**Routine ultrasound at 32 versus 36 weeks' gestation:
prediction of small for gestational age neonates**

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Short title: Third trimester screening for SGA

Key words: Third trimester screening; Small for gestational age; Adverse perinatal outcome; Estimated fetal weight; Fetal biometry; Symphysial-fundal height; Pyramid of pregnancy care.

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ABSTRACT

Objective: To evaluate and compare the performance of routine ultrasonographic estimated fetal weight (EFW) and fetal abdominal circumference (AC) at 31^{+0} - 33^{+6} and 35^{+0} - 36^{+6} weeks' gestation in the prediction of small for gestational age (SGA) neonates.

Methods: This was a prospective study of 21,989 singleton pregnancies that had undergone routine ultrasound examination at 31^{+0} - 33^{+6} weeks' gestation and 45,847 that had undergone routine ultrasound examination at 35^{+0} - 36^{+6} weeks' gestation. In each case the estimated fetal weight (EFW) from measurements of fetal head circumference (HC), AC and femur length (FL) was calculated by the Hadlock formula and this was expressed as percentile according to the Fetal Medicine Foundation fetal and neonatal population weight charts. The same charts were used for defining SGA neonates with birthweight <10th and <3rd percentiles. For each gestational window the screen positive and detection rate, at different EFW percentile cut-offs between the 10th and 50th percentile, were calculated for prediction of delivery of SGA neonates with birthweight <10th and <3rd percentiles within two weeks and at any stage after assessment. The areas under the receiver operating characteristics curve (AUROC) of screening for SGA neonates by EFW and AC at 31^{+0} - 33^{+6} and at 35^{+0} - 36^{+6} weeks' gestation were compared.

Results: First, the AUROCs of screening by EFW for SGA neonates with birthweight <10th and <3rd percentiles within two weeks and at any stage after screening at 35^{+0} - 36^{+6} weeks' gestation were significantly higher than those at 31^{+0} - 33^{+6} weeks (p<0.001). Second, at both 35^{+0} - 36^{+6} and 31^{+0} - 33^{+6} weeks' gestation, the predictive performance for SGA neonates with birthweight <10th and <3rd percentiles born at any stage after screening was significantly higher with EFW Z-score than AC Z-score. Similarly, at 35^{+0} - 36^{+6} weeks, but not at 31^{+0} - 33^{+6} weeks, the predictive performance for SGA neonates with birthweight <10th and <3rd percentiles born within two weeks of screening was significantly higher with EFW Z-score than AC Z-score. Third, screening by EFW <10th percentile at 35^{+0} - 36^{+6} weeks' gestation predicted 70% and 84% of neonates with birthweight <10th and <3rd percentiles born within two weeks after assessment and the respective values for neonates born at any stage after assessment were 46% and 65%. Fourth, prediction of >85% of SGA neonates with birthweight <10th percentile born at any stage after screening at 35^{+0} - 36^{+6} weeks' gestation requires use of EFW <40th percentile. Screening at this percentile cut-off predicted 95% and 99% of neonates with birthweight <10th and <3rd percentiles born within two weeks after assessment and the respective values for neonates born at any stage after assessment were 88% and 94%.

Conclusion: The predictive performance for SGA neonates by routine ultrasonographic examination during the third trimester is higher if first, the scan is carried out at 35^{+0} - 36^{+6} weeks' gestation than at 31^{+0} - 33^{+6} weeks; second, the method of screening is EFW than fetal AC; third, the outcome measure is birthweight <3rd than <10th percentile; and fourth, if delivery occurs within two weeks than at any stage after assessment. Prediction of SGA neonates by EFW <10th percentile is modest and prediction of >85% of cases at 35^{+0} - 36^{+6} weeks' gestation necessitates use of EFW <40th percentile.

INTRODUCTION

National guidelines from many developed countries define fetal growth restriction on the basis of ultrasonographic estimated fetal weight (EFW) or fetal abdominal circumference (AC) <10th percentile and severe growth restriction as EFW <3rd percentile.[1] There are also extensive reports on how best to manage pregnancies with small for gestational age (SGA) fetuses,[1,2] However, there is uncertainty as to the best approach for identifying such SGA fetuses, because of first, the existence of a wide range of charts for fetal size and birthweight, second, the controversy of universal versus selective ultrasound examination based on maternal risk factors and the results of abdominal palpation or serial measurements of symphysial-fundal height, third, lack of consistent data on the performance of EFW versus AC for prediction of SGA neonates, and fourth, limited data on the best time for a universal third trimester scan at 32 versus 36 weeks' gestation.

