Tropical Medicine and International Health

volume 1 no. 4 pp 510–521 august 1996

The value of maternal height as a risk factor of dystocia: a meta-analysis

Bruno Dujardin[1], Roger Van Cutsem[2] and Thierry Lambrechts[3]

[1] *Public Health Unit, Institute of Tropical Medicine, 155 Nationalestraat, B-2000 Antwerpen*
[2] *13 rue du Muturnia, B-6220 Heppignies*
[3] *188 rue H. Dunant, B-7000 Mons*

Summary Ten publications and studies on the relation between maternal height and the risk of dystocia due to cephalopelvic disproportion (CPD) are analysed. The rate of Caesarean sections was chosen as the CPD indicator. When maternal height is presented in percentiles, curves can be superimposed, and sensitivities and specificities of the various studies may be analysed together. One biased study was excluded; the remaining 9 were pooled and regression lines calculated for sensitivity (Se) and specificity (Sp) of the entire set of points. The resulting model, i.e. $Se=10.9+1.99\ Y$ and $Sp=99.9-0.99\ Y$, permits easy calculation of the expected sensitivity and specificity for each percentile Y. When the frequency of Caesarean section due to CPD is known, positive and negative predictive values can also be calculated. The proposed formulas can also be used to determine confidence intervals.

The findings in terms of the sensitivity and specificity of low maternal height as a risk factor for dystocia indicate that 1 out of 5 pregnant women would have to be referred for further investigation to identify half of the cases of mechanical dystocia necessitating Caesarean section. The predictive value for a Caesarean rate of 2% (a value often seen in developing countries) for this 20th percentile would be only 5%. Practical ways of choosing a reference criterion are suggested. A two-track strategy (antenatal check-ups and community monitoring) is proposed.

keywords maternal height, meta-analysis, screening, Caesarean

correspondence Bruno Dujardin, Public Health Unit, Institute of Tropical Medicine, 155 Nationalestraat, B-2000 Antwerpen, Belgium

Introduction

An estimated 500 000 women die every year in childbirth and more than 8 million suffer from complications related to pregnancy or childbirth (Royston & Armstrong 1990). Preparatory documents for the 'Safe Motherhood Initiative' (Nairobi, February 1987) show that more than 99% of these deaths and complications occur in developing countries. Cephalopelvic disproportion (CPD), also known as mechanical dystocia, is the cause of a high proportion of the maternal morbidity and mortality in developing countries and is a frequent cause of perinatal death (Royston & Armstrong 1990). CPD is responsible directly or indirectly for 20–30% of maternal deaths (Royston & Armstrong 1990; Dujardin & Van Balen 1991). The sequelae—rectal or vesico-vaginal fistulae, incontinence, uterine rupture, and sterility—have major socioeconomic and marital consequences (Howard 1987).

Many of these tragedies could be avoided if the dystocic births were referred in time to specialized facilities able to offer the right medical care, including symphysiotomy and Caesarean section, if

 © 1996 Blackwell Science Ltd

necessary. In rural areas of developing countries, where medical resources are very limited and giving birth at home is the rule for both economic and cultural reasons, only screening and referring to hospitals women at risk of complicated labour is feasible and acceptable. If screening is to be worth while, the referral criterion must be both easy to use for health workers and accepted by the population. Its cost must be minimal and its measurement as reliable as possible: sensitivity, specificity, positive and negative predictive values of the criterion must be sufficient to differentiate correctly women who are at risk from those who are not (Sackett & Holland 1975).

The criterion of maternal height definitely meets the first conditions; measuring a woman's height and pelvic diameter is simple, acceptable, reproducible and costs next to nothing. Since Baird's (1952) pioneering work, many authors have revealed a significant association between low maternal height and the risk of CPD (Aitken & Walls 1986; Everett 1975; Kasongo Project Team 1984; Mahmood *et al.* 1981; Pongthai *et al.* 1988; Sokal *et al.* 1991; Yudkin & Redman 1986; Baird 1985). In other words, the shorter the women, the higher the incidence of mechanical dystocia. Current knowledge of the relation between maternal height and the incidence of CPD justifies in-depth analysis of the literature on this subject.

The objectives of this meta-analysis are consequently (i), to show the reproducibility of the relation between low maternal height and increased incidence of mechanical dystocia, that is, whether identical levels of sensitivity and specificity correspond to a given maternal height, regardless of the population examined; (ii), to develop a simple model to determine expected sensitivity, specificity and positive and negative predictive values for a given maternal height.

Methods

A computer search (Medline data base) was made of international literature from 1984 through the first half of 1992 using the keywords *height*, *dystocia*, *cephalopelvic disproportion*, *Caesarean section*, *obstructed labour* and *maternal health and risk factors*. We also searched for published and unpublished studies (university and PhD theses, survey reports, etc.) to provide quantitative data needed to calculate the sensitivity and specificity of maternal height as a risk factor for dystocia.

The rate of Caesarean sections (CS) was chosen as the indicator for dystocia. The CS rate for CPD (or, lacking this, the overall CS rate) was chosen as the most reliable indicator of the incidence of CPD for the following reasons:

There is no problem defining a CS, unlike variables such as 'prolonged labour', 'dystocia', etc.

In the literature the CS rate is the variable most commonly associated with mother's height. Duration of labour, another variable indicative of CPD, has rarely been studied. Perinatal mortality, which is sometimes used as an indicator of dystocia, is not always clearly defined.

