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A Comparative Study of Clinical and Sonographic Fetal Weight Estimation at Term with the Actual Birth Weight

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Keywords
Fetal weight, sonography, Johnson's formula, Insler's formula, Hadlock's Formula

Abstract
Introduction
Determination of fetal weight is of utmost importance in obstetrics as it helps in monitoring intrauterine growth, detecting high risk pregnancy, labour management and delivery of the baby.
Objective
The aim of our study is to compare the accuracy in estimating fetal weight with ultrasound-based Hadlock's formula, clinically based methods- Insler's, Johnson's formula and actual birth weight.
Methodology
This prospective comparative study was done in a tertiary care centre between December 2021 and March 2022. 60 consecutive antenatal women were recruited in this study after giving informed consent. Hadlock's formula was used to calculate the estimated fetal weight by ultrasonography and the clinical weight estimation was done by using Johnson's and Insler's formula and was compared with actual birth weight.
Results
The mean actual birth weight is 3026.93 ± 372.40 grams, the average birth weight determined by Johnson's formula is 3391.92 ± 306.16 grams and the average birth weight determined by Insler's formula is 3344.13 ± 589.50 grams. The Hadlock's Formula as compared to Johnson's and Insler's formula, has proven to be a very accurate predictor of the baby's actual birth weight with a sensitivity of 96.55%(96.55%> 79.31%> 65.52%).

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Conclusion
Ultrasonography estimation is recommended over clinical estimation method as it yields more accurate fetal weight than other clinical modalities. Also, Johnson's formula has been reported to be more sensitive than Insler's formula. Thus, in developing countries where the access to the ultrasound is challenging, estimation of fetal weight close to term can be done by clinical method employing Johnson's formula.

1. Introduction

Fetal weight determination is vital in obstetrics as it help in monitoring intrauterine growth, detecting high risk pregnancy, labour management and delivery of the baby [1, 2]. In the past few years, fetal weight estimation has been included in the routine antenatal checkups for all pregnancies to identify the high risk pregnancies earlier and for their deliveries. Weight of the fetus is now thought to be a separate risk factor for significant perinatal morbidity and mortality. Delivering a macrosomic fetus is associated with complications like labour dystocia, increased maternal risks such birth canal injuries and postpartum hemorrhage, as well as other delivery traumas like shoulder dystocia, brachial plexus injuries, and intrapartum hypoxia [3]. Identification of intrauterine growth restricted fetuses as high risk is required in order to lower perinatal risks such intrauterine fetal death or neonatal death [4].

Fetal weight (either low or high) during birth can affect both the mother and the child by causing issues in labour and delivery [5]. Therefore during routine antenatal checkups, fetal weight estimation can help the obstetrician to come to a conclusion regarding the time of labor induction and the method of delivery. In order to provide quality perinatal management, obstetricians should employ examination methodologies which not only estimate fetal weights accurately but the methods used should be reliable, simple and valid. The ultrasound and clinical examination methods are widely used in estimating fetal weight globally. Ultrasound technique has been considered as the most preferred method owing to its accessibility, objectivity and precision in estimating the fetal weight. Hadlock's formula, which includes fetal head circumference, biparietal diameter, abdominal circumference, and femur length, is the most commonly used formula for fetal weight estimation [6]. Hence our study aim is to comparethe accuracy in estimating fetal weight with ultrasound-based- Hadlock's formula, clinically-based methods- Johnson's and Insler's formula and with actual birth weight.

2. Materials & Methods

This prospective comparative study was done in the Department of Obstetrics and Gynaecology of a tertiary health care centre between December 2021 and March 2022. Singleton pregnant women who were admitted for a planned birth at term through caesarean section or labour induction were included as study subjects.

