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Controlled trial of fundal height measurement plotted on customised antenatal growth charts

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Objective The purpose of this study was to evaluate the effect of a policy of standard antenatal care which included plotting fundal height measurements on customised antenatal charts in the community.

Design Prospective, non-randomised, controlled, population-based study.

Population Two defined and separate referral areas from community to teaching hospital, with similar delivery rates and socioeconomic characteristics. A total of 1272 consecutively booked women with singleton pregnancies and dating ultrasound scans before 22 weeks of gestation.

Intervention In the study area customised fundal height charts were issued to each mother at the routine hospital booking scan, on which regular fundal height measurements were to be plotted by community midwives. The charts adjusted limits according to maternal characteristics including height, weight, parity and ethnic group. Usual management in the control area included fundal height assessment by abdominal palpation and recording on a standard co-operation card.

Outcome measures Antenatal detection of small and large for gestational age babies; number of antenatal investigations for fetal growth in each group.

Results The study group had a significantly higher antenatal detection rate of small for gestational age babies (48% *vs* 29%, odds ratio 2·2, 95% confidence interval 1·1–4·5) and large for gestational age babies (46% *vs* 24%, OR 2·6, CI 1·3–5·5). There was no increase in the study group in the overall number of scans per pregnancy done in the ultrasound department (1·2 *vs* 1·3, $P = 0·14$), but a slight decrease in repeat (two or more) third trimester scans (OR 0·8, CI 0·6–1·0, $P = 0·08$). Women in the study group had significantly fewer referrals for investigation in a pregnancy assessment centre (OR 0·7, CI 0·5–0·9; $P = 0·01$) and fewer admissions to the antenatal ward (OR 0·6, CI 0·4–0·7, $P < 0·001$). There were no differences in perinatal outcome.

Conclusions Serial measurement of fundal height plotted on customised charts leads to increased antenatal detection of small and large babies. This is accompanied by fewer investigations, which is likely to represent increased confidence in the community to recognise normal fetal growth. With adjustments for physiological variables, fundal height measurements appear to be a cost effective screening method which can result in substantial improvements in the antenatal assessment of fetal growth.

INTRODUCTION

A principal aim of antenatal care is the early detection of fetal growth abnormalities, as they can lead to adverse pregnancy outcome, including perinatal morbidity and mortality. However, abnormal growth has not been defined, and, as a surrogate measure, size is usually used to define limits: large for gestational age (LGA) and small for gestational age (SGA) which can be taken, for example, at the 90th and 10th centile limits, respectively. A baby is more likely to have abnormal morphometry and tests of wellbeing if its weight falls outside such limits[1,2], but many are in fact normal and only constitutionally large or small. The limits are usually applied irrespective of variables such as maternal height, booking weight, parity and ethnic group, even though these are known to affect birthweight and feta' growth in normal pregnancies[3–7].

The detection of growth abnormalities requires serial measurement[8,9]. Repeated ultrasound scans in all pregnancies might improve detection[10,11], but they are costly and logistically unfeasible, especially as more and more antenatal care is devolved into the community. Instead, many units rely on clinical assessment of uterine size followed by referral for further investigation as considered appropriate. Using fundal height measurement instead of ultrasound as the primary screening tool for

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small babies results in a lower detection rate and a higher rate of false positives[12].

In everyday practice there is a common but erroneous perception that fundal height in centimetres should equal gestational age in weeks. The results are usually recorded in a column next to the gestational age. Awareness of gestational age introduces error and tends to artificially increase the recorded measurement[13]. This would reduce the ability to detect growth retardation when it occurred. Antenatal screening strategies are aimed to detect babies with abnormal size for gestation, but performance has been poor. For example, only 26% of SGA babies were suspected to be small before birth in an unselected hospital population[14]. In a low risk population in Nottingham, 16% of SGA infants were detected with standard methods of antenatal assessment[15].

The purpose of this study was to evaluate the effect of a policy which asked for serial fundal height measurements to be plotted on customised fundal height charts as a screening method for fetal growth.

