for detecting small for gestational age infants in low-risk pregnant women. Cochrane Database Syst Rev. 2014;(5):CD008549. [doi:10.1002/14651858.CD008549.pub3]
10. Francis A, Hugh O, Gardosi J. Customized vs INTERGROWTH-21st standards for the assessment of birthweight and stillbirth risk at term. Am J Obstet Gynecol. 2018; (2S):S692-9. [doi:10.1016/j.ajog.2017.12.013]
11. Gardosi J, Chang A, Kalyan B, Sahota D, Symonds E. Customised antenatal growth charts. Lancet. 1992;339(8788):283-7. [doi:10.1016/0140-6736(92)91342-6]
12. Bukowski R, Burgett AD, Gei A, Saade GR, Hankins GDV. Impairment of fetal growth potential and neonatal encephalopathy. Am J Obstet Gynecol. 2003;188(4):1011-5. [doi:10.1067/mob.2003.233]
13. Verburg BO, Steegers EAP, De Ridder M, Snijders RJM, Smith E, Hofman A, et al. New charts for ultrasound dating of pregnancy and assessment of fetal growth: longitudinal data from a population-based cohort study. Ultrasound Obstet Gynecol. 2008;31(4):388-96. [doi:10.1002/uog.5225]
14. Za'im Sahul Hameed M, Sutan R, Mahdy ZA, Tamil AM, Sulong S. Maternal variables as determinant of fetal growth: study protocol on customized fetal growth charts in Malaysia (GROW-My). Front Med (Lausanne). 2021;8:592462. [doi:10.3389/fmed.2021.592462]
15. Haksari EL, Lafeber HN, Hakimi M, Pawirohartono EP, Nyström L. Reference curves of birth weight, length, and head circumference for gestational ages in Yogyakarta, Indonesia. BMC Pediatr. 2016;16(1):188. [doi:10.1186/s12887-016-0728-1]
16. Iyiola AA, Ebeigbe PN, Ochei UA, Oyeribhor AJ, Okungbowa GE. Foetal weight estimation, at term, using a multivariate algorithm of maternal characteristics, has an accuracy similar to that of ultrasonography. Ghana Med J. 2024;58(4):303-10. [doi:10.4314/gmj.v58i4.8]

17. Curti A, Zanello M, De Maggio I, Moro E, Simonazzi G, Rizzo N, et al. Multivariable evaluation of term birth weight: a comparison between ultrasound biometry and symphysis-fundal height. J Matern Fetal Neonatal Med. 2014;27(13):1328-32. [doi:10.3109/14767058.2013.858241]
18. Granfors M, Mantel A, Axelsson O, Cnattingius S, Lindström L. Impact of fetal and maternal characteristics on the accuracy and precision of sonographic fetal weight estimation: population-based study. Ultrasound Obstet Gynecol. 2025;66(6):747-53. [doi:10.1002/uog.70117]
19. Espinola-Sánchez M, Limay-Rios A, Campaña-Acuña A, Sanca-Valeriano S. Machine learning models for estimating fetal weight based on ultrasonographic biometry: development and validation study. Digit Health. 2025;11:20552076251342012. [doi:10.1177/20552076251342012]
20. Liu Z, Han N, Su T, Ji Y, Bao H, Zhou S, et al. Interpretable machine learning to identify important predictors of birth weight: a prospective cohort study. Front Pediatr. 2022;10:899954. [doi:10.3389/fped.2022.899954]
21. Ghosal S, Gleason JL, Grantz KL, Chen Z. Maternal BMI and diagnostic accuracy of using estimated fetal growth to predict abnormal birthweight: results from NICHD Fetal Growth Studies. Diagnostics (Basel). 2025;15(11):1398. [doi:10.3390/diagnostics15111398]
22. Nurwati Y, Santoso BI, Hardinsyah H, Marliyati SA, Anggraini D, Ristanti IK, et al. Maternal factors associated with newborn birth weight: a retrospective cohort study of anemia, gestational weight gain, and nutritional status. J Obstet Gynecol Cancer Res. 2026;11(64):1039-46. [doi:10.24200/jogcr.11.11.1039]
23. de Souza LR, Urquia ML, Sgro M, Ray JG. One size does not fit all: differences in newborn weight among mothers of Philippine and other East Asian origin. J Obstet Gynaecol Can. 2012;34(11):1026-37. [doi:10.1016/S1701-2163(16)35432-9]
24. Husaini YK, Sandjaja, Husaini MA. KMS remaja, relevansinya dengan pemantauan tumbuh kembang dalam upaya meningkatkan gizi dan kesehatan. Penelit Gizi Makan. 1994;17. [doi:10.22435/pgm.v0i0.1945]
25. Ministry of Health of the Republic of Indonesia (Kemenkes RI). Keputusan Menteri Kesehatan Republik Indonesia. Jakarta: Kemenkes RI; 2023.
26. Fattah ANA, Pratiwi KN, Susilo SA, Berguna JSN, Irwinda R, Wibowo N, et al. Indonesian local fetal-weight standard: a better predictive ability for low Apgar score of small-for-gestational-age neonates. Med J Indones. 2016;25(4):228-33. [doi:10.13181/mji.v25i4.1301]
27. Anggraini D, Abdollahian M, Marion K. The development of an alternative growth chart for estimated fetal weight in the absence of ultrasound: application in Indonesia. PLoS One. 2020;15(10):e0240436. [doi:10.1371/journal.pone.0240436]
28. Anggraini D, Abdollahian M, Hayah N, Mehta WA, Lestia AS, Armanza F, et al. Development of local birth weight reference based on gestational age and sex in South Kalimantan Province, Indonesia. Int J Gen Med. 2022;15:4101-21. [doi:10.2147/IJGM.S349709]
29. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet. 2007;370(9596):1453-7. [doi:10.1016/S0140-6736(07)61602-X]
30. Amalare AA, Ekum MI, Ogunsanya AS. Modeling third trimester gestational age using transcerebellar diameter and fetal kidney length: a comparative statistical evaluation. Sci Afr. 2025;30. [doi:10.1016/j.sciaf.2025.e02944]
31. Stirnemann J, Villar J, Salomon LJ, Ohuma E, Ruyan P, Altman DG, et al. International estimated fetal weight standards of the INTERGROWTH-21st Project. Ultrasound Obstet Gynecol. 2017;49(4):478-86. [doi:10.1002/uog.17347]
32. Harrell FE Jr, Lee KL, Mark DB. Multivariable prognostic models: issues in developing models, evaluating assumptions and adequacy, and measuring and reducing errors. Stat Med. 1996;15(4):361-87. [doi:10.1002/(SICI)1097-0258(19960229)15:4<361::AID-SIM168>3.0.CO;2-4]
33. Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR. A simulation study of the number of events per variable in logistic regression analysis. J Clin Epidemiol. 1996;49(12):1373-9. [doi:10.1016/S0895-4356(96)00236-3]