Given the importance of this intervention, we believe that the indications for CS, even if they vary from one author to the next, are set with circumspection. This is certainly less often the case in deciding to use forceps or vacuum extraction.

CS is a very specific dependent variable for CPD, although it is not very sensitive. This specificity is real, however, only if Caesarean section is performed for CPD and other reasons for performing surgery (placenta praevia, acute fetal distress, etc.) can be ruled out. In studies on developing countries, which report an overall CS rate of 1–2%, it is warranted to consider that most of these are motivated by maternal conditions, mainly due to mechanical dystocia. The margin of error will thus be acceptable for a first analysis.

Some studies were excluded from meta-analysis according to the following criteria:

Studies of fewer than 500 births (Frame *et al.* 1985; Haddad *et al.* 1986; Hughes *et al.* 1987; Kennedy & Greenwald 1988), as reliability of the quantitative analysis would have been reduced;

case studies (Kappel *et al.* 1987; Liljestrand *et al.* 1985; Scotte *et al.* 1989), since this type of investigation is not appropriate to evaluate the real incidence of Caesarean sections in the target population;

cases in which the number of women of small stature was deliberately inflated (Camilleri 1981; Harrison *et al.* 1985);

studies that contain fewer than 3 classes of maternal height (Baird 1952; Molloy 1969); since one of

 © 1996 Blackwell Science Ltd

the aims of this meta-analysis was to determine the sensitivities (Se) and specificities (Sp) associated with various decision thresholds, we had to have various cut-off points on a given curve;

studies using data from another study (Baird 1985);

studies in which the dependent variable was poorly defined (Cox 1963), e.g. 'dystocia' without further explanation;

studies that used the total Caesarean rate as a dependent variable when the rate of surgery was above 10% (Pongthai *et al.* 1988; Thomson 1959); in such samples the size effect of a CS risk factor would be diluted by other indications, notably fetal indications. We then divided the studies into two groups, a and b, depending on quality and reliability of data and importance of selection bias. Group a was composed of three community studies carried out in developing countries (Kasongo Project Team 1984; Mati *et al.* 1983; Voorhoeve *et al.* 1984) and hospital studies carried out in areas where the overwhelming majority of births take place in hospitals (Mahmood *et al.* 1981; Yudkin & Redman 1986; Thomson & Hanley 1988). Group b consisted of studies with a stronger selection bias: they were conducted in referral hospitals to which a large number of the district's at-risk deliveries were referred (Aitken & Walls 1986; Everett 1975; Sokal *et al.* 1991; Family Health International 1988). We also indicate for each study whether the dependent variable was CS for CPD (Aitken & Walls 1986; Everett 1975; Kasongo Project Team 1984; Mahmood *et al.* 1981; Sokal *et al.* 1991; Yudkin & Redman 1986; Thomson & Hanley 1988), or combined all Caesareans (Mati *et al.* 1983; Voorhoeve *et al.* 1984; Family Health International 1988). The latter also included Caesareans performed for placenta praevia and other indications not directly related to CPD. The selected studies and their most important features are summarized in Table 1.

To evaluate the usefulness of maternal height as a predictor for CPD we used the concepts of sensitivity, specificity and positive and negative predictive value, which are well known in the literature and often serve to evaluate screening and diagnostic tests (Fletcher *et al.* 1988).

Sensitivity (Se): The sensitivity of maternal height is 100% if the height chosen as the decision threshold permits identification of 100% of CPDs which will occur during labour.

Specificity (Sp): The specificity will be 100% if 100% of the women who are taller than the cut-off height have normal deliveries.

Positive predictive value (PPV): The PPV or *a posteriori* probability measures the frequency of CPD occurring in 'undersized women', i.e. those below the decision cut-off point.

Negative predictive value (NPV): The NPV measures the frequency of deliveries without CPD in 'normal-sized' women, i.e. those above the decision cut-off point.

Technical characteristics of a test, i.e. Se and Sp, are inversely related and depend above all on the chosen cut-off point. They may thus be used from one population to the next (Fletcher *et al.* 1988). Operational characteristics, i.e. PPV and NPV, depend not only on Se and Sp but also on the prevalence of CPD (measured by the CS rate) in the women who give birth. All these variables are proportions and express probabilities.

The predictive values are useful for decision-making because they relate to the extent to which health personnel may rely on the measurement of maternal height as a reference criterion. Their major disadvantage is that they depend on prevalence. They vary from one study to the next and thus cannot be used directly as assessment criteria to evaluate the effectiveness of a screening test.

Finally, in the last stage of our study we pooled all results for meta-analysis. We then used its outcome to construct a simple predictive model that permits calculation of expected sensitivity and specificity for each maternal height value (expressed in percentiles) from regression lines if it is chosen as the cut-off point. The positive and negative predictive values may also be calculated if the frequency of obstetric surgery (CS for CPD) is known. Regression lines, correlation coefficients and global confidence intervals were calculated using Statworks 1.2 for Apple computers.