The estimated sample size was 60 that was computed with the formula $N = Z^2pq/d^2$; Where Z =1.96, *P* = 10% [7] q = (1-p), d = 5%.The inclusion criteria were met by sixty consecutive pregnant women. Inclusion criteria include- singleton pregnancies with cephalic presentation that were counseled and gave informed consent were included in the study. The exclusion criteria were - i) presentation other than cephalic presentation, ii) patients with polyhydramnios or oligohydramnios, iii) pre-term labour, iv) ruptured membranes, v) multiple pregnancies, vi) Fetal anomalies, and vii) Intra uterine Fetal death viii) intra uterine growth restriction. The duration between ultrasound and clinical estimation of fetal weight was less than 7 days from the measurement of actual fetal weight.

The senior sonologists performed the ultrasound-based estimation of the Fetal weight using Hadlock's formula which is depends on Head circumference measurements (HC) Biparietal Diameter (BPD), Abdominal Circumference (AC), and Femoral Length (FL). The sonologist was unaware of the clinical fetal weight estimation. The scan machine used was GE logic P9 machine with a convex probe of 1.75-4.95 MHz The clinician assigned to the labour ward performed the clinical weight estimation utilizing a centimeters calibrated flexible tape. This tape was used to measure the height of the uterine fundus, which was taken from the highest point on the uterine fundus to the middle

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of the upper border of the pubic symphysis. In order to avoid bias, the measurement was taken with the inch side of the tape facing up. The same tape was used to measure the abdominal circumference at the umbilicus. Insler's and Johnson's formula were used and estimated fetal weight was calculated in grams. The labour ward staff nurse weighed the newborn within 15 minutes of birth using a scale that has been approved by the IAF (International Accreditation Forum) and has zero error correction.

Ethical approval was obtained from ethical committee of SRM Medical College Hospital and Research Centre (Ethical clearance number-2377/IEC/2020). All information in the study has been kept confidential and has been accessed only for scientific research purposes.

3. Results

Total 60 women were recruited for the study. Patients were analyzed based on their age, BMI, parity, gestational age, mode of delivery, comorbidities and baby weight - actual weight, clinical and sonological Fetal weight. The mean maternal age the patient was 26.98 ± 4.49 years [Table 1]. 55% of the patients had BMI within the range of 18.5-24.9, 36.7% within the range of 25.0-29.9 and only 8.3% had BMI within the range of 30.0-34.9. Among the 60 pregnant women, 51.7% were primi gravidas and 48.3% were multi gravidas. 61.7 % among the women were between the gestational age of 37 weeks- 38weeks + 6 days and 38.3% were between the gestational age of 39weeks - 40 weeks+6 days. The analysis of the mode of delivery revealed that, 53.3% of babies were delivered by lower (uterine) segment Caesarean section (LSCS), 45% by normal vaginal delivery (NVD) and 1.7 % by instrumental delivery [Table 2/Figure 1-4].

Table 1: Descriptive analysis of age in study population

	Mean ± SD	**Median**	**Range**	**95% CI**	
				Lower	**Upper**
Age	26.98 ± 4.49	26	19 - 37	25.82	28.14

Table 2: Descriptive table showing variables among study population

SI.No.	**Variables**	**Frequency**	**Number**
1	**BMI**		
	18.5-24.9	33	55.0%
	25.0- 29.9	22	36.7%
	30.0-34.9	5	8.3%
2	**Gravida**		

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	Primi Gravida	31	51.7%
	Multi Gravida	29	48.3%
3	**Gestational Age**		
	37wks - 38wks +6	37	61.7%
	39 wks - 40wks + 6	23	38.3%
4	**Mode of Delivery**		
	Normal Vaginal Delivery (NVD)	27	45.0%
	A lower (uterine) segment Caesarean section (LSCS)	32	53.3%
	Instrumental	1	1.7%