We have addressed the issue of inconsistency between fetal and neonatal growth charts by developing EFW and birthweight reference ranges with a common median.[3] Previous studies provided evidence that the predictive performance of the traditional method of identifying pregnancies with SGA fetuses by maternal abdominal palpation and serial measurements of symphysial-fundal height is poor.[4,5] There is some evidence that improved prediction of SGA is achieved by universal sonographic fetal biometry during the third trimester; a study in 3,977 nulliparous women, reported that universal third trimester ultrasonography tripled the detection of SGA neonates compared to selective ultrasonography based on maternal risk factors and the results of measurements of symphysial-fundal height.[6] A recent systematic review and meta-analysis of 21 prospective and retrospective cohort studies in low-risk or non-selected singleton pregnancies with screening ultrasound performed at ≥32 weeks' gestation reported that the predictive performance for SGA neonates of fetal AC and EFW was similar.[7] However, a study of 5,163 singleton pregnancies with fetal biometry at 22-43 weeks' gestation and livebirth of phenotypically normal neonates within two days of the ultrasound examination reported that the most accurate formula for prediction of birthweight, among 70 models identified by systematic review of 45 studies, was that of Hadlock et al.,[8] which incorporated measurements of head circumference (HC), AC and femur length (FL).[9] As for the issue of timing of the third trimester scan there is some evidence that the predictive performance of a scan at 36 weeks may be superior to that at 32 weeks; a randomized study in 2,586 low-risk singleton pregnancies reported that the predictive performance for SGA neonates <10th and <3rd percentiles was superior at 36 compared to 32 weeks' gestation.[10]

The objective of this study is to evaluate and compare the performance of routine ultrasonographic EFW and fetal AC at 31^{+0} - 33^{+6} and 35^{+0} - 36^{+6} weeks' gestation in the prediction of SGA neonates born within two weeks and at any stage after assessment.

METHODS

This was a prospective study of 21,989 singleton pregnancies that had undergone routine ultrasound examination at 31^{+0} - 33^{+6} weeks' gestation and 45,847 that had undergone routine ultrasound examination at 35^{+0} - 36^{+6} weeks' gestation at King's College Hospital, London or Medway Maritime Hospital, Gillingham, UK. In the participating hospitals all women with singleton pregnancies are offered routine ultrasound examinations at 11^{+0} - 13^{+6} and at 19^{+0} to 23^{+6} weeks' gestation. During a period (May 2011 to March 2014) an additional scan was offered at 31^{+0} to 33^{+6} weeks, but subsequently (March 2014 and September 2018) this was changed to 35^{+0} to 36^{+6} weeks. In the selection of patients care was taken to include routine scans and not follow-up scans for maternal medical conditions or a suspected problem in fetal growth.

In the first or second trimester visit we recorded maternal demographic characteristics and medical history and in the third trimester visits we carried out an ultrasound examination for fetal anatomy and measurement of fetal HC, AC and FL for calculation of EFW using the formula by Hadlock et al.[8] Gestational age was determined by the measurement of fetal crown-rump length at 11-14 weeks or the fetal head circumference at 19-24 weeks.[11,12] The ultrasound examinations were carried out by examiners who had obtained the Fetal Medicine Foundation certificate of competence in ultrasound examination for fetal abnormalities. Data from the patients included in this study were the subject of previous publications.[13-17]

The women gave written informed consent to participate in the study, which was approved by the NHS Research Ethics Committee. The inclusion criteria for this study were singleton pregnancies examined at 31^{+0} - 33^{+6} or 35^{+0} - 36^{+6} weeks' gestation and delivering a non-malformed live birth or stillbirth. We excluded pregnancies with aneuploidies and major fetal abnormalities.

Patient characteristics

Patient characteristics recorded included maternal age, racial origin (White, Black, South Asian, East Asian and mixed), method of conception (natural, *in vitro* fertilization or use of ovulation induction drugs), cigarette smoking during pregnancy, medical history of chronic hypertension and diabetes mellitus, obstetric history including parity (parous or nulliparous if no previous pregnancies at $\geq$ 24 weeks' gestation), and previous pregnancy with SGA. The maternal weight and height were measured.

Outcome measures

Data on pregnancy outcome were collected from the hospital maternity records or the general medical practitioners of the women. The outcome measures of the study were birth of a neonate with birthweight <10th or <3rd percentile for gestational age at delivery.[3]

Statistical analysis

Data were expressed as median (interquartile range [IQR]) for continuous variables and n (%) for categorical variables. Mann-Whitney U-test and χ^2-square test or Fisher's exact test, were used for comparing outcome groups for continuous and categorical data, respectively. Significance was assumed at 5%.