Results

First objective

The first objective was to study the reproducibility of maternal height as a risk factor for mechanical

 © 1996 Blackwell Science Ltd

Table 1 Selected studies and their most important features

First author	Country Town (Date)	Population studied (*n*)	Class no.	Indicator of dystocia Rate (%) (*n*)	Studies' reliability[1] (a, b)
Aitken	Sierra Leone Segbwema (1979–1982)	Primiparas delivered in reference hospital (550)	11	Caesareans for CPD 7.1 (39)	b
Everett	Tanzania Dar Es Salaam (1972)	Primiparas delivered at reference hospital (622)	6	Caesareans for CPD 3.4 (21)	b
Kasongo Project Team	Zaire Kasongo (1971–1975)	Women registered for ANC (4702)	7	Caesareans for CPD 0.5 (22)	a
Mahmood	Scotland Inverness (1979)	Primiparas delivered in reference hospital (563)	5	Caesareans for CPD 13.1 (74)	a
Sokal	Burkina Faso Ouagadougou (1986)	All hospital deliveries (1714)	6	Caesareans for CPD 1.5 (26)	b
Yudkin	England Oxford (1978–1983)	Primiparas delivered at reference hospital (13 100)	4	Caesareans for dystocia 3.5 (457)	a
Thomson	Scotland Aberdeen (1948–1957)	All primiparas below 30 years (9003)	4	Caesareans for dystocia 0.9 (82)	a
Mati	Kenya Nairobi (1981)	All deliveries (3934)	3	Caesareans 5.9 (234)	a
Voorhoeve	Kenya Machakos (1975–1978)	All deliveries (4429)	8	Caesareans 1.1 (48)	a
Family Health International	Zaire Karawa (1984–1986)	All hospital deliveries (3628)	5	Caesareans 9.9 (358)	b

[1]Cf text for explanations. Class, maternal height class; CPD, cephalopelvic dystocia; ANC, antenatal clinic.

dystocia. The results of this meta-analysis are given in Figures 1–4. Figure 1a (studies with a lower bias probability) and 1b (studies with a higher probability of bias) show the relation between mother's height (in cm) and its positive predictive value (the frequency of Caesarean sections for dystocia in parturients whose height is equal to or under the cut-off point). For example, 30% of the Zairian women in Karawa (Figure 1b) who were less than 145 cm tall had to have Caesareans; this rate exceeded 50% if their height was less than 140 cm. Note that curves could not be superimposed but showed the same general pattern—the shorter the stature, the higher the PPV.

Obviously, not all populations compared in these studies have the same average height. Each woman's height must thus be compared with the distribution in her ethnic group. To accommodate this, the heights given in Figure 2a and b are expressed in percentiles rather than centimetres.

At the 100th percentile the PPV is equal to the frequency of Caesarean section. This frequency differs from one study to the next. The Nairobi study (Mati *et al.* 1983) seems to differ from the other curves, but this may be explained by the great distance between the first two cut-off points, that is, the 6th and 54th percentiles. On the Inverness curve (Mahmood *et al.* 1981) one point (P36) gives an outlying value. In the case of Ouagadougou (Sokal *et al.* 1991), the incidence of Caesareans for CPD differs significantly from one cut-off point to the

 © 1996 Blackwell Science Ltd

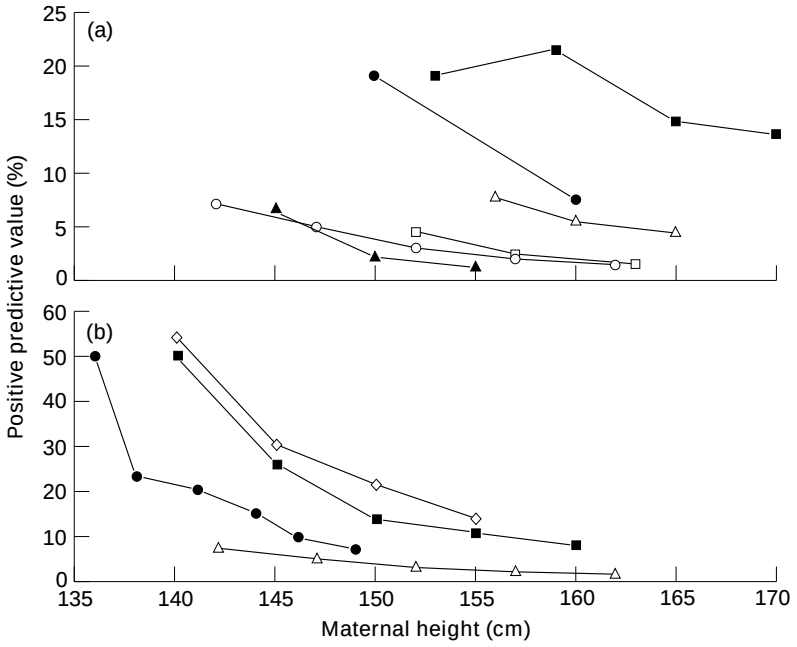

Figure 1 Positive predictive value of maternal height as a risk factor for CPD. a, ■, Inverness (9); △, Oxford (12)[1]; □, Aberdeen (18); ●, Nairobi (27)[2]; ▲, Kasongo (8); ○, Machakos (28)[2]. b, ◇, Karawa (29)[2]; ■, Segbwema (6); ●, Dar Es Salaam (7); △, Ouagadougou (11). [1]Caesareans for CPD; [2]all indications.