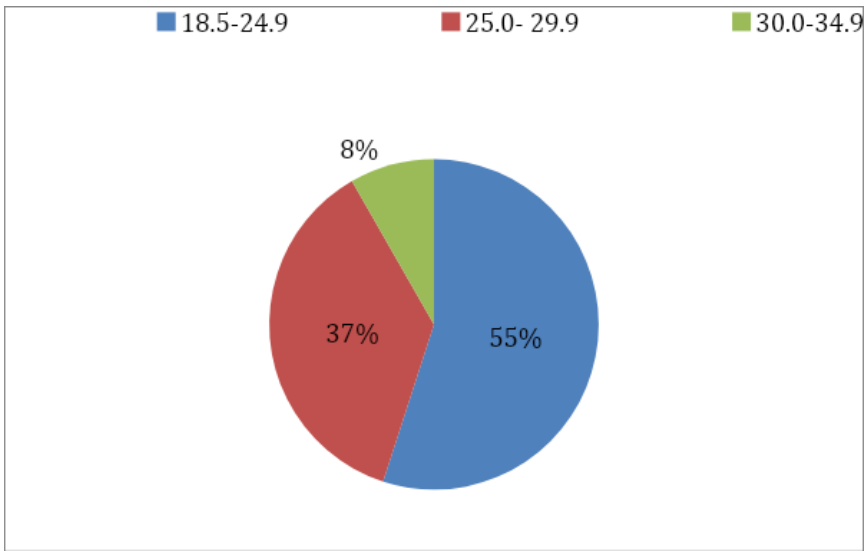

Figure 1. Pie chart describing BMI of the patients

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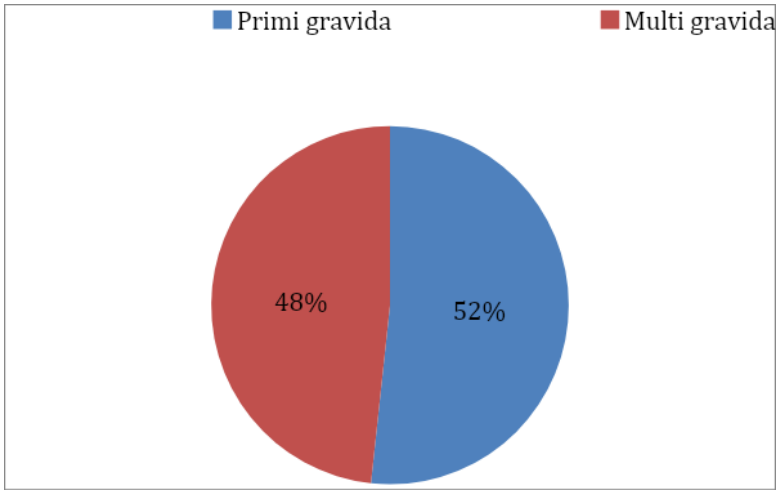