The observed measurements of EFW and birthweight were converted to Z-scores and percentiles adjusted for gestational age according to the Fetal Medicine Foundation fetal and neonatal population weight charts.[3] Similarly AC was converted to Z-scores and percentiles adjusted for gestational age according to the reference ranges of Snijders and Nicolaides.[12] Logistic regression analysis was undertaken to determine the significance of contribution of AC and EFW Z-score in prediction of delivery of SGA neonates <10th and <3rd percentile. The performance of screening was determined by receiver operating characteristic (ROC) curves and the areas under the ROC curves (AUROC) of screening at 31^{+0} - 33^{+6} and 35^{+0} - 36^{+6} weeks' gestation in the prediction of SGA neonates were compared.[18] For each gestational window the screen positive and detection rate, at different EFW percentile cut-offs between the 10th and 50th percentile, were calculated for prediction of delivery of SGA neonates with birthweight <10th and <3rd percentiles within two weeks and at any stage after assessment.

The statistical software package SPSS 24.0 (IBM SPSS Statistics for Windows, Version 24.0, Armonk, NY: IBM Corp; 2016) and Medcalc (Medcalc Software, Mariakerke, Belgium) were used

for data analyses.

RESULTS

Patient characteristics

The characteristics of the study population are shown in Table 1. The characteristics of those with a scan at 31^{+0} - 33^{+6} weeks' gestation were similar to those with a scan at 35^{+0} - 36^{+6} weeks. In both study periods in the group of neonates with birthweight <10th percentile, compared to those with birthweight ≥10th percentile, the median maternal age, weight and height, EFW Z-score, AC Z-score, birthweight Z-score and gestational age at delivery were lower, more women were of non-White racial origin, were smokers, were parous with previous affected pregnancy by SGA, and less women were parous without previous SGA.

Delivery within two weeks of the ultrasound examination at 31^{+0} - 33^{+6} weeks' gestation occurred in 234 (1.1%) of the 21,989 pregnancies. These included 143 (61.1%) that delivered after spontaneous onset of labor and 91 (38.9%) that delivered after induction of labor or elective cesarean section. The indications for iatrogenic delivery were: (a) severe preeclampsia and / or fetal growth restriction (78.0%); (b) antepartum hemorrhage due to placenta previa or abruption (11.0%); (c) non-SGA fetuses with abnormal fetal Doppler, abnormal fetal heart rate pattern or reduced fetal movements (4.4%); (d) fetal death (2.2%); (e) fetal anemia (2.2%), (f) obstetric cholestasis (1.1%), (g) maternal pneumonia (1.1%).

Delivery within two weeks of the ultrasound examination at 35^{+0} - 36^{+6} weeks' gestation occurred in 5,342 (11.7%) of the 45,847 pregnancies. These included 2,988 (55.9%) that delivered after spontaneous onset of labor and 2,354 (44.1%) that delivered after induction of labor or elective cesarean section. The indications for iatrogenic delivery were: (a) chronic hypertension, preeclampsia, gestational hypertension, diabetes mellitus, gestational diabetes or obstetric cholestasis (40.1%); (b) other maternal medical condition or maternal request (6.1%); (c) SGA fetuses with or without abnormal fetal Doppler findings (23.8%); (d) non-SGA fetuses with abnormal fetal Doppler or fetal heart rate pattern, reduced fetal movements or oligohydramnios (6.1%); (e) previous cesarean section or myomectomy (8.8%); (f) antepartum hemorrhage due to placenta previa or abruption (5.6%); (g) breech or transverse lie (4.7%); (h) previous stillbirth or other adverse perinatal outcome (2.2%); (i) polyhydramnios and / or large for gestational age (2.1%); (j) fetal death (0.5%).

Performance of screening for SGA neonates

Screening at 35^{+0} - 36^{+6} versus 31^{+0} - 33^{+6} weeks' gestation

The AUROCs of screening by EFW for SGA neonates with birthweight <10th percentile within two weeks and at any stage after screening at 35^{+0} - 36^{+6} weeks' gestation (0.933; 95% CI 0.926 - 0.941 and 0.833; 95% CI 0.879 - 0.888) were significantly higher than those at 31^{+0} - 33^{+6} weeks (0.906; 95% CI 0.870 - 0.942; p<0.001 and 0.822; 95% CI 0.814 - 0.830; p<0.001) (Table 2; Figure 1). Similarly, the AUROCs of screening by EFW for SGA neonates with birthweight <3rd percentile within two weeks and at any stage after screening at 35^{+0} - 36^{+6} weeks' gestation (0.945; 95% CI 0.937 - 0.952 and 0.918; 95% CI 0.912 - 0.923) were significantly higher than those at 31^{+0} - 33^{+6} weeks (0.897; 95% CI 0.857 - 0.937; p=0.034 and 0.858; 95% CI 0.847 - 0.869; p<0.001) (Table 2, Figure 2).