34. Abdollahian M, Nuryani S, Anggraini D. Modelling weight of a newborn based on baby's characteristics for low birth weight babies. In: Proceedings of the 20th International Congress on Modelling and Simulation (MODSIM2013); 2013. [doi:10.36334/modsim.2013.i4.abdollahian]
35. Anggraini D, Abdollahian M, Marion K. Foetal weight prediction models at a given gestational age in the absence of ultrasound facilities: application in Indonesia. BMC Pregnancy Childbirth. 2018;18(1):436. [doi:10.1186/s12884-018-2047-z]
36. Sotiriadis A, Eleftheriades M, Papadopoulos V, Sarafidis K, Pervanidou P, Assimakopoulos E. Divergence of estimated fetal weight and birth weight in singleton fetuses. J Matern Fetal Neonatal Med. 2018;31(6):761-9. [doi:10.1080/14767058.2017.1297409]
37. Hadlock FP, Harrist RB, Sharman RS, Deter RL, Park SK. Estimation of fetal weight with the use of head, body, and femur measurements: a prospective study. Am J Obstet Gynecol. 1985;151(3):333-7. [doi:10.1016/0002-9378(85)90298-4]
38. Grantz KL, Hinkle SN, He D, Owen J, Skupski D, Zhang C, et al. A new method for customized fetal growth reference percentiles. PLoS One. 2023;18(3):e0282791. [doi:10.1371/journal.pone.0282791]
39. Saw SN, Lim MC, Liew CN, Ahmad Kamar A, Sulaiman S, Saaid R, et al. The accuracy of international and national fetal growth charts in detecting small-for-gestational-age infants using the Lambda-Mu-Sigma method. Front Surg. 2023;10:1123948. [doi:10.3389/fsurg.2023.1123948]
40. Gardosi J, Francis A, Turner S, Williams M. Customized growth charts: rationale, validation and clinical benefits. Am J Obstet Gynecol. 2018;218(2S):S609-S18. [doi:10.1016/j.ajog.2017.12.011]

How to Cite This Article:

Nurwati Y, Anggraini D, Hardinsyah, Anna Marliyati S, Iman Santoso B, Candra Dewi R, et al. Preliminary Nonlinear Regression-Based Reference Values for Fetal Biometry at 35-40 Weeks of Gestation Incorporating Maternal Height in Indonesia: A Retrospective Cross-Sectional Study. J Obstet Gynecol Cancer Res. 2027;12(1):49-58.

Download citation: RIS | EndNote | Mendeley | BibTeX |