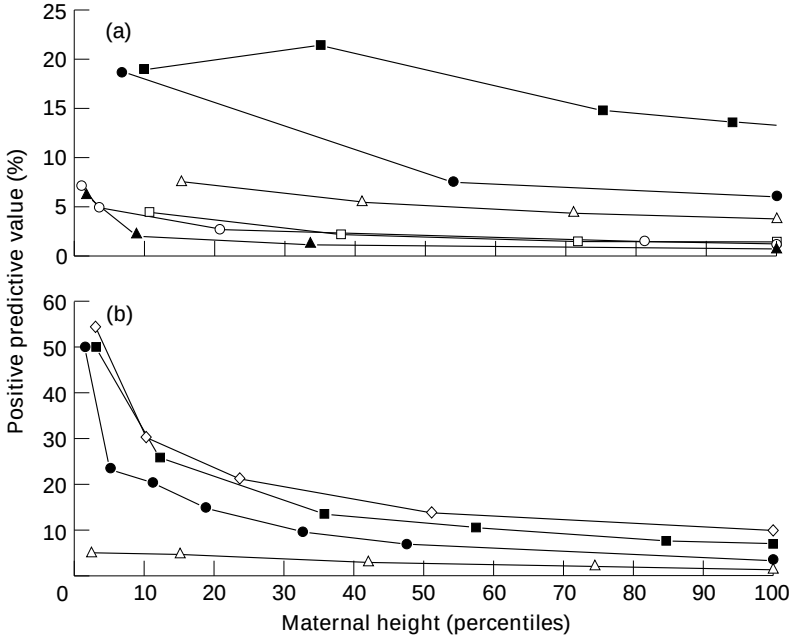

Figure 2 Positive predictive value of maternal height (percentiles) as a risk factor for CPD. Key as in Figure 1.

next (at P15 the relative risk is 4.9, 95% confidence interval 2.3–10.5), but these differences do not appear clearly in the graph. Despite these disparities, it is interesting to note that the curves become parallel. Nevertheless, the second graph is not satisfactory, since the PPV depends on prevalence.

In Figure 3 we plotted the sensitivity and specificity of each cut-off point for each of the a and b

 © 1996 Blackwell Science Ltd

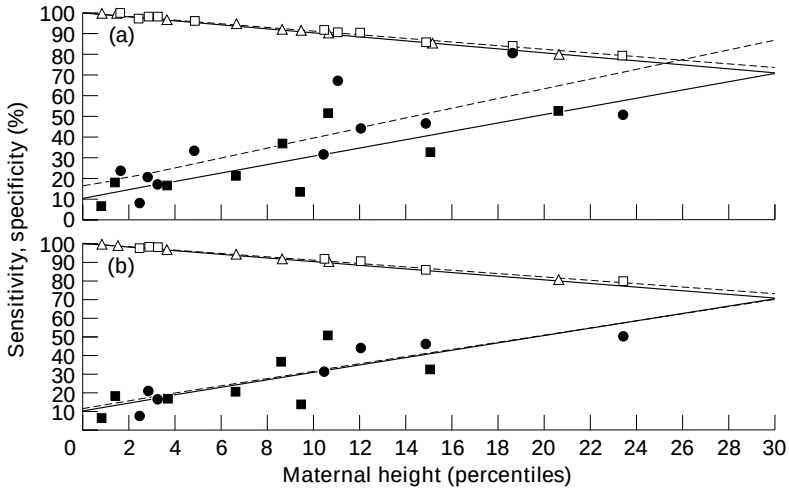

Figure 3 Sensitivity and specificity of maternal height (percentiles) as a risk factor for CPD. a, Unbiased series (—, a studies): 8, 9, 12, 18, 27, 28; biased series (- - -, b studies): 6, 7, 11, 29. b, Unbiased series (—, a studies): 8, 9, 12, 18, 27, 28; biased series (- - -, b studies): 6, 11, 29. Dar Es Salaam study (24) dropped.

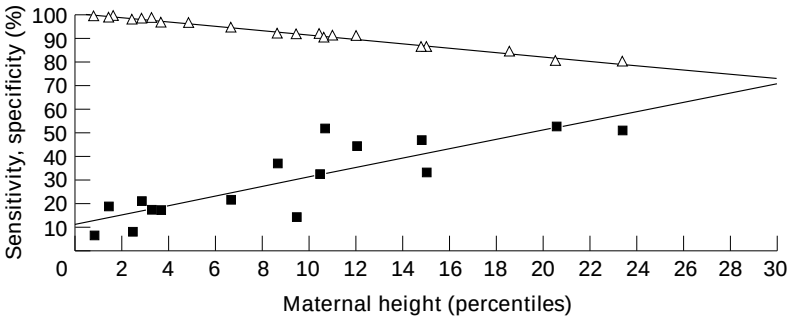

Figure 4 Sensitivity and specificity of maternal height (percentiles) as a risk factor for CPD. ■, Sensitivity, a; △, specificity, b. All series except Dar Es Salaam (24).

studies. In the interest of clarity, we limited the graphs from the 1st to 30th percentiles, since these are the most commonly used cut-off points for detecting small women and their eventual referral for hospital delivery.

The specificity results of the a and b studies agree almost perfectly and thus may be combined for meta-analysis. The sensitivity values, by contrast, are more scattered. This greater variability is doubtless due to the smaller number of cases and relative imprecision of the diagnosis of Caesareans for CPD. It is interesting to see that the two regression lines are almost parallel, even though the biased studies constantly overestimate the sensitivity of the 'low maternal height' risk factor. This overestimation seems to be due solely to the Dar Es Salaam study (Everett 1975), in which the selection biases mentioned by the author contributed to the over-representation of short women. Indeed, when the results of this study are dropped from the analysis (Figure 3b), the resulting regression lines are almost identical for the two groups of studies, whether one considers sensitivity or specificity. We therefore dropped this study's data (4 points in all) from the rest of our analysis. The results of the two groups could then be pooled for meta-analysis.