Screening by EFW versus fetal AC

Comparisons of the AUROC in screening for SGA neonates by EFW and AC are shown in Table 2 and Figures 1 and 2. At both 35^{+0} - 36^{+6} and 31^{+0} - 33^{+6} weeks' gestation, the predictive performance for SGA neonates with birthweight <10th and <3rd percentiles born at any stage after screening was significantly higher with EFW Z-score than AC Z-score. Similarly, at 35^{+0} - 36^{+6} weeks, but not at 31^{+0} - 33^{+6} weeks, the predictive performance for SGA neonates with birthweight <10th and <3rd percentiles born within two weeks of screening was significantly higher with EFW Z-score than AC Z-score.

Screening at different EFW percentile cut-offs

The predictive performance for SGA neonates with birthweight <10th percentile in screening by EFW at a series of cut-offs between the 10th and 50th percentile at 35^{+0} to 36^{+6} and 31^{+0} to 33^{+6} weeks' gestation is shown in Table 3; the respective values for SGA neonates with birthweight <3rd percentile are shown in Table 4. Screening by EFW <10th percentile at 35^{+0} - 36^{+6} weeks' gestation predicted 70% and 84% of neonates with birthweight <10th and <3rd percentiles born within two weeks after assessment and the respective values for neonates born at any stage after assessment were 46% and 65%.

Prediction of >85% of SGA neonates with birthweight <10th percentile born at any stage after screening at 35^{+0} - 36^{+6} weeks' gestation requires use of EFW <40th percentile. Screening at this percentile cut-off predicted 95% and 99% of neonates with birthweight <10th and <3rd percentiles born within two weeks after assessment and the respective values for neonates born at any stage after assessment were 88% and 94%.

DISCUSSION

Main findings of the study

The findings of this study demonstrate that the predictive performance for SGA neonates by routine ultrasonographic examination during the third trimester is higher if first, the scan is carried out at 35^{+0} - 36^{+6} weeks' gestation than at 31^{+0} - 33^{+6} weeks; second, the method of screening is EFW than fetal AC; third, the outcome measure is birthweight <3rd than <10th percentile; and fourth, if delivery occurs within two weeks than at any stage after assessment. Prediction of SGA neonates by EFW <10th percentile is modest and prediction of >85% of cases at 35^{+0} - 36^{+6} weeks' gestation necessitates use of EFW <40th percentile.

For SGA neonates born within two weeks of assessment at 31^{+0} - 33^{+6} weeks' gestation there was no significant difference in predictive performance between EFW and fetal AC. This is not surprising because in about 30% of the babies born within two weeks of assessment there was iatrogenic delivery because of severe preeclampsia and / or fetal growth restriction and in such cases the fetal AC would be affected more than the HC and FL. In contrast, at 35^{+0} - 36^{+6} weeks' gestation in only about 10% of the babies born within two weeks of assessment there was iatrogenic delivery for fetal growth restriction.

Screening by EFW <10th percentile at 35^{+0} - 36^{+6} weeks' gestation predicted 70% and 84% of neonates with birthweight <10th and <3rd percentiles born within two weeks of assessment with positive predictive values of 19.6 and 13.0, respectively. The respective values for neonates born at any stage after assessment were 46%, 65%, 59.1 and 31.8. Screening by EFW <40th percentile predicted 95% and 99% of neonates with birthweight <10th and <3rd percentiles born within two weeks after assessment with positive predictive values of 6.5 and 3.7, respectively; the respective

values for neonates born at any stage after assessment were 88%, 94%, 27.3 and 11.2.

Comparison with findings from previous studies

We found that the predictive performance for SGA neonates of EFW is superior to that of fetal AC. This finding is consistent with the results of a study that investigated the ability of ultrasonographic fetal biometry to predict birthweight in neonates born within two days of the ultrasound examination and reported that models incorporating measurements of fetal HC, AC and FL were superior to those using AC alone or AC and FL.[9] Our findings that the predictive performance for SGA neonates by fetal biometry at 35^{+0} - 36^{+6} weeks' gestation is superior to that at 31^{+0} - 33^{+6} weeks is consistent with the results of a previous study in 2,288 pregnancies undergoing ultrasound examination in both of these gestational windows[19] and those of a randomized trial comparing the performance of ultrasound examination at 36 vs. 32 weeks' gestation.[10]

Implications for clinical practice

Justification of prenatal screening for SGA fetuses is based on first, evidence that such fetuses are at increased risk of stillbirth and adverse perinatal outcome,[20-23] and second, the expectation that these risks can be reduced by medical interventions, such as early delivery.[1] In this respect, all pregnant women should be offered a routine third trimester scan because such policy is more effective in identifying SGA fetuses than selective ultrasonography based on maternal risk factors and the results of measurements of symphysial-fundal height.[6]