METHODS

The customised antenatal growth chart displays computer-generated curves for fetal weight and fundal height, adjusted according to physiological characteristics in each pregnancy[4,5]. By means of multiple regression coefficients derived from our population, the optimal weight predicted at term is calculated by adjusting for maternal height, booking weight, parity and ethnic group, and by excluding known pathological variables such as smoking. Through the calculated endpoints of the 50th centile weight at 40 weeks and the 90th and 10th centile limits, proportionality curves outline the normal range of fetal weight gain for each pregnancy[5]. A second ordinate axis for fundal height was constructed on the basis of a linear ultrasound fetal weight/fundal height relationship derived from simultaneous third trimester measurements[16]. As a result of adjusting the curves to the physiological characteristics in each pregnancy, the slope or increment over time of fundal height varies for each pregnancy. Two illustrative examples are shown in Fig. 1.

The usual local pattern of antenatal care includes booking by general practitioner and/or midwife in the community followed by referral to one of nine consultant units in the hospital. In most instances, this first hospital visit was arranged during the second trimester, aimed to coincide with a routine 18–19 week detailed scan. Subsequently, and unless more frequent visits were indicated, most consultant units had, at the time of the study, a policy of seeing the woman at most only once or twice during the third trimester, and at 41 weeks if the pregnancy was still continuing. In the community, visits were usually 4 weekly until 28 weeks, fortnightly until 36 weeks and weekly thereafter. The women were seen by midwives either alone or in conjunction with the general practitioner.

Assessment of fetal growth usually includes a consideration of past history and circumstances of the current pregnancy (e.g. whether there is hypertension, or whether the mother smokes) and a clinical assessment of uterine size. If the recorded fundal height lags behind that expected according to gestational age, or if there is any other concern about the pregnancy, referral for investigations was undertaken in one of three ways:

1. To the next hospital antenatal clinic of the relevant consultant team, often preceded by a scan in the adjoining ultrasound department;
2. To the hospital's pregnancy assessment centre, run by a maternal-fetal medicine specialist, where tests for fetal wellbeing are carried out as indicated, including ultrasound scan, Doppler flow and/or fetal heart rate monitoring;
3. In after-hours cases, or where the team responsible for the pregnancy is not available, admission to an antenatal ward for subsequent investigations.

The policy for the study group was conventional antenatal care and, in addition, plotting of fundal height measurements on customised charts at each visit. The study was preceded by a two month period, during which visits to community midwives and general practitioners in the Health Centres of the study group area were undertaken to explain the new protocol. Midwives were shown a method of fundal height measurement with non-elastic tapes, similar to that previously described[17]. The side of the tape without the centimetre scale was to be used for the initial measurement. With the woman in a comfortable, semi-recumbent position, the fundus was found by palpation caudally from the xiphisternum. Measurement was from the fundus along the uterine axis to the top of the symphysis pubis. The uterine axis was not to be corrected if it was deviated from the mid-line.

The indications for referral were as in the conventional management group. In addition, referral could be to the trial coordinators on the basis of fundal height measurements plotted on the customised growth charts. Further investigations for fetal growth were to be ordered if the fundal height measurement fell outside the customised limits (10th and 90th centile). Referral was also indicated if the last two measurements were within these limits but suggested a slope which was steeper or flatter than the 90th and 10th centile lines, respectively. As an example, in the lower figure the serial plots show that a fundal height growth of 3 cm over four weeks is less than the slope of the 10th centile curve, even though individual measurements do not fall outside the centile limit.