Figure 2. Pie chart describing Gravida of the patients

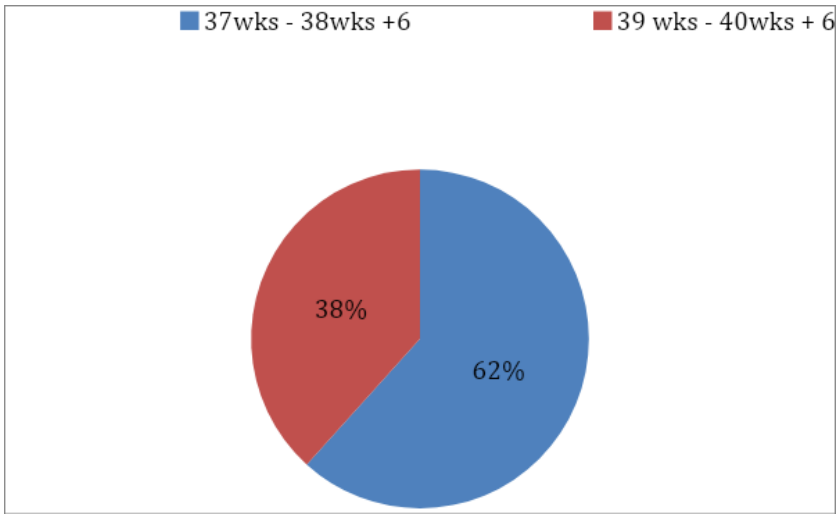

Figure 3. Pie chart describing gestational age of the patients

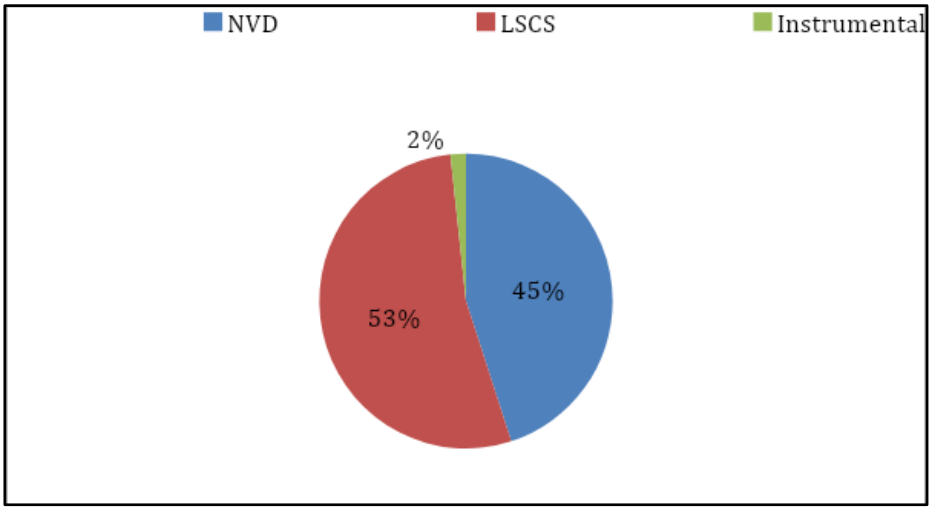

Figure 4. Pie chart describing mode of delivery of the patients

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In our study, the mean actual birth was 3026.93 ± 372.40 grams, the mean birth weight based on Johnson's formula was 3391.92 ± 306.16 grams and based on Insler's formula was 3344.13 ± 589.50 grams. The Hadlock's Formula was seen to be a fair predictor of actual birth weight of the baby among the study population, as indicated by area under the curve of 0.974 (95% CI of 0.924 to 1.000 and p value of 0.024). With the Hadlock's Formula cutoff value greater than or equal to 2629, it has been reported to be an excellent actual birth weight predictor of the baby with a sensitivity of 96.55% [Table 3/Figure 5].

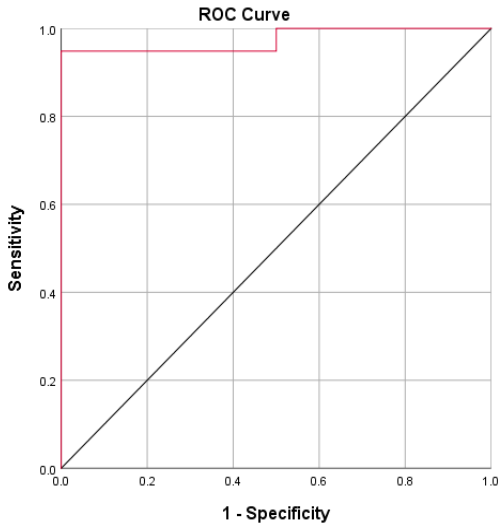

Figure5. Predictive validity of Hadlock's Formula in predicting Actual Birth Weight of the Baby

Area Under the Curve				
Test Result Variable(s): Hadlock's Formula				
Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.974	0.026	0.024	0.924	1.000
a. Under the nonparametric assumption				
b. Null hypothesis: true area = 0.5				

Table 3. Table describing area under the curve for Hadlock's formula

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The Insler's Formula was seen to be a fair actual fetal weight predictor among the study population, as indicated by area under the curve of 0.664 (95% CI 0.294 to 1.000, p value 0.434). With the Insler's Formula cutoff value greater than or equal to 3194, it has been considered as a poor actual birth weight predictor of the baby with a sensitivity of 65.52% [Table 4/Figure 6].