Since 85% of SGA neonates are born at term[17] and the predictive performance for SGA neonates is highest if the scan is carried out close to the time of birth the best time for a routine scan is about 36 weeks' gestation. Identification of SGA fetuses born before 36 weeks' gestation would require ultrasound scans at 26-28 and 30-32 weeks and we have previously proposed that selection of the subgroup of the population requiring such additional scans should be based on stratification of risks at 20 weeks' gestation.[24] In relation to SGA born <32 weeks' gestation, there is evidence of a high association with preeclampsia and that the risk can be reduced by first trimester screening for preeclampsia and treatment of the high-risk group with aspirin.[25-30]

The findings of this study highlight that a routine third trimester ultrasound scan constitutes a screening rather than diagnostic test for SGA neonates and that the EFW cut-off of the 40th rather than the 10th percentile should be used to identify a group in need of further investigations. However, only about one in four of such fetuses would actually be SGA at birth and the objective of further investigations would be to distinguish between true and false positives. Such an objective could potentially be achieved by serial ultrasound scans to define subsequent growth and wellbeing; supportive evidence for such expectation is that the predictive performance for SGA neonates is considerably higher in pregnancies delivering within two weeks of assessment than in those with a longer interval. Alternative strategies, including addition of fetal growth velocity between 20 or 32 and 36 weeks' gestation and addition of maternal risk factors, serum placental growth factor, uterine artery pulsatility index and the cerebroplacental ratio, had limited success in improving the predictive performance for SGA neonates of EFW at 36 weeks.[15-17,31,32]

Strengths and limitations of the study

The strengths of this screening study for SGA neonates are first, examination of a large population of pregnant women attending for routine assessment of fetal growth and wellbeing at either 31^{+0} - 33^{+6} or 35^{+0} - 36^{+6} weeks' gestation, second, trained sonographers that carried out fetal biometry

according to a standardized protocol and use of a widely used model for calculation of EFW [8] which has been shown to be the most accurate one among 70 previously reported models,[9] third, use of the Fetal Medicine Foundation fetal and neonatal references ranges which have a common median,[3] and fourth, direct comparison of the predictive performance of EFW and fetal AC.

A limitation of the study, in relation to the comparison of predictive performance for SGA neonates of the scan at 31^{+0} - 33^{+6} vs. that at 35^{+0} - 36^{+6} weeks' gestation, is that this was not a randomized study. However, the findings are valid because during the two consecutive periods of study the characteristics of the population were similar, the two hospitals were the same and the ultrasonographers carrying out the scans had received the same training and followed the same protocol for conducting the scan.

Conclusions

The predictive performance for SGA neonates by routine ultrasonographic examination during the third trimester is higher if the scan is carried out at 35^{+0} - 36^{+6} weeks' gestation than at 31^{+0} - 33^{+6} weeks, but prediction of SGA neonates by EFW <10th percentile is modest and prediction of >85% of cases at 35^{+0} - 36^{+6} weeks necessitates use of EFW <40th percentile for selecting the group in need of further assessment. Future studies will investigate potential methods for reducing the false positive rate in the group with EFW <40th percentile.

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FIGURE LEGENDS

Figure 1. Receiver operating characteristics curves of estimated fetal weight (red curve) and abdominal circumference (black curve) at 35^{+0} - 36^{+6} weeks' gestation (solid lines) and at 31^{+0} - 33^{+6} weeks (interrupted lines), in the prediction of small for gestational age neonates with birthweight below the 10th percentile delivering within two weeks (left) and at any time (right) from assessment.

Figure 2. Receiver operating characteristics curves of estimated fetal weight (red curve) and abdominal circumference (black curve) at 35^{+0} - 36^{+6} weeks' gestation (solid lines) and at 31^{+0} - 33^{+6} weeks (interrupted lines), in the prediction of small for gestational age neonates with birthweight below the 3rd percentile delivering within two weeks (left) and at any time (right) from assessment.

Table 1. Maternal and pregnancy characteristics of the study populations.