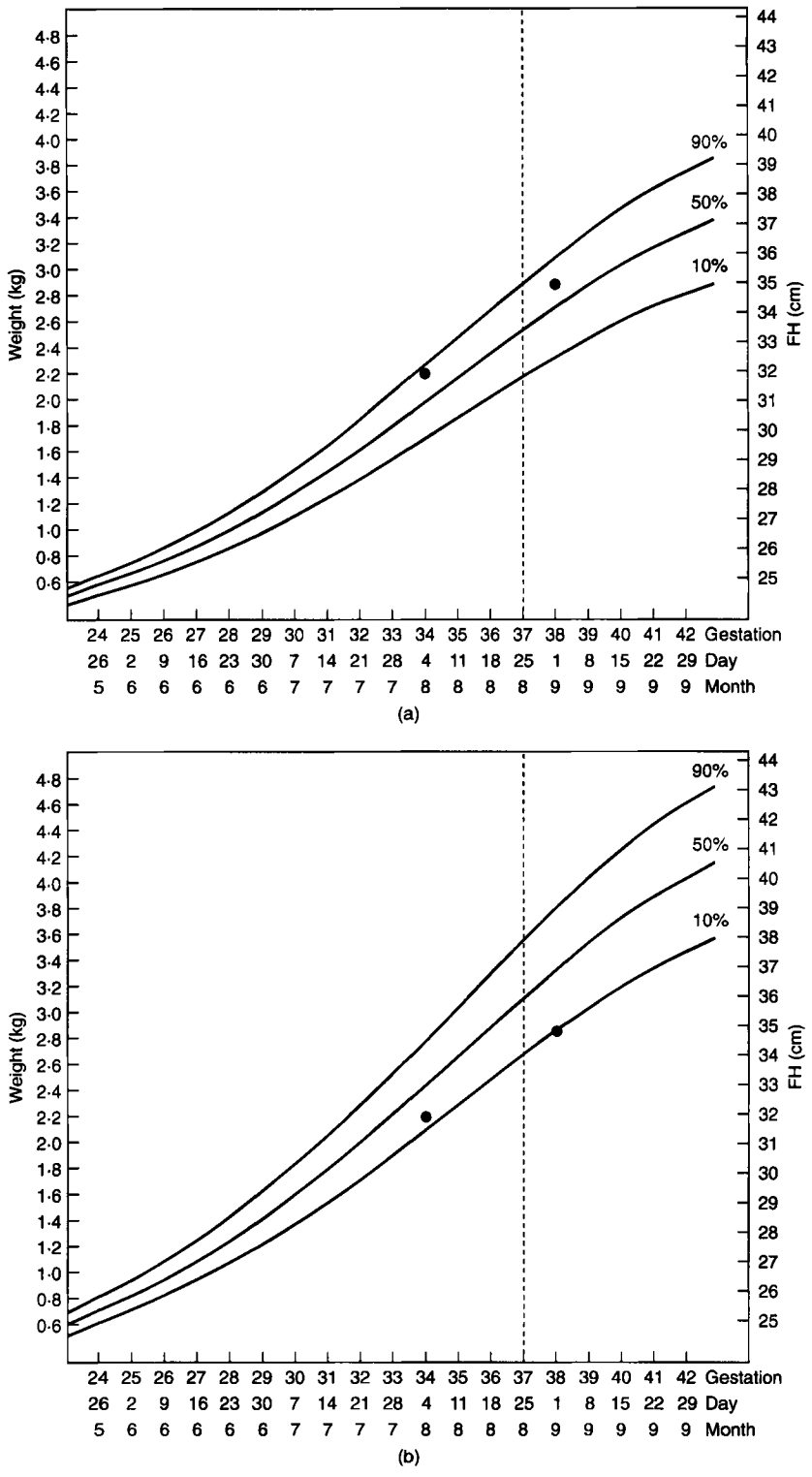

Fig. 1. Examples of customised growth charts. The X axis shows day and month of each gestational week, with 15th September at 40·0 weeks as the expected date of delivery. The line through 37·0 weeks denotes the onset of 'term'. Left Y axis is for weight (fetal- and birthweight); right Y axis is the fundal height scale. The lines represent the median and 90th and 10th centiles of the individually adjusted limits of fetal weight- and fundal height growth. For (A) (height 150 cm, booking weight 49 kg, Pakistani), the expected median fundal height measurement at 34 and 38 weeks are 31 and 34 cm, respectively (i.e. an increment of 0·75 cm per week). In contrast, for (B) (maternal height 178 cm, booking weight 90 kg, European), the increment during the same interval should be 33 to 37 cm, or 1 cm per week. An example of serial measurements at these gestations of 32 and 35 cm, respectively, are plotted (●); they show satisfactory growth for (A) but suggest possible growth restriction in the pregnancy of (B).

The outcome measures were defined at the beginning of the study. The primary outcome was the number of cases of SGA (< 10th centile) and LGA (> 90th centile) babies which were detected antenatally in each group. Secondary outcomes were the total number of investigations in each group, including referrals to the ultrasound department or to the pregnancy assessment unit, and admissions to the ward.