Figure 4 shows results of the meta-analysis of the entire sets of data (minus the Dar Es Salaam study) for maternal heights $\leqslant$P30, i.e. a total of 16 points.

The correlation coefficients and regression line equations for sensitivity and specificity are given in Table 2.

The correlation coefficients are statistically significant: $P<0.001$ for sensitivity and $P<0.0001$ for specificity. The high values argue in favour of the reproducibility of the association of short maternal height and increased risk of dystocia.

 © 1996 Blackwell Science Ltd

Table 2 Regression lines and correlation coefficients for correlations between percentiles (independent variable *Y*) and sensitivity and specificity (dependent variables)

Regression lines	Correlation coefficient	*P*
Sensitivity		
Se=10.9+1.99 × *Y*	0.84	<0.001
l.l. Se=7.1+1.65 × *Y*		
u.l. Se=14.8+2.33 × *Y*		
Specificity		
Sp=99.9 − 0.99 × *Y*	0.99	<0.0001
l.l. Sp=96.8 − 0.96 × *Y*		
u.l. Sp=103.3 − 1.02 × *Y*		

l.l., Lower limit of 95% confidence interval;
u.l., upper limit of 95% confidence interval.

Second objective

The second objective was to identify a simple model enabling one to determine the expected sensitivity and specificity and positive and negative predictive values for a given maternal height. The regression line equations (Table 2) enable calculation of expected sensitivity, specificity, and predictive values for a given maternal height (expressed as a percentile). This information is particularly interesting for developing pregnancy monitoring strategies. Let us take the example of a strategy in which at-risk pregnancy detection includes maternal height as a risk factor of dystocia. The at-risk pregnancies will be referred to a hospital for delivery. To avoid overstretching the hospital, it is decided to refer no more than 10% of pregnant women based on the 'short stature' risk factor alone. What results can be expected from this strategy in terms of sensitivity and specificity? The values are easy to calculate. The value of $Y=10$ is simply plugged into the regression line equations in Table 2, reaching the following results (with the lower and upper limits values of the 95% confidence interval):

$$Se=10.9+1.99 \times 10=31\% \text{ (95\% CI 24–38)}$$

$$Sp=99.9-0.99 \times 10=90\% \text{ (95\% CI 87–93)}$$

To calculate the predictive values the frequency of intervention must be known, that is, the rate of Caesareans for CPD; with this information, predictive values may be calculated using formulas derived from Bayes's theorem (Feinstein 1985):

$$PPV=Se \times Pr/\{(Se \times Pr)+(1-Pr) \times (1-Sp)\} \quad (1)$$

$$NPV=(1-Pr) \times Sp/\{(1-Pr) \times Sp+Pr \times (1-Se)\} \quad (2)$$

Let us take the case of a 2% prevalence (Pr) of Caesareans for CPD for all reference hospital deliveries. The PPV for a maternal height corresponding to the 10th percentile will be:

$$PPV=0.31 \times 0.02/\{(0.31 \times 0.02)+(1-0.02) \times (1-0.90)\}$$
$$=0.059=6\% \text{ (95\% CI 5–7)}$$

and the NPV will be 98% (95% CI 98–99). In the case of a 5% prevalence and 10th percentile, the expected PPV and NPV will be 14 and 96%, respectively.

The same formulas may be used to calculate limits of the 95% confidence interval, using the Se and Sp values determined by equations corresponding to the upper and lower limits (Table 2). With spreadsheet software such as Lotus and MS-Excel these calculations can be automated. The programme and formulas used are described in Appendix 1.

Table 3 gives expected Se, Sp, PPV, and NPV values and their 95% confidence intervals for various cut-off points (percentiles) and frequencies of Caesarean of 1, 2 and 5%. These frequencies are frequently observed in developing countries (Evrard & Gold 1977). This is illustrated in graph form in Figure 5 for a Caesarean frequency of 5%.

Discussion

Our first objective, to demonstrate reproducibility of the association between short maternal height and increased incidence of mechanical dystocia, is confirmed. There is a significant association between short maternal height and an increased risk of Caesarean section for CPD. This association is universal, as it is found among Africans (Aitken & Walls 1986; Everett 1975; Kasongo Project Team 1984; Sokal *et al.* 1991; Mati *et al.* 1983; Voorhoeve *et al.* 1984), Europeans (Mahmood *et al.* 1981; Yudkin & Redman 1986; Thomson & Hanley 1988) and Asians (Pongthai *et al.* 1988). The association is reproducible, for the regression lines show that its value is approximately the same, regardless of the population studied, provided that patient

 © 1996 Blackwell Science Ltd

Table 3 Sensitivity, specificity, and positive and negative predictive values expected for various cut-off points and frequencies of intervention (Caesarean section for cephalopelvic dystocia; 95% confidence interval)

