Epidemiologic Identification of Infants with Low Birth Weight in Urban Areas of Latin America: II. A Simplified Risk Score for Early Prenatal Identification in Guatemala City

E. Kestler, J. Villar, L. Bolaños, & W. Calvert

A simple, empirically derived instrument is needed in developing countries to identify mothers at risk of delivering low birth weight (LBW) infants, in order to help reduce the incidence of LBW deliveries and provide mothers at high risk with appropriate health care. The study reported here was devoted to developing an instrument of this kind using data obtained before the twenty-sixth week of gestation from an urban study population of 17,135 Guatemalan women. It appears that this instrument could be appropriately applied to urban populations in other developing countries.

Low birth weight (LBW), defined as birth weight below 2,500 g, is one of the most important maternal and child health problems in both developed and developing countries. The incidence of LBW in different populations varies from as little as 3.6% in Sweden to as much as 40% in some parts of India and Guatemala (1). LBW infants have a higher risk of neonatal morbidity and mortality (2, 3) and of abnormal postnatal growth and neurologic development than do their counterparts with normal birth weights (4-6).

The early identification of pregnant women at relatively high risk of delivering LBW infants can enable health care workers to implement appropriate prenatal interventions to reduce the risk of LBW. If prevention is not possible, such early notice can at least help ensure that adequate care is available for the infant at birth.

Several obstetric risk scores aimed at early detection of these high-risk mothers have been reported in the literature. With some exceptions (7, 8), these scores were evolved using populations from developed areas.

A review indicates that several methodologic and practical problems diminish these scores’ usefulness. Among other things, outcome variables (including LBW) are seldom clearly defined. In general, LBW is simply termed “prematurity.” Only one score uses LBW in-
dependently of other variables (9). Many of these risk scores are calculated using subjective sampling weights based on clinical experiences rather than statistically derived weights (10-12). And those risk scores which are statistically derived are too complex to be used in clinical settings in a developing country (13, 14).

Although two studies have derived risk scores based on populations from developing countries (7, 8), these scores' usefulness for predicting LBW in developing countries is diminished by sociocultural differences within the populations studied and methodologic problems involved in deriving the scores. Specifically, Lechtig's score for predicting LBW in rural Guatemala (7) is simple and yields acceptable predictability rates; nevertheless, it cannot be used in an urban setting because one of the main variables, "housing characteristics," differs markedly in urban and rural areas. Fortney and Whitehorn's risk score (8), developed in Colombia, includes data that must be obtained during labor and delivery, and hence is of little or no use for early detection and referral of high-risk mothers.

In other words, a simple, empirically derived instrument is needed in developing countries to identify mothers at risk of delivering LBW infants. Such an instrument could provide information useful for deciding about rational distribution of perinatal care resources, permitting allocation of more sophisticated diagnostic and treatment resources to mothers and newborns at high risk of morbidity and mortality associated with LBW.

MATERIALS AND METHODS

We selected our study population from the prenatal care clinics of the Gynecology and Obstetrics Hospital (GOH) of the Guatemalan Social Security Institute in Guatemala City. This 230-bed hospital is the place where all eligible Guatemala City women who use the social security system deliver their babies. A detailed description of our study's population characteristics and resources has been published elsewhere (15).

The study enrolled pregnant women who made their first visit to the hospital's prenatal clinic between 1 April 1984 and 10 January 1986. Women who did not receive any prenatal care (who accounted for 9% of the hospital's deliveries) or who attended the system's peripheral clinics (22% of the total deliveries) were not eligible to participate. In the latter case, this was because appropriate standardized procedures and data quality control could not be applied in the peripheral clinics.

A total of 17,135 women enrolled in the study when they registered at one of the hospital's clinics after having their pregnancy confirmed on-site or by a laboratory. During each subsequent visit to the clinic, a medical record form for each woman was filled out by available personnel (the nurses, a GOH resident, or the clinic staff). A social worker obtained sociodemographic data. This form, part of the GOH's prenatal record, conforms to that proposed by PAHO for Latin America (16).

After each prenatal visit, study personnel abstracted information from the medical record and the social worker's form to a precoded data collection form developed especially for this study. At the time of delivery and before discharge, study interviewers visited each participating mother to collect any further information needed by the study to minimize missing values in the final data set.