The aim of the study was to enable evaluation of a new strategy within the context of overall care. In consultation with midwifery managers and general practitioners, it was agreed that a randomised design was unsuitable. Assigning women randomly to each group would have meant that the care-givers would be expected not to apply newly learned methods to some of the mothers in their care. Randomising midwives and doctors would also be unsatisfactory, as they tend to work in teams. Instead, we defined two similar catchment areas to our hospital which were served by separate and non-overlapping groups of community midwives and general practitioners. The areas each referred approximately 1000 maternity cases per annum for booking at the Queen's Medical Centre, were approximately equidistant from the hospital, and had a similar mix of ethnic and socioeconomic backgrounds. The area from which the first recruitment would be made after commencement of the study was designated to be the study group, and the other the control group. The study group consisted of 5 community midwife areas with 20 midwives and 76 general practitioners from 28 health centres or individual practices. The control group comprised 7 community midwife areas with 22 midwives and 84 general practitioners from 26 health centres or individual practices.

The study was approved by the hospital ethical committee, the Obstetrics and Gynaecology directorate, the Local Medical Committee and Nottingham Community Health.

We expected that 10% of the population would be SGA (< 10th centile) at birth. We hypothesised that the study protocol would increase the antenatal detection of SGA from an expected 25% to 50%, which at 5% significance level and 80% power, would require 55 SGA babies in each group (2-tailed). Hence we aimed for 600 pregnancies in each arm of the study.

The control group consisted of 605 consecutive singleton pregnancies booked before 22 weeks which subsequently delivered at our hospital. Mothers and midwives in the control group were not informed of the study in progress, and the pregnancies were managed as usual.

Women in the study group were informed of the project and asked for verbal consent at the time of the hospital visit coinciding with the routine 18–19 week scan. A customised chart was then printed out and either given to the woman or sent to her community midwife, to be appended to the co-operation card. With one exception, all women agreed to this protocol; this woman's pregnancy was subsequently not monitored with a customised chart but the details and outcome were included with the study group for analysis.

Recruitment commenced in May 1994 and was ended in March 1995, past the original target number to allow for possible losses to follow up. During this period, with the exception of the one woman who refused consent, all women in the study group catchment area who booked with a singleton pregnancy before 22 weeks of gestation were issued customised charts (n = 734). Sixty-seven of these pregnancies were subsequently excluded because they miscarried or because the mother had moved from the area before delivery, which resulted in 667 deliveries in the study group. Jarman scores as a measure of underprivileged areas[18] were calculated for both groups.

The outcome measures and pregnancy characteristics for both groups were collected from the women's notes and co-operation cards, the hospital records of referrals, and the computerised obstetric database. Data collection was undertaken by an experienced midwife and subsequently checked by a research assistant. Data were analysed with statistical software (SPSS for Windows, Version 7·0) and spreadsheet (Microsoft Excel, Version 5·0) with add-in functions for odds ratios, confidence limits and P values according to standard formulae[19].

RESULTS

The pregnancy characteristics in the study and control groups showed no statistical differences with the exception of a clinically insignificant difference in maternal age. The two groups also had similar Jarman scores (Table 1).

Of the 667 customised charts issued in the study group, 642 (96·3%) were retrieved after birth. Of these, 70 (10·9%) had fewer than three symphysis–fundus measurements plotted; 477 (74·3%) had between three and seven, and 95 (14·8%) had eight or nine. The median number of plotted measurements per pregnancy was five (range 0–9).

A significantly higher proportion of the small for gestational age infants in the study group were suspected antenatally to be small than in the control group (47·9 *vs* 29·2%). (Table 2). Similarly, more infants who were large for gestational age at birth were identified in the study group (45·7 *vs* 24·2%). However, this was not associated with any differences in outcome (Table 3).

The reasons for referral for further investigations were not always well documented and were often due to more than one indication. Hence the antenatal suspicion

Table 1. Pregnancy characteristics. Values are given as mean [SD] or *n* (%) unless otherwise indicated.