Characteristic	Screening at 31^{+0} - 33^{+6} weeks		Screening at 35^{+0} - 36^{+6} weeks	
	BW ≥10th percentile (n=19,190)	BW <10th percentile (n=2,799)	BW ≥10th percentile (n=40,567)	BW <10th percentile (n=5,280)
Maternal age in years, median (IQR)	30.7 (26.1, 34.5)	29.8 (24.9, 34.2)**	31.7 (27.4, 35.4)	30.9 (26.2, 35.0)**
Maternal weight in Kg, median (IQR)	77.1 (69.0, 88.0)	72.0 (64.0, 81.8)**	79.9 (71.5, 91.0)	73.4 (65.5, 83.2)**
Maternal height in cm, median (IQR)	165 (160, 169)	163 (158, 167)**	165 (161, 170)	163 (158, 167)**
Racial origin				
White, n (%)	13,789 (71.9)	1,635 (58.4)	30,812 (76.0)	3,348 (63.4)**
Black, n (%)	3,864 (20.1)	799 (28.5)**	6,065 (15.0)	1,131 (21.4)**
South Asian, n (%)	732 (3.8)	212 (7.6)**	1,697 (4.2)	488 (9.2)**
East Asian, n (%)	388 (2.0)	66 (2.4)	813 (2.0)	126 (2.4)
Mixed, n (%)	417 (2.2)	87 (3.1)*	1,180 (2.9)	187 (3.5)*
Cigarette smoker, n (%)	1,860 (9.7)	527 (18.8)**	2,961 (7.3)	762 (14.4)**
Conception				
Natural, n (%)	18,645 (97.2)	2,717 (97.1)	39,190 (96.6)	5,080 (96.2)
Ovulation drugs, n (%)	162 (0.8)	24 (0.9)	223 (0.5)	34 (0.6)
In vitro fertilization, n (%)	383 (2.0)	58 (2.1)	1,154 (2.8)	166 (3.1)
Medical conditions				
Chronic hypertension, n (%)	240 (1.3)	66 (2.4)**	490 (1.2)	90 (1.7)*
Diabetes mellitus type 1, n (%)	77 (0.4)	5 (0.2)	162 (0.4)	5 (0.1)*
Diabetes mellitus type 2, n (%)	112 (0.6)	23 (0.8)	189 (0.5)	19 (0.4)
Past obstetric history				
Nulliparous, n (%)	8,978 (46.8)	1,062 (57.2)	17,911 (44.2)	2,949 (55.9)
Parous with prior SGA, n (%)	1,167 (6.1)	434 (15.5)**	3,112 (7.7)	964 (18.3)**
Parous without prior SGA, n (%)	9,045 (47.1)	763 (27.3)**	19,544 (48.2)	1,367 (25.9)**
GA at screening, median (IQR)	32.2 (32.0, 32.6)	32.2 (32.0, 32.6)	36.1 (35.9, 36.4)	36.1 (35.9, 36.4)
EFW Z-score, median (IQR)	0.02 (-0.63, 0.66)	-1.18 (-1.79, -0.59)**	0.01 (-0.59, 0.60)	-1.39 (-2.08, -0.85)**
AC Z-score, median (IQR)	-0.05 (-0.48, 0.42)	-0.76 (-1.15, -0.35)	0.00 (-0.47, 0.49)	-1.02 (-1.49, -0.57)**
GA at delivery in weeks, median (IQR)	40.4 (39.0, 40.9)	39.5 (38.2, 40.5)**	40.0 (39.1, 40.9)	39.4 (38.2, 40.3)**
Birthweight Z-score, median (IQR)	0.09 (-0.49, 0.72)	-1.76 (-2.20, -1.48)**	0.13 (-0.45, 0.75)	-1.72 (-2.14, -1.48)**
Birthweight in grams, median (IQR)	3470 (3200, 3770)	2710 (2460, 2870)**	3490 (3220, 3790)	2715 (2510, 2860)**

GA = gestational age; EFW = estimated fetal weight; IQR = interquartile range; SGA = small for gestational age; PE = preeclampsia.

Table 2. Comparisons of areas under the curve (95% confidence interval) in screening for SGA neonates by estimated fetal weight and fetal abdominal circumference.

Outcome measure	Delivery within two weeks of screening			Delivery at any time after screening		
	Estimated fetal weight	Abdominal circumference	P value	Estimated fetal weight	Abdominal circumference	P value
35^{+0} - 36^{+6} weeks						
BW <10th percentile	0.933 (0.926 - 0.941)	0.915 (0.906 - 0.924)	P<0.001	0.883 (0.879 - 0.888)	0.860 (0.854 - 0.865)	P<0.001
BW <3rd percentile	0.945 (0.937 - 0.952)	0.930 (0.920 - 0.939)	P<0.001	0.918 (0.912 - 0.923)	0.898 (0.891 - 0.905)	P<0.001
31^{+0} - 33^{+6} weeks						
BW <10th percentile	0.906 (0.870 - 0.942)	0.895 (0.849 - 0.931)	P=0.256	0.822 (0.814 - 0.830)	0.795 (0.790 - 0.801)	P<0.001
BW <3rd percentile	0.897 (0.857 - 0.937)	0.892 (0.850 - 0.934)	P=0.607	0.858 (0.847 - 0.869)	0.831 (0.819 - 0.842)	P<0.001

Table 3. Predictive performance for small for gestational age neonates with birthweight <10th percentile in screening by estimated fetal weight below specific percentile cut-offs at 35^{+0} to 36^{+6} and 31^{+0} to 33^{+6} weeks' gestation.