Percentile	Frequency of intervention (%)	Se (95% CI) (%)	Sp (95% CI) (%)	PPV (95% CI) (%)	NPV (95% CI) (%)
01	1	13 (9–17)	99 (96–100)	11 (7–14)	99 (99–99)
	2			19 (14–24)	98 (98–98)
	5			38 (30–45)	96 (95–96)
02	1	15 (10–19)	98 (95–100)	7 (5–9)	99 (99–99)
	2			13 (9–16)	98 (98–98)
	5			27 (21–33)	96 (95–96)
03	1	17 (12–22)	97 (94–100)	5 (4–7)	99 (99–99)
	2			10 (7–13)	98 (98–98)
	5			22 (17–22)	96 (95–96)
05	1	21 (15–26)	95 (92–98)	4 (3–5)	99 (99–99)
	2			8 (6–10)	98 (98–98)
	5			18 (14–22)	96 (96–96)
07	1	25 (19–31)	93 (90–96)	3 (3–4)	99 (99–99)
	2			7 (5–8)	98 (98–99)
	5			16 (12–19)	96 (95–96)
10	1	31 (24–38)	90 (87–93)	3 (2–4)	99 (99–99)
	2			6 (5–7)	98 (98–98)
	5			14 (11–17)	96 (96–97)
15	1	41 (30–52)	85 (82–88)	3 (2–3)	99 (99–99)
	2			5 (4–6)	98 (98–99)
	5			13 (10–15)	97 (96–97)
20	1	51 (40–61)	81 (80–82)	3 (2–3)	99 (99–99)
	2			5 (4–6)	98 (98–99)
	5			12 (10–14)	97 (96–98)

height is expressed as a percentile of the female population. In other words, a 140-cm tall woman and a 150-cm tall woman will have about the same risk of CPD if their respective heights belong to the same percentile in the populations from which they come. Extrapolating the same cut-off height (for example, 150 cm), for populations with different median heights is not useful. Figure 5 shows that screening based on the mother's height has good positive predictive value for heights below the 10th and especially below the 5th percentile. In contrast, negative predictive values remain at very high levels (96–99%) and vary little with the CS rate from the 1st to the 25th percentile. Selection bias and other sources of error associated with the selected studies (population selected, reliability of diagnoses) do not seem to have marked effects. Indeed, except for the Dar Es Salaam study, results obtained for biased (group b) and unbiased studies (group a) are a perfect match. The significantly elevated values of the correlation coefficients are an important argument in favour of the reproducibility of this association.

Our second objective, to develop a model to easily calculate expected sensitivity, specificity, and positive and negative predictive values from a known height, is also achieved. The regression lines in Table 2 facilitate calculation of expected Se and Sp values as well as their 95% confidence intervals. Formulas (1) and (2) of Bayes's theorem enable calculation of the PPV and NPV and their confidence intervals.

 © 1996 Blackwell Science Ltd

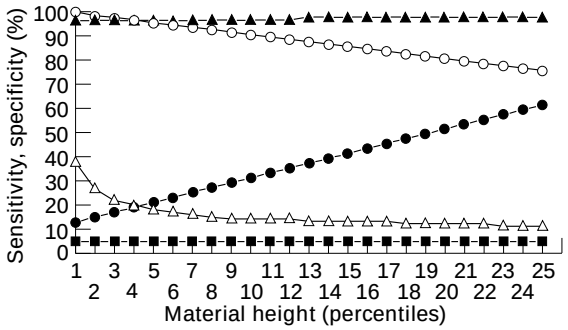

Figure 5 Sensitivity and specificity of maternal height (percentiles) as a risk factor for Caesarean section for CPD; positive and negative predictive values for a Caesarean rate of 5%. ●, Sensitivity; ○, specificity; △, PPV (5%); ▲, NPV (5%); ■, PPV=Pr=5%. PPV (5%), Positive predictive value for a Caesarean rate of 5%; PPV=Pr=5%: when the test does not yield better prediction than chance, the probability after the test (i.e. PPV) will be the same as the probability before the test (i.e. the prevalence Pr).

The computer program described in Appendix 1 facilitates these calculations.

Given these results, we might recall briefly the practical requirements that must be met in selecting a pertinent cut-off point. In a memorandum on maternal anthropometry published by WHO (1991), a panel of around 50 experts stressed the fact that in choosing the cut-off point one must take not only technical criteria into account but also operational ones such as available resources. We feel that these operational constraints are decisive and propose to discuss various steps involved in choosing a cut-off point.

First, the height distribution of women of childbearing age must be obtained for each ethnic group considered (anthropometric data are generally available from central administrations). If the median height varies noticeably from one ethnic group to the next, each specific percentile will correspond to a different height in centimetres in each ethnic group. A study conducted in Mozambique (Liljestrand *et al.* 1985) showed that the average height of adult women could vary 7 cm from one region to the next within the same country. This percentile is a maximum which will have to be lowered depending on the frequency of the other reference criteria that may be used.

To obtain the best combination of sensitivity and specificity one must reach a compromise between the sensitivity and specificity of each of the risk factors used. A lack of sensitivity will increase the number of false negatives (the number of women who should have given birth in a maternity clinic). A lack of specificity will increase the referral rate and the number of false positives (the number of women who are referred to hospitals unnecessarily). As a consequence of an excessively high referral rate the reference hospital may be swamped with problem-free deliveries. If too many women are referred unnecessarily, the acceptability of such referrals will drop. In case of maternal height, an easy way to increase the criterion's specificity without inordinately reducing its sensitivity is to apply the risk criterion only to nulliparas and primiparas with previous obstetrical problems.