Both before data collection was begun and during the study period, a standardization and quality control system was instituted that covered all measurement
variables. This system was used to mini-
mize the potential influence of variations
in different individuals' data collection
methods. A study of inter-rater agree-
ment (17) was performed to demonstrate
how well these procedures worked and
to evaluate the reliability of collected
data.

Data were collected on 97 variables
about which information was available to
clinicians before and after their patient's
26th week of gestation. These variables
related to the patient's sociodemographic
status, work and physical activity during
pregnancy, obstetric history, medical
conditions, and prenatal care. The main
outcome variable was LBW, defined as a
birth weight not over 2,500 g. The in-
fant's gestational age was determined
using the date of the mother's last men-
strual period and physical evaluation of
the newborn (18).

To develop the risk score, we took a
random sample of 30% of the total study
population (N=5,125). We then calcu-
lated odds ratios and 95% confidence in-
tervals for all variables in the univariate
analysis, retaining a particular variable
for further analysis if its odds ratio was
significant at the p<0.10 level, if it
showed a biologically important trend to-
ward an effect on the outcome variable,
or if it had a well-known association with
birth weight in other populations.

The variables were then grouped into
the following categories: (1) maternal
work and physical activity, (2) indicators
of socioeconomic status, (3) obstetric his-
tory, (4) items relating to the present
pregnancy and prenatal care, including
drugs or treatments received during ges-
tation, and (5) maternal nutritional sta-
tus. Each category was analyzed sepa-
rately using a logistic regression model
(19). After doing these subanalyses and
adjusting for all other variables, we se-
lected for consideration in the final model
those variables that remained statistically
significant at the p<0.05 level. We also
did a final multiple regression analysis,
again using the logistic model, to select
those variables that were independent
predictors of the increased risk of LBW in
this population.

We then transformed the logistic re-
gression coefficients obtained in this final
model into odds ratios. These ratios were
used to weigh each variable in construct-
ing the risk score, and the risk score itself
was then evaluated by applying it to the
6,542 eligible women who had received
prenatal care at the hospital clinic before
26 weeks of gestation but who had not
been included in the foregoing analysis.
Using these women as a sample, the sen-
sitivity, specificity, and predictive value
of a range of risk scores were assessed
(20). We also charted sensitivity versus
specificity for different risk scores in or-
der to help in selecting the best score to
use as a cutoff point for identifying
mothers at high risk of delivering LBW
infants (21).

RESULTS

In the univariate analysis (used to de-
rive a crude odds ratio and 95% confi-
dence interval), neither the variables indi-
cating socioeconomic status (marital
status, sanitation, zone of home, average
number of persons per bedroom, home
water supply, house floor, monthly in-
come per capita) nor those related to ma-
ternal work and physical activity during
pregnancy yielded statistically significant
odds ratios.

However, a history of LBW in the two
previous pregnancies was strongly asso-
ciated with delivery of an LBW infant
(Figure 1). For mothers delivering two
normal birth weight (NBW) infants
(>2500 g), the incidence of LBW in the
third gestation was only 5.8%. Con-
versely, after delivery of two previous

Kessler et al. Screening for Low Birth Weight 141
LBW infants, the incidence of LBW in the third pregnancy was 20.6%.

Interestingly, the birth weight of the immediately preceding pregnancy had the strongest effect on the next birth weight. As Figure 1 shows, an NBW delivery followed by an LBW delivery was associated with an LBW rate on the next delivery of 18.0%. In contrast, an LBW delivery followed by an NBW delivery was associated with an LBW rate on the next delivery of only 10.5%.

Multivariate analysis yielded the following results: The presence of medical pathology during pregnancy (respiratory infections before 26 weeks of gestation, vaginal hemorrhage, cardiopathy, hypertension, diabetes) was found to independently increase the risk of LBW. Mothers who did not make their first visit to the prenatal clinic until after 19 weeks of gestation had an odds ratio of 1.53 (95% CI 1.08-2.18). Mothers over 35 years old were twice as likely as others in the sample to deliver LBW infants. Mothers under 17 years of age seemed more likely to deliver LBW infants (odds ratio 1.98, 95% CI 0.90-4.37) than did those 17-19 years old (odds ratio 1.53, 95% CI 0.98-2.40), although the observed associations were not statistically significant. A previous LBW was associated with an increased risk of LBW, the odds ratio being 5.55 if the previous birth weight was less than 1,500 g and 2.18 if it was between 1,501 g and 2,500 g. Two indicators of early maternal nutritional status, maternal weight at first visit <47 kg (odds ratio 1.73, 95% CI 1.10-2.71) and weight gain per week <21 g (odds ratio 1.85, 95% CI 1.19-2.87), were also significantly associated with LBW, independent of other nutri-
tional factors. Finally, uterine height below the tenth percentile was associated with an increased risk of LBW (odds ratio 1.78, 95% CI 1.32-2.40).