	Study group ($n = 667$)	Control group ($n = 605$)	OR	95% CI	*P*
Maternal age (years)	27·9 [5·0]	27·2 [5·6]			0·02*
Maternal height (cm)	163 [7·0]	163·4 [6·8]			0·30*
Booking weight (kg)	66·2 [12·4]	65·5 [12·6]			0·32*
Parity					
0	266 (39·9)	247 (40·8)	0·96	0·77–1·20	0·78†
1	236 (35·4)	210 (34·7)			
2	104 (15·6)	91 (15·0)			
3	34 (5·1)	40 (6·6)			
4+	27 (4·0)	17 (2·6)			
Ethnic group					
Anglo-European	542 (81·3)	497 (82·1)	0·94	0·71–1·25	0·74‡
Indian / Pakistani	85 (12·7)	69 (11·4)			
Afro-Caribbean	20 (3·0)	25 (4·1)			
Other	20 (3·0)	14 (2·3)			
Smoker (at booking)	132 (20·1)	140 (23·1)	0·82	0·63–1·07	0·17§
Jarman score	+2·3 [25·6]	+1·2 [16·9]			
No. with score > 20	121 (18·1)	95 (15·7)			0·25¶

*Student's *t* test.
χ^2 tests: †nullipara *vs* multipara; ‡European *vs* non-European; §smokers *vs* non-smokers; ¶Jarman score > 20 *vs* ≤ 20.

of growth problems was likely to be understated in the notes. Also, referrals for investigations were often made without reasons stated, and at times a suspicion of growth abnormality was withdrawn. Therefore, no attempt was made to count false positives (i.e. where there were apparently wrong suspicions of individual infants being small or large for gestational age). Instead, the total number of actual referrals to the ultrasound department and to the pregnancy assessment centre were counted for each group.

Table 4 lists the number of third trimester referrals for ultrasound scans. There was no difference in the number of scans between the study and control groups. The most frequent primary indication for one or more third trimester scans was for concern about growth and/or liquor volume, which occurred in 34·7% of pregnancies in the study group and 35·8% in the control group.

Most referrals to the pregnancy assessment centre were for concerns about fetal growth or lack of fetal movement, and the evaluation usually also included an ultrasound scan. There were significantly fewer referrals from the study group, both in number of women referred and in total number of visits (Table 5). Taking referrals to the pregnancy assessment centre and to the ultrasound department together showed that women in the study group had fewer referrals for investigations per pregnancy (1·56) than women in the control group (1·91; $P < 0·001$). There were also significantly fewer women in the study group admitted to the antenatal ward (Table 6).

DISCUSSION

The results showed a significant increase in the detection of infants who are small or large for gestational age by the strategy adopted in this study. In the control group the antenatal detection rate of small for gesta-

Table 2. Antenatal detection of small for gestational age (SGA) and large for gestational age (LGA) babies. Values are given as *n* (%) unless otherwise indicated.

	Study group ($n = 667$)	Control group ($n = 605$)	OR	95% CI	*P*
SGA	71 (10·6)	72 (11·9)			
Suspected	34 (47·9)	21 (29·2)	2·23	1·12–4·45	0·03
Not suspected	37 (52·1)	51 (70·8)			
LGA	81 (12·1)	62 (10·2)			
Suspected	37 (45·7)	15 (24·2)	2·63	1·27–5·45	0·01
Not suspected	44 (54·3)	47 (75·8)			

Table 3. Pregnancy outcome. Values are given as *n* (%) or mean [SD] unless otherwise indicated. SVD = spontaneous vaginal delivery; CS = caesarean section; SGA = small for gestational age; LGA = large for gestational age; SCBU = special care baby unit.