Finally, a remark on methodology. The PPV rises with an increased frequency of intervention (Fletcher *et al.* 1988), but obviously the aim of screening based on maternal height is not to increase the rate of CS, even if this may be the consequence. In developing countries the risk for the mother if a Caesarean is performed is too high to justify promoting broader indications for its use (Cheng *et al.* 1986; Evrard & Gold 1977). The goal of antenatal screening is to refer women who run the risk of CPD to a hospital in time. Once there, usually only a labour trial will decide what mode of delivery is best.

A meta-analysis of studies published in the scientific literature may be marred by publication bias if negative results are not published. We believe this is not the case here. We included data from unpublished sources, i.e. the study of Family Health International (1988), which gave the same results as published ones. Another problem with meta-analysis is that possible design effects may lead to overestimated *P*-values. However, in our case the significance reached is so high ($P<0.001$ for Se and $P<0.0001$ for Sp) that a possible design effect will exert only marginal influence. Finally, the results could perhaps have been refined by a weighted regression analysis to take into account the varying number of subjects for each point.

Conclusions

The sensitivity and specificity of short maternal height as a risk factor of dystocia are not very good. If this risk criterion alone is used, one out of five

 © 1996 Blackwell Science Ltd

pregnant women (i.e. a 20th percentile) will have to be referred to a hospital to obtain 50% sensitivity, that is, identification of half of the cases of CPD requiring a CS. For a Caesarean rate of 2%, which is the value frequently observed in developing countries (VandenBroek *et al*. 1989), the predictive value associated with this 20th percentile will be only 5%, meaning that for 100 referrals only 5 Caesareans for CPD will be performed.

Despite these discouraging findings we believe that maternal height should continue to be used as a CPD risk factor. This is because in terms of the reduction of maternal suffering, Caesareans for CPD are merely the result of other types of suffering, e.g. prolonged labour, fatigue, the pain of ineffectual contractions, elevated risks of infection and sterility, neonatal distress, neonatal death and vesico-vaginal fistulas, which are not necessarily associated with Caesareans. The benefits achieved in terms of reducing maternal morbidity will doubtless be much greater than that measured by the CS rate alone.

Therefore a two-track strategy should be adopted: women with a high risk of CPD could be identified during antenatal clinics. Screening, based notably on the use of maternal height as a risk factor, must be sufficiently specific to be accepted by the pregnant women and must not overload the maternity clinic. In rural areas where the hospital is not easily accessible, the 5th percentile should be preferred. In the community, interventions must ensure that women who will suffer from dystocia but are not detected as being at risk (false negatives) can be referred to hospitals without delay.

Acknowledgement

This research was supported by a grant from the 'Fonds National de la Recherche Scientifique', Belgium.

References

Aitken IW & Walls B (1986) Maternal height and cephalopelvic disproportion in Sierra Leone. *Tropical Doctor* **16,** 132–134.

Baird D (1952) The cause and prevention of difficult labour. *American Journal of Obstetrics and Gynecology* **63,** 1200–1212.

Baird D (1985) Dystocia due to faults in the pelvis. *British Journal of Obstetrics and Gynaecology* **92,** 1235–1245.

Camilleri AP (1981) The obstetric significance of short stature. *European Journal of Obstetrics, Gynaecology and Reproductive Biology* **12,** 347–356.

Cheng CI, Whatley A, Wilkens L *et al.* (1986) In-hospital maternal mortality risk by caesarean and vaginal deliveries in two less developed countries. *International Journal of Gynaecology and Obstetrics* **24,** 121–131.

Cox ML (1963) Contracted pelvis in Nigeria. *Journal of Obstetrics and Gynaecology of the British Commonwealth* **70,** 487–497.

Dujardin B & Van Balen H (1991) L'initiative pour une maternité sans risque: quelles perspectives? *Journal de Gynécologie Obstétrique et Biologie de la Reproduction* **20,** 397–405.

Everett VJ (1975) The relationship between maternal height and cephalopelvic disproportion in Dar Es Salaam. *East Africa Medical Journal* **52,** 251–256.

Evrard JR & Gold EM (1977) Caesarean section and maternal mortality in Rhode Island. *Obstetrics and Gynaecology* **50,** 594–597.

Family Health International (1988) Pregnancy care monitoring: Karawa Health Zone Zaire. Final report.

Feinstein AR (1985) *Clinical Epidemiology. The architecture of clinical research*. Saunders, Philadelphia.

Fletcher RH, Fletcher SW & Wagner EH (eds) (1988) *Clinical Epidemiology: the Essentials*. Williams & Wilkins, Baltimore.

Frame S, Moore J, Peters A & Hall D (1985) Maternal height and shoe size as predictors of pelvis disproportion: an assessment. *British Journal of Obstetrics and Gynaecology* **92,** 1239–1245.

Haddad NG, Baezley JM & Chia KV (1986) Shoe size and outcome of labour: a prospective anthropometric study. *Journal of Obstetrics and Gynaecology* **7,** 97–99.

Harrison KA, Rossiter CE & Chong H (1985) Relations between maternal height, fetal birthweight and cephalopelvic disproportion suggest that young Nigerian primigravidae grow during pregnancy. *British Journal of Obstetrics and Gynaecology* **S5,** 40–48.

Howard D (1987) Aspects of maternal morbidity: the experience of less developed countries. In *Advances in International Maternal and Child Health* (eds DB Jelliffe & EFP Jelliffe), Clarendon Press, Oxford, pp 1–35.