EFW cut-off	Screen positive rate	Birth at ≤ 2 weeks from assessment		Birth at any time from assessment	
		Detection rate	Positive predictive value	Detection rate	Positive predictive value
35^{+0} to 36^{+6} weeks	**n/45,847 (%; 95% CI)**	**n/1,156 (%; 95% CI)**	**% (95% CI)**	**n/5,280 (%; 95% CI)**	**% (95% CI)**
<10th percentile	4,109 (9.0; 8.7-9.3)	804 (70; 67-72)	19.6 (17.4-21.3)	2,429 (46; 45-47)	59.1 (57.6-61.2)
<15th percentile	6,125 (13.4; 13.1-13.7)	883 (76; 74-79)	14.4 (12.1-16.7)	3,034 (58; 56-59)	49.5 (47.7-51.3)
<20th percentile	8,089 (17.6; 17.3-17.9)	952 (82; 80-85)	11.8 (9.7-13.4)	3,483 (66; 65-67)	43.1 (41.5-45.6)
<25th percentile	10,215 (22.3; 22.0-22.6)	1,004 (87; 85-89)	9.8 (7.6-11.8)	3,888 (74; 72-75)	38.1 (36.3-40.5)
<30th percentile	12,402 (27.1; 26.8-27.4)	1,044 (90; 89-92)	8.4 (6.5-10.2)	4,192 (79; 78-81)	33.8 (31.6-35.7)
<35th percentile	14,694 (32.1; 31.8-32.4)	1,079 (93; 92-95)	7.3 (5.3-9.5)	4,436 (84; 83-85)	30.2 (28.4-32.5)
<40th percentile	16,918 (36.9; 36.6-37.2)	1,101 (95; 94-96)	6.5 (4.4-8.7)	4,619 (88; 87-88)	27.3 (25.8-29.6)
<45th percentile	19,221 (41.9; 41.6-42.2)	1,120 (97; 96-98)	5.8 (3.6-7.8)	4,797 (91; 90-92)	25.0 (23.1-27.0)
<50th percentile	21,536 (47.0; 46.7-47.3)	1,127 (98; 97-98)	5.2 (3.3-7.5)	4,926 (93; 93-94)	22.9 (21.8-24.6)
31^{+0} to 33^{+6} weeks	**n/21,989 (%, 95% CI)**	**n/93 (%, 95% CI)**	**% (95% CI)**	**n/2,799 (%, 95% CI)**	**% (95% CI)**
<10th percentile	2,164 (9.8; 9.4-10.2)	72 (77; 69-86)	3.3 (2.6-4.0)	1,072 (38; 36-40)	49.5 (47.6-51.4)
<15th percentile	3,306 (15.0; 14.6-15.4)	79 (85; 78-92)	2.4 (1.8-3.0)	1,408 (50; 48-53)	42.6 (40.8-44.4)
<20th percentile	4,459 (20.3; 19.9-20.7)	83 (89; 83-96)	1.9 (1.3-2.5)	1,638 (59; 56-61)	36.7 (34.9-38.5)
<25th percentile	5,578 (25.4; 25.0-25.8)	87 (94; 89-98)	1.6 (1.0-2.2)	1,855 (66; 64-68)	33.3 (31.6-35.1)
<30th percentile	6,667 (30.3; 29.9-30.7)	88 (95; 90-98)	1.3 (0.7-1.9)	2,032 (73; 71-75)	30.5 (28.8-32.2)
<35th percentile	7,773 (35.3; 34.9-35.7)	90 (97; 92-99)	1.2 (0.6-1.8)	2,177 (78; 76-80)	28.0 (26.3-29.7)
<40th percentile	8,842 (40.2; 38.8-40.6)	92 (99; 95-100)	1.0 (0.5-1.6)	2,295 (82; 80-84)	26.0 (24.4-27.6)
<45th percentile	9,940 (45.2; 44.8-45.6)	92 (99; 95-100)	0.9 (0.4-1.3)	2,396 (86; 84-87)	24.1 (22.5-25.7)
<50th percentile	11,035 (50.2; 49.8-50.6)	93 (100; 96-100)	0.8 (0.3-1.1)	2,485 (89; 87-89)	22.5 (20.9-24.1)

CI = confidence interval; EFW = estimated fetal weight.