All these variables identified in the subgroup analysis were included in the final logistic regression model to identify those which were independent contributors to the incidence of LBW, after the other variables in the model were accounted for (Table 1). We used these latter variables to construct a risk score index, multiplying the odds ratio for each variable by 5.0063 and rounding off to obtain a whole number representing the risk score for that variable. Then, by adding together the scores corresponding to the variables present in each case, it was possible to assign a total score (corresponding to an LBW risk level) to each pregnant woman before her 26th week of gestation. A maximum score of 100 was possible if all the adverse variables were present.

When risk scores were assigned to the 6,542 enrolled women who had received prenatal care at the hospital clinic but were not included in the foregoing analysis, it was found, as would be expected, that relatively high cutoff scores yielding increased sensitivity also produced decreased specificity. Table 2 shows the pattern involved. In our case, using a risk score between 5 and 10 to select mothers at high risk of LBW delivery was found to produce a sensitivity of 4264% and a specificity of 57-76%.

Naturally, the best cutoff point to

Table 1. Adjusted odds ratios\textsuperscript{a} for variables associated with low birth weight (LBW) deliveries among 5,125 women selected at random from the study population. Logistic regression analysis: number of LBW deliveries = 429, logistic regression = 364; number in total sample = 5,125, logistic regression = 4,447.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Adjusted odds ratio\textsuperscript{a}</th>
<th>95% CI</th>
<th>Risk score\textsuperscript{b}</th>
<th>Incidence of LBW (%)</th>
<th>% of total LBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical pathology</td>
<td>1.84</td>
<td>1.07-3.16</td>
<td>9</td>
<td>14.71</td>
<td>4.66</td>
</tr>
<tr>
<td>Respiratory infections</td>
<td>2.77</td>
<td>1.16-6.57</td>
<td>14</td>
<td>18.75</td>
<td>2.10</td>
</tr>
<tr>
<td>First visit at &gt; 19 weeks</td>
<td>1.74</td>
<td>1.22-2.49</td>
<td>9</td>
<td>10.20</td>
<td>26.11</td>
</tr>
<tr>
<td>Maternal age &gt; 35 years</td>
<td>1.81</td>
<td>1.07-3.09</td>
<td>9</td>
<td>11.10</td>
<td>6.80</td>
</tr>
<tr>
<td>Last delivery weight:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1,500 g</td>
<td>6.38</td>
<td>2.52-16.14</td>
<td>32</td>
<td>33.30</td>
<td>2.80</td>
</tr>
<tr>
<td>1,500-2,500 g</td>
<td>1.68</td>
<td>1.10-2.54</td>
<td>8</td>
<td>16.71</td>
<td>14.22</td>
</tr>
<tr>
<td>&gt;3,000 g</td>
<td>0.58</td>
<td>0.42-0.81</td>
<td>-8</td>
<td>5.25</td>
<td>25.87</td>
</tr>
<tr>
<td>Maternal weight at first visit &lt; 47 kg</td>
<td>2.09</td>
<td>1.47-2.99</td>
<td>10</td>
<td>13.50</td>
<td>32.63</td>
</tr>
<tr>
<td>Maternal weight gain (g/week):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;21 g</td>
<td>1.55</td>
<td>1.07-2.24</td>
<td>8</td>
<td>11.15</td>
<td>27.20</td>
</tr>
<tr>
<td>&lt;132 g</td>
<td>1.41</td>
<td>0.97-2.05</td>
<td>9</td>
<td>9.37</td>
<td>23.35</td>
</tr>
<tr>
<td>Uterine height:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 value &lt;10th percentile</td>
<td>1.78</td>
<td>1.32-2.40</td>
<td>9</td>
<td>13.65</td>
<td>17.25</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Adjusted odds ratios were obtained from the natural antilog of the logistic regression coefficient.