Hughes AB, Jenkins DA, Newcombe RG *et al.* (1987) Symphysis-fundus height, maternal height, labour pattern and mode of delivery. *American Journal of Obstetrics and Gynaecology* **156,** 644–648.

Kappel B, Eriksen G, Hansen KB *et al.* (1987) Short stature in Scandinavian women. *Acta Obstetrica et Gynaecologica Scandinavica* **66,** 153–158.

Kasongo Project Team (1984) Antenatal screening for fetopelvic dystocias. A cost-effectiveness approach to the

 © 1996 Blackwell Science Ltd

choice of simple indicators for use by auxiliary personnel. *Journal of Tropical Medicine and Hygiene* **87,** 173–183.

Kennedy JL & Greenwald E (1988) Correlation of shoe size and obstetric outcome: an anthropometric study. *American Journal of Obstetrics and Gynecology* **140,** 466–467.

Liljestrand J, Bergstrom S & Westman S (1985) Maternal height and perinatal outcome in Mozambique. *Journal of Tropical Pediatrics* **31,** 306–310.

Mahmood TA, Campbell DM & Wilson AW (1981) Maternal height, shoe size and outcome of labour in white primigravidas: a prospective anthropometric study. *British Medical Journal* **297,** 515–517.

Mati JKG, Aggarwal VP, Lucas S *et al.* (1983) The Nairobi birth survey IV: early perinatal mortality rate. *Journal of Obstetrics and Gynaecology of East Central Africa* **2,** 129–133.

Molloy WB (1969) Labour in short women. *Obstetrics and Gynaecology* **34,** 330–334.

Pongthai S, Chaturachinda K, Piyapinyo P *et al.* (1988) Relationship of maternal height and weight at first prenatal visit with type of delivery in primipara. *Journal of the Medical Association of Thailand* **71,** 12–14.

Royston E & Armstrong S (1990) *La prévention des décès maternels*. WHO, Geneva.

Sackett DL & Holland VW (1975) Controversy in the detection of disease. *Lancet* **i,** 357–359.

Scotte RT, Stricland DM, Hankins GDV *et al.* (1989) Maternal height and weight gain during pregnancy as risk factors for caesarean section. *Military Medicine* **154,** 365–367.

Sokal D, Sawadogo L, Adjibade A & Operations Research Team (1991) Short stature and cephalopelvic disproportion in Burkino Faso, West Africa. *International Journal of Gynaecology and Obstetrics* **35,** 347–350.

Thomson AM (1959) Maternal height and reproductive efficiency. *Eugenics Review* **51,** 157–162.

Thomson M & Hanley J (1988) Factors predisposing to difficult labour in primipares. *American Journal of Obstetrics and Gynecology* **158,** 1074–1078.

VandenBroek N, Van Lerberghe W & Pangu K (1989) Cesarean sections for maternal indications in Kasongo (Zaire). *International Journal of Gynaecology and Obstetrics* **28,** 337–342.

Voorhoeve AM, Muller AS & W'Oigo H (1984) The outcome of pregnancy. In *Maternal and Child Health in Rural Kenya* (eds JK Van Ginneken & AS Muller) Croom Helm, London, pp 223–240.

WHO (1991) Maternal anthropometry for prediction of pregnancy outcomes: Memorandum from USAID/WHO/DAHO/Mother Care Meeting *WHO Bulletin* **69,** 523–532.

Yudkin PI & Redman CWG (1986) Caesarean section dissected. *British Journal of Obstetrics and Gynaecology* **93,** 135–144.

 © 1996 Blackwell Science Ltd

Appendix 1 Program for computerized calculation of sensitivity, specificity, and positive and negative predictive values (PPV and NPV).
Software: Lotus 2.1 (may be used with MS-Excel, Works, and MS-Word for Windows). Explanations in *italics*.

Cell No.	(F2)=Formula '=Statement
b3	'Percentile=
c3	10 *plug in the value of the percentile considered: p10 in this case*
d3	'Prevalence=
e3	2 *plug in the prevalence considered: Pr=2 in this example*
b5	'Se=
c5	10.9+1.99*c3
d5	'Sp=
e5	99.9 − 0.99*c3
b6	'Se u.l.=
c6	14.75+2.33*c3
d6	'Sp u.l.=
e6	103.3 − 1.02*c3
b7	'Se l.l.=
c7	7.05+1.65*c3
d7	'Sp l.l.=
e7	96.8 − 0.96*c3
b9	'PPV=
c9	(F2)((c5/100*e3/100))/((c5/100*e3/100)+(1 − e3/100)*(1 − e5/100))
d9	'NPV=
e9	(F2)((1 − e3/100)*e5/100)/((1 − e3/100)*e5/100+e3/100*(1 − c5/100))
b10	'PPV u.l.=
c10	(F2)((c6/100*e3/100))/((c6/100*e3/100)+(1 − e3/100)*(1 − e5/100))
d10	'NPV u.l.=
e10	(F2)((1 − e3/100)*e6/100)/((1 − e3/100)*e6/100+e3/100*(1 − c5/100))
b11	'PPV l.l.=
c11	(F2)((c7/100*e3/100))/((c7/100*e3/100)+(1 − e3/100)*(1 − e5/100))
d11	'NPV l.l.=
e11	(F2)((1 − e3/100)*e7/100)/((1 − e3/100)*e7/100+e3/100*(1 − c5/100))

 © 1996 Blackwell Science Ltd