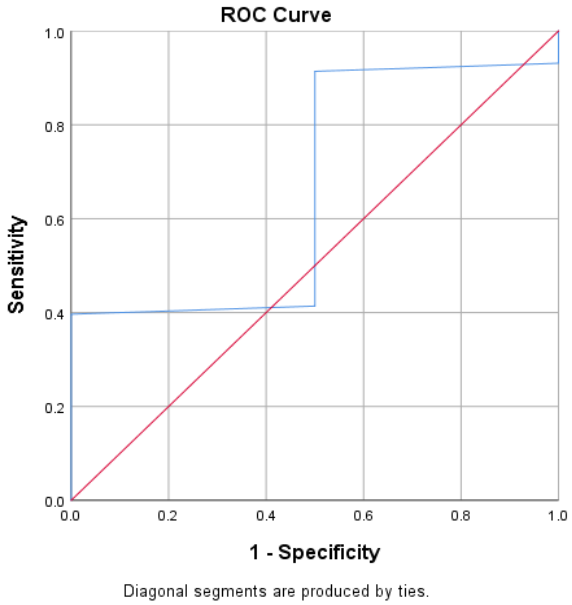

Figure 6: Predictive validity of Insler's Formula in predicting Actual Birth Weight of the Baby

Table 4. Table describing area under the curve for Insler's formula

Area Under the Curve				
Test Result Variable(s): Insler's Formula				
Area	**Std. Error[a]**	**Asymptotic Sig.[b]**	**Asymptotic 95% Confidence Interval**	
			Lower Bound	**Upper Bound**
0.664	0.189	0.434	0.294	1.000
The test result variable(s): INSLER'S FORMULA has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.				
a. Under the nonparametric assumption				
b. Null hypothesis: true area = 0.5				

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The Johnson's Formula was reported to be a fair actual fetal weight predictor among the study population, as indicated by area under the curve of 0.815 (95% CI 0.568 to 1.000, p value 0.133). With the Johnson's Formula cutoff value greater than or equal to 3177.50, it can be considered as a good actual birth weight predictor of the baby with a sensitivity of 79.31% [Table 5/Figure7].

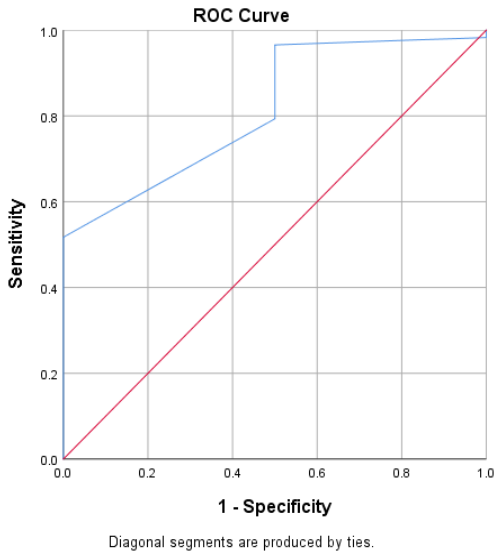

Figure 7: Predictive validity of Johnson's Formula in predicting Actual Birth Weight of the Baby

Table 5. Table describing area under the curve for Johnson's formula

Area Under the Curve				
Test Result Variable(s): Johnson's Formula				
Area	**Std. Error**	**P value**	**Asymptotic 95% Confidence Interval**	
			Lower Bound	**Upper Bound**
0.815	0.126	0.133	0.568	1.000
The test result variable(s): JOHNSON'S FORMULA has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.				
a. Under the nonparametric assumption				
b. Null hypothesis: true area = 0.5				

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4. Discussion

Accurate assessment of antenatal fetal weight is pivotal for the prevention of possible potential complications that can arise from both growth restricted as well as macrosomic babies during labor and the puerperium. Fetal prematurity is one of the perinatal complications of low birth weight and intra uterine growth restriction babies [8] and for macrosomia babies, the following perinatal complications may occur: cervical tears, perineal lacerations, postpartum hemorrhage, shoulder dystocia, bone injuries/fractures, prolonged labour, birth asphyxia/low Apgar scores, brachial plexus palsy and instrumental deliveries - forceps or vacuum extraction. There is increased of rates in instrumental vaginal delivery or cesarean section in a macrocosmic baby due to increased incidence of cephalopelvic disproportion when compared to normal fetus [9]. In our study it has been revealed that the fetal weight estimation using Hadlock's formula is more accurate than using Johnson's or Insler's formula. Our result is in the same line with other studies conducted recently under the objective of fetal weight estimation [10, 11].