	Study group ($n = 667$)	Control group ($n = 605$)	OR	95% CI	*P*
Induction of labour	105 (15·7)	101 (16·7)	0·93	0·69–1·26	0·70†
Mode of delivery					
SVD	444 (66·6)	401 (66·3)	1·01	0·80–1·28	0·96‡
Forceps	45 (6·7)	39 (6·4)			
Ventouse	56 (8·4)	51 (8·4)			
Assisted breech	4 (0·6)	6 (1)			
Elective CS	45 (6·7)	48 (7·9)			
Emergency CS	73 (10·9)	60 (9·9)			
Boys	376 (56·4)	312 (51·6)	1·21	0·97–1·51	0·10§
Birthweight (median)	3370	3320			
Gestational age (median)	278	280			
Preterm births (< 37 wks)	52 (7·8)	39 (6·4)	1·23	0·80–1·88	0·35§§
Birthweight centile	52·3 [29·6]	49·9 [30·2]			0·14*
SGA (< 10th)	71 (10·6)	72 (11·9)			
LGA (> 90th)	81 (12·1)	62 (10·2)			
Admissions to SCBU	22 (3·3)	16 (2·6)	1·26	0·65–2·41	0·60¶
Resuscitation at birth	110 (16·5)	87 (14·4)	1·18	0·87–1·56	0·34¶
Fetal abnormality	7 (1)	9 (1·5)	0·70	0·26–1·90	0·65¶
Stillbirth	5 (0·7)	4 (0·7)	1·14	0·30–4·25	0·88¶

*Mann-Whitney *U* test.
χ^2 tests: †induction of labour *vs* spontaneous onset; ‡SVD *vs* not SVD; §boys *vs* girls; §§preterm *vs* term births; ¶occurrence *vs* non-occurrence of adverse event.

Table 4. Third trimester ultrasound scans. Values are given as *n* (%) or mean [SD] unless otherwise indicated.

	Study group ($n = 667$)	Control group ($n = 605$)	OR	95% CI	*P*
Referrals for scan					
0	260 (39·0)	212 (35·0)			
1	187 (28·0)	164 (27·1)	0·84	0·67–1·06	0·16*
2	105 (15·7)	118 (19·5)	0·81	0·64–1·02	0·08**
3	70 (10·5)	61 (10·1)			
4+	45 (6·7)	50 (8·3)			
Total no. of scans	824	819			
Scans per pregnancy	1·24 [1·38]	1·35 [1·40]			0·14†

χ^2 tests of frequency of ultrasound scans: *1 or more *vs* none; **2 or more *vs* 0 or 1.
†Mann-Whitney *U* test.

Table 5. Referrals to the Pregnancy Assessment Centre (PAC). Values are given as *n* (%) or mean [SD] unless otherwise indicated.

	Study group ($n = 667$)	Control group ($n = 605$)	OR	95% CI	*P*
Visits to PAC					
0	547 (82·0)	461 (76·2)			
1	76 (11·4)	73 (12·1)	0·70	0·54–0·92	0·01*
2	22 (3·3)	30 (5·0)	0·53	0·36–0·79	0·002**
3	12 (1·8)	16 (2·6)			
4+	10 (1·5)	25 (4·1)			
Total no. of visits	217	337			
Visits per pregnancy	0·33 [0·93]	0·56 [1·36]			< 0·005†

χ^2 tests on frequency of: *one or more visits to PAC; **two or more visits to PAC.
†Mann-Whitney *U* test.

Table 6. Admissions to the ward. Values are given as *n* (%) or mean [SD] unless otherwise indicated.

	Study group ($n = 667$)	Control group ($n = 605$)	OR	95% CI	*P*
Admissions to the ward					
0	546 (81·9)	433 (71·6)			
1	96 (14·4)	121 (20·0)	0·56	0·43–0·73	< 0·001*
2	19 (2·8)	38 (6·3)	0·42	0·26–0·69	< 0·001**
3+	6 (0·9)	13 (2·1)			
Total no. of admissions	153	237			
Admissions per pregnancy	0·23 [0·54]	0·39 [0·71]			< 0·001†

χ^2 tests of frequency of admissions to the ward: *1 or more *vs* none; **2 or more *vs* 0 or 1.
†Mann-Whitney *U* test.

tional age infants was 29%, which is similar to the 26% in a study in Glasgow[14], and better than the 16% achieved in a selected low-risk population[15]. In comparison, the results in the study group showed a significant improvement, to 48% of the small for gestational age infants being detected (Table 2).