\textsuperscript{b}The risk score was obtained by multiplying the odds ratio for each variable by a scaling factor of 5.0063 to obtain a maximum of 100 if all the adverse variables (including a last delivery birth weight < 1,500 g) were present in a pregnant woman.
Table 2. Cumulative distribution by total risk score of the 6,542 women to whom the risk scores shown in Table 1 were applied, showing the distribution of LBW deliveries predicted by adopting each particular score as a cutoff—together with the sensitivity, specificity, and percentage of false positive results obtained by applying each cutoff.

<table>
<thead>
<tr>
<th>Score</th>
<th>Study subjects with equal or greater scores</th>
<th>LBW deliveries</th>
<th>False positive rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>30</td>
<td>99</td>
<td>1.5</td>
<td>28</td>
</tr>
<tr>
<td>29</td>
<td>103</td>
<td>1.5</td>
<td>30</td>
</tr>
<tr>
<td>28</td>
<td>141</td>
<td>2.1</td>
<td>41</td>
</tr>
<tr>
<td>27</td>
<td>234</td>
<td>3.5</td>
<td>62</td>
</tr>
<tr>
<td>26</td>
<td>245</td>
<td>3.7</td>
<td>65</td>
</tr>
<tr>
<td>25</td>
<td>272</td>
<td>4.1</td>
<td>72</td>
</tr>
<tr>
<td>24</td>
<td>278</td>
<td>4.2</td>
<td>75</td>
</tr>
<tr>
<td>23</td>
<td>285</td>
<td>4.3</td>
<td>76</td>
</tr>
<tr>
<td>22</td>
<td>290</td>
<td>4.4</td>
<td>76</td>
</tr>
<tr>
<td>20</td>
<td>320</td>
<td>4.8</td>
<td>82</td>
</tr>
<tr>
<td>19</td>
<td>554</td>
<td>8.4</td>
<td>119</td>
</tr>
<tr>
<td>18</td>
<td>776</td>
<td>11.8</td>
<td>149</td>
</tr>
<tr>
<td>17</td>
<td>1,000</td>
<td>15.2</td>
<td>181</td>
</tr>
<tr>
<td>16</td>
<td>1,027</td>
<td>15.6</td>
<td>185</td>
</tr>
<tr>
<td>14</td>
<td>1,048</td>
<td>16.0</td>
<td>185</td>
</tr>
<tr>
<td>11</td>
<td>1,534</td>
<td>23.4</td>
<td>242</td>
</tr>
<tr>
<td>10</td>
<td>1,643</td>
<td>25.1</td>
<td>258</td>
</tr>
<tr>
<td>9</td>
<td>2,375</td>
<td>36.3</td>
<td>339</td>
</tr>
<tr>
<td>8</td>
<td>2,880</td>
<td>44.0</td>
<td>389</td>
</tr>
<tr>
<td>5</td>
<td>2,895</td>
<td>44.2</td>
<td>390</td>
</tr>
<tr>
<td>2</td>
<td>3,084</td>
<td>47.1</td>
<td>403</td>
</tr>
<tr>
<td>1</td>
<td>3,194</td>
<td>48.8</td>
<td>411</td>
</tr>
<tr>
<td>0</td>
<td>5,112</td>
<td>78.1</td>
<td>554</td>
</tr>
<tr>
<td>−1</td>
<td>5,315</td>
<td>81.2</td>
<td>559</td>
</tr>
<tr>
<td>−8</td>
<td>6,542</td>
<td>100.0</td>
<td>607</td>
</tr>
</tbody>
</table>

As shown in Table 2, we calculated the proportion of the population included at different cutoff points and the extent to which application of the risk scores at those cutoff points would have predicted LBW. For example, if those 1,534 women (23.4%) with a risk score of 11 or higher had been deemed at high risk of LBW, we would have predicted 39.8% of the LBW deliveries (sensitivity 39%, specificity 78%, false positive rate 84%).