In a study conducted by Oliver Preyer et al, showed that estimation of Fetal weight by ultrasound is significantly more accurate than Leopold's maneuvers in obese women on the other hand, the study found no evidence that, in normal-weight women, ultrasonography weight estimation was more significant than Leopold maneuvers [12].Watson WJ et al, concluded that, even at the extreme birth weight, no statistically significant difference was seen between clinical and ultrasound estimation of the term fetus's birth weight [13]. Also, A. Fleming et al. concluded that, out of all the five current formulas used to estimate fetal weight in term and large fetuses, the four-parameter method of Hadlock provided the best estimate of fetal weight [14].

Sereke SG et al. conducted a prospective study in Uganda to assess the precision of the Hadlock 1, Hadlock 2, Hadlock 3, Hadlock 4, and Shepard formulas for sonographic determination of fetal weight. They came to the conclusion that Shepard's formula was more precise in estimating actual fetal birth weight below 4000 g than all of Hadlock's formulas were at estimating actual birth weights over 4000 g [15]. In a recent study by Nicolaides et al. which sought to create weight charts for the Fetal and neonatal populations stated that the reference ranges for estimated fetal weight served as a representation of the entire population. Given that a significant fraction of preterm births result from pathological pregnancy, the conventional method of determining birth weight charts was inaccurate. The study came to the additional conclusion that it was inappropriate to require a single global standard for birth weight across all nations. There are other newer methods which can also be used to estimate fetal weight. In a study done by GL Malin et al regarding the estimation of fetal weight by Magnetic Resonance Imaging (MRI), concluded that estimation of fetal weight (EFW) by MRI is not superior to the EFW derived by 2D ultrasound [17].

Thus in developing countries, due to lack of clinical resources, estimation of fetal weight are done only by clinical method. Hence, Fetal weight overestimation yielded by clinical methodologies can be considered as a positive sign which will alert medical professionals working in the primary health care centers, for earlier referral of antenatal women with macrosomic fetuses, which will ultimately contribute to a reduction in the incidence of obstructed labour and its associated complications [18]. There are certain strengths of our study, as this study was a single blinded study and the doctors as well as the sonologists were not aware of the clinical weight estimation. However, small sample size and involvement of multiple sonologists for the estimation of birth weight in this can be considered as limitations.

Our study demonstrated that Fetal weight estimation by Ultrasound using Hadlock's formula is more sensitive (96.55% sensitive) than the clinical estimation method. Hence, Ultrasonography estimation is recommended over clinical estimation method as it has proved to yield more accurate fetal weight than other clinical modalities which will further and to further help in the evaluation of fetal well-being. Also, among the clinical estimation methods, Johnson's formula has been reported to be more sensitive (79.31% sensitive) than Insler's formula (65.52% sensitive). Thus, in developing countries where the access to the ultrasound is challenging, estimation of Fetal weight close to term can be done by clinical method employing Johnson's formula.

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Figure legends

Figure 1. This figure describes the various categories of BMI of the patients. Majority of the patients had the BMI of 18.5-24.9 (55%).

Figure 2. This figure describes the gravida status of the patients. Majority of the patients were multi gravida (52%).

Figure 3. This figure describes the various gestational age categories of the patients. Majority

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of the patients had the gestational age of 39 weeks-40 weeks+ 6 (62%).

Figure 4. This figure describes the various mode of delivery of the patients. Majority of the patients undergone LSCS mode of delivery (53%).

Figure 5. Hadlock's Formula has been reported to be an excellent actual birth weight predictor of the baby with a sensitivity of 96.55%.

Figure 6. Insler's Formula has been reported to be a poor actual birth weight predictor of the baby with a sensitivity of 65.52%.

Figure 7. Johnson's Formula has been reported to be a good actual birth weight predictor of the baby with a sensitivity of 79.31%.

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None

Conflicts of interest

There are no conflicts of interest

Title page

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- Running title- Comparative fetal weight estimation

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