Formal measurement of symphysis–fundus height has been advocated[17,20–24] but also questioned as to usefulness[25,26]. Symphysis–fundus measurement can be subject to considerable inter-observer variation[27,28], although it has been suggested that this could be improved by better technique and training[29]. As a method for assessing fetal size, fundal height measurement has long been known to perform poorly[30,31]. However, current practice and lack of training may not do this parameter justice. The prevailing method of comparing fundal height measurement against the gestational age can be misleading[13]. Furthermore, none of the standards allows adjustment of the normal range according to individual characteristics, even though it is clear that fundal height measurements are affected by variables such as maternal weight[32] and ethnic group[33,34]. Apart from the fetus as the object of interest, symphysis-fundus measurement is also influenced by surrounding amniotic fluid, placenta, myometrial thickness, abdominal wall fat and the relationship of the uterus to the bony pelvis. It is the fetus which is the most rapidly changing in size, and serial assessment will reduce the influence of other factors (i.e. the 'noise' in this measurement). When fundal height increment was compared retrospectively with measurements on newborn infants, a highly significant correlation was shown between slow fundal height growth and small for gestational age babies[35]. The true value in fundal height measurement as a predictor of growth restriction has to come from serial assessment of change[8]. We believe that the new strategy increased the detection rate because of a combination of factors, which include that:

1. The study group was taught a proper method of fundal height measurement;
2. Customised limits for SGA and LGA made the measurement more sensitive;
3. Serial plotting on predicted growth curves can reveal slow growth.

Against an improved detection of fetal size outside the screening limits, one could expect an increased rate of investigations, and previous fundal height studies reported high false-positive rates which can lead to unnecessary investigations[36,37]. However, our study has found the opposite. To get a true measure of the number of investigations each strategy leads to, we compared the total number of first and subsequent referrals. This method was chosen as the assessment of false-positivity has to include the clinical decision to act, and may be subject to a number of confounders (e.g. a decision to change one's assessment). For example, a single measure outside the normal limits may be revised by a subsequent examination and may not lead to referral for a scan. Fundal height measurement should not be seen as an isolated technique, but part of an overall clinical assessment, the individual components of which are difficult to quantify. These components include a clinician's impression of the mother's overall wellbeing, her account of fetal movements, the estimation of liquor, previous risk factors seen within the context of new findings, and possibly other, unspecified variables. Any of these alone or in combination may raise suspicion for referral for further investigation, and the indication for such a referral is often not clearly stated. Hence we felt that the total number of investigations or admissions would be the most reliable indicator of the rate of false positive investigations.

The study showed that despite the improved detection rate of small and large babies, there were significantly *fewer* initial and repeat investigations requested in the group monitored with customised charts. This may be due to a number of reasons. Firstly, serial plotting of fundal height on a chart emphasised the importance of the slope or increment between subsequent measurements. Even if a single estimation of uterine size falls

outside the range because of normal variation, the increment of serially plotted fundal height is less likely to fall outside expected limits if fetal growth is normal. Secondly, the adjustment of normal limits increases the precision of the measurement and reduces unnecessary concern that the infant is small, when in effect it is small–normal. This confirms previous reports where the parameter studied was ultrasound fetal weight[38] and birthweight[4,39,40]. Thus in a heterogeneous population, fewer pregnancies are unnecessarily suspected of abnormal fetal growth if the standard is individually adjusted. The reduced referral rates may also indicate a higher level of confidence in the community that growth was proceeding satisfactorily. Clearly, fewer referrals and investigations translate into less maternal anxiety and concern, and substantial savings in the overall cost of antenatal care.

But the most important implication of these findings is that potentially more babies can be referred for increased antenatal surveillance including tests for fetal growth and wellbeing. Outcome measures are difficult to define in studies of fetal growth, especially if the result of the test is revealed. Interventions may alter the natural history and benefits may be obscured. For this evaluation, we chose a simple primary endpoint, the antenatal detection of SGA and LGA babies, which is a principal aim of antenatal care. There is evidence of a strong association between intrauterine growth restriction and antepartum stillbirths[41], which makes better strategies for antenatal detection of fetuses at risk of growth restriction all the more urgent. We suggest that we now have an easily applied tool for fetal growth screening which needs to be tested in larger, multicentre trials, with perinatal mortality and morbidity as primary endpoints.

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