Table 3 shows the population-attributable risk of the different variables significantly associated with LBW, population-attributable risk being defined as the extent to which the outcome variable (LBW) could be reduced by eliminating
Table 3. Attributable risks for the variables directly associated with LBW (p<0.05).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Adjusted odds ratio</th>
<th>Population with the risk factor present (%)</th>
<th>Population-attributable risk (%)a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical pathology</td>
<td>1.84</td>
<td>2.70</td>
<td>2.2</td>
</tr>
<tr>
<td>Respiratory infections</td>
<td>2.77</td>
<td>0.94</td>
<td>0.9</td>
</tr>
<tr>
<td>First visit at &gt; 19 weeks</td>
<td>1.74</td>
<td>23.11</td>
<td>18.7</td>
</tr>
<tr>
<td>Maternal age &gt; 35 years</td>
<td>1.81</td>
<td>5.10</td>
<td>4.8</td>
</tr>
<tr>
<td>Last delivery weight:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1,500 g</td>
<td>6.38</td>
<td>1.03</td>
<td>1.0</td>
</tr>
<tr>
<td>1,500–2,500 g</td>
<td>1.68</td>
<td>10.13</td>
<td>9.1</td>
</tr>
<tr>
<td>Maternal weight at first visit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 47 kg</td>
<td>2.09</td>
<td>20.56</td>
<td>17.0</td>
</tr>
<tr>
<td>Maternal weight gain (g/week):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 21 g</td>
<td>1.55</td>
<td>19.96</td>
<td>16.6</td>
</tr>
<tr>
<td>&lt; 132 g</td>
<td>1.41</td>
<td>20.38</td>
<td>16.9</td>
</tr>
<tr>
<td>Uterine height:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 value &lt; 10th percentile</td>
<td>1.78</td>
<td>10.60</td>
<td>9.5</td>
</tr>
</tbody>
</table>

The attributable risk for the total population (as a percentage of the total risk) is expressed by the following equation:

\[
\text{Attributable risk (\%)} = \frac{100 \times (\text{OR} - 1)}{1 + F \times (\text{OR} - 1)}
\]

where \( F \) is the decimal portion of the population with the risk factor present and \( \text{OR} \) is the odds ratio.

The particular risk factor in question from the population. This was calculated for all the risk factors shown in Table 1, based on each risk factor's prevalence in the study population and the odds ratio for that factor.

These calculations give an idea of the expected impact that preventive programs could have in reducing the incidence of the outcome variable (LBW) under consideration, an impact heavily influenced by the prevalence of the risk factor involved. For example, as Table 3 shows, the number of women in our population who received late prenatal care or who had a poor maternal nutritional status before and during the first part of pregnancy accounted for up to 19% of the LBW infants, even though the odds ratios involved were relatively low. In contrast, while both respiratory infections during pregnancy and the previous birth of an infant weighing less than 1,500 g carried high relative risks, reduction of these factors would have contributed only minimally to reduction of LBW because of their low prevalences.

We also constructed a receiver-operating characteristic curve (22) to depict the relationship between sensitivity and specificity at different cutoff levels. This curve, using reciprocal X-axis values to chart specificity, is shown in Figure 2. In this format, the closer a dot is to the diagonal line, the less the predictive value of the particular risk score cutoff point it represents.

Such a curve can be used to select the best risk score cutoff point to employ when several combinations of variables are available or when previous scores have to be compared. For example, Fig-
Figure 2. Receiver operating characteristics curve for the LBW risk scores of 6,542 study women. The white dots represent risk scores based on odds ratios, while the black dots represent risk scores based on attributable risk.

Figure 2 compares the risk scores reflecting odds ratios (the only risk scores we have employed up to this point, see Table 1) with other risk scores reflecting population-attributable risks (see the right-hand column of Table 3 for this risk score index). No significant differences were observed in the results obtained with the two methods.

DISCUSSION

In illustrating our method of deriving a risk score that could be used in developing countries to select women at high risk of delivering an LBW infant, we chose LBW itself as the outcome variable because it is the simplest dependent variable and the one most commonly referred to in similar studies. We recognize, however, that LBW is a heterogeneous syndrome (1, 23) and that the two causes of LBW, prematurity and intrauterine growth retardation (IUGR), can be associated with different risk factors (23).