Table 4. Predictive performance for small for gestational age neonates <3rd percentile in screening by estimated fetal weight below specific percentile cut-offs at 35+0 to 36+6 and 31+0 to 33+6 weeks' gestation.

EFW cut-off	Screen positive rate	Birth at ≤ 2 weeks from assessment		Birth at any time from assessment	
		Detection rate	Positive predictive value	Detection rate	Positive predictive value
35+0 to 36+6 weeks	**n/45,847 (%; 95% CI)**	**n/638 (%; 95% CI)**	**% (95% CI)**	**n/2,017 (%; 95% CI)**	**% (95% CI)**
<3rd percentile	1,636 (3.6; 2.7-4.5)	437 (69; 65-72)	26.7 (23.7-29.7)	855 (42; 39-46)	52.2 (48.9-55.5)
<10th percentile	4,109 (9.0; 8.7-9.3)	535 (84; 82-86)	13.0 (10.4-15.6)	1,308 (65; 62-68)	31.8 (29.8-33.8)
<15th percentile	6,125 (13.4; 13.1-13.7)	569 (89; 87-92)	9.3 (7.1-11.6)	1,513 (75; 73-77)	24.7 (22.9-26.5)
<20th percentile	8,089 (17.6; 17.3-17.9)	588 (92; 90-94)	7.3 (5.3-9.3)	1,630 (81; 79-83)	20.2 (18.5-21.9)
<25th percentile	10,215 (22.3; 22.0-22.6)	608 (95; 94-97)	6.0 (4.1-7.8)	1,741 (86; 85-88)	17.0 (15.4-18.6)
<30th percentile	12402 (27.1; 26.8-27.4)	619 (97; 96-98)	5.0 (3.3-6.7)	1,810 (90; 88-91)	14.6 (13.1-16.0)
<35th percentile	14,694 (32.1; 31.8-32.4)	629 (99; 97-99)	4.3 (2.7-5.8)	1,867 (93; 92-94)	12.7 (11.3-14.1)
<40th percentile	16,918 (36.9; 36.6-37.2)	632 (99; 98-100)	3.7 (2.2-5.1)	1,900 (94; 93-95)	11.2 (9.9-12.6)
<45th percentile	19,221 (41.9; 41.6-42.2)	635 (100; 99-100)	3.3 (1.9-4.7)	1,942 (96; 96-97)	10.1 (8.8-11.4)
<50th percentile	21,536 (47.0; 46.7-47.3)	635 (100; 99-100)	2.9 (1.6-4.2)	1,961 (97; 97-98)	9.1 (7.8-10.2)
31+0 to 33+6 weeks	**n/21,989 (%, 95% CI)**	**n/73 (%, 95% CI)**	**% (95% CI)**	**n/1,155 (%, 95% CI)**	**% (95% CI)**
<3rd percentile	766 (3.5; 2.2-4.8)	49 (67; 58-76)	6.4 (4.7-8.0)	340 (29; 26-33)	44.4 (41.1-47.7)
<10th percentile	2,164 (9.8; 9.4-10.2)	60 (82; 74-90)	2.8 (1.9-3.8)	603 (52; 49-55)	27.9 (25.3-30.4)
<15th percentile	3,306 (15.0; 14.6-15.4)	64 (88; 81-94)	1.9 (1.1-2.7)	736 (64; 61-67)	22.3 (19.9-24.7)
<20th percentile	4,459 (20.3; 19.9-20.7)	66 (90; 84-96)	1.5 (0.8-2.2)	816 (71; 68-73)	18.3 (16.1-20.5)
<25th percentile	5,578 (25.4; 25.0-25.8)	68 (93; 88-97)	1.2 (0.6-1.8)	894 (77; 75-80)	16.0 (13.9-18.1)
<30th percentile	6,667 (30.3; 29.9-30.7)	69 (95; 90-98)	1.0 (0.4-1.6)	954 (83; 80-85)	14.3 (12.3-16.3)
<35th percentile	7,773 (35.3; 34.9-35.7)	71 (97; 94-98)	0.9 (0.4-1.4)	1,002 (87; 85-89)	12.9 (11.0-14.8)
<40th percentile	8,842 (40.2; 38.8-40.6)	72 (99; 95-100)	0.8 (0.3-1.3)	1,039 (90; 88-92)	11.8 (9.9-13.7)
<45th percentile	9,940 (45.2; 44.8-45.6)	72 (99; 95-100)	0.7 (0.2-1.2)	1,062 (92; 90-94)	10.7 (8.9-12.5)
<50th percentile	11,035 (50.2; 49.8-50.6)	73 (100; 96-100)	0.7 (0.3-1.2)	1,081 (94; 92-95)	9.8 (8.1-11.5)

CI = confidence interval; EFW = estimated fetal weight.