The variables we selected by using a multiple regression logistic model are similar to ones previously reported as being associated with LBW. Various maternal medical complications early in pregnancy are known indicators of maternal health before pregnancy (8). The effect of late prenatal care attendance, measured by gestational age at the first visit, is also recognized as a risk factor for adverse pregnancy outcomes (8, 24), though it has been suggested that this adverse effect may be due to some methodologic limitations of the published studies (25, 26). Another well-recognized risk factor for LBW, a woman's history of delivering LBW infants or infants of low gestational
age (27), is also recognized as a risk factor for delivering both preterm (28) and IUGR (29) infants.

Prepregnancy weight and early maternal weight gain, two indicators of maternal nutritional status, are also associated with LBW (30). Twenty percent of the women in our study population gained less than 21 g per week, and 70% of these (14% of the total) actually had weight losses. The association we observed with LBW further indicates a need for early weight gain during pregnancy as a “preparatory” step for fetal growth during late pregnancy. In addition, our data confirm that systematic use of uterine height measurements provides an excellent way of monitoring fetal growth (20, 31-33).

We found respiratory infections to exert a strong independent effect on LBW. Because of the low prevalence of respiratory infections in our population (0.94%), their effect on the overall incidence of LBW was very slight (attributable risk = 1%, see Table 3).

Respiratory infections could be seen as a proxy indicator of overall maternal health rather than as a direct influence on LBW. However, this indicator’s independent significant association and lack of an interaction effect with other indicators of maternal nutritional status point more toward a causal or direct relationship. Recently, a preventive effect of erythromycin treatment on LBW has been reported (34). It could be that this effect is mediated, at least partially, through an effect on respiratory as well as vaginal infections (34).

Our risk score index uses data obtained before 26 weeks of pregnancy. Data on some of the variables used (e.g., maternal age, last delivery weight) can be obtained at any time during pregnancy, but others (e.g., weight gain, uterine height) require an early prenatal care visit. Our analysis used 26 weeks as the latest time at which information should be obtained. If high-risk mothers are detected as early as that in pregnancy, it is likely that interventions to prevent LBW deliveries would have a chance of being effective. After 26 weeks, the probability of prevention would be lower; and referring patients to a tertiary care center for their delivery might then be the only available course in preparing to deal with a predicted problem.

Several methodologic problems can help to explain the poor performance to date of previously published risk scores. For one thing, the outcome variable is often not clearly stated (8). Also, risk scores have sometimes been evaluated without using the most appropriate epidemiologic methods (20), or the methods have been poorly described in the publications—less information being provided than what is needed to allow the reader to perform the evaluation. Also, the screening is sometimes done too late in pregnancy to permit successful preventive interventions (8); and the weights assigned to each variable are sometimes derived without using appropriate statistical techniques. In our analysis, we have tried to overcome all of these limitations.

One limitation we could not control in this study was the effect of “treatment” on pregnancy outcome. It is possible that physicians, by providing treatment in response to the presence of a known risk factor, thereby avoided the negative outcome. A mother originally classified as having a high-risk pregnancy could thus deliver a normal (2,500 g) infant as a result of treatment and be registered in the evaluation as a false positive result. However, while such possible misclassification seems relatively likely to affect delivery outcome variables involving death or morbidity, it seems less likely to affect LBW—particularly in this study, where no special intervention was offered. This does not exclude the possibility that the
high false positive rate observed in applying our risk scores might to some degree represent an overestimation.

The best overall predictability was obtained when 25% of the population was classified as being at high risk (score = 10, with high-risk mothers accounting for 42% of all LBW deliveries). At this cutoff point sensitivity was 42%, specificity was 76%, and the false positive rate was 84% (see Table 2).

It should be noted that the false positive rate is heavily influenced by the incidence of LBW in the population (20). That is, the lower the incidence the higher the false positive rate. Thus, when the risk score approach described is used in other developing populations with higher LBW rates, the score may show lower false positive rates and higher positive predictive values than those obtained for our study population, where the LBW rate was 8.4%. Unfortunately, populations with higher LBW rates tend to have fewer prenatal care services available and tend to start prenatal care later in pregnancy, when data on some of the important variables (e.g., early weight gain) are difficult to obtain.

Of course, the cutoff point applied above is by no means the only one that might have been selected for use with this risk score. The final selection of the cutoff value depends on several factors. For one thing, the value selected always represents a trade-off between sensitivity and specificity. For another, the selection made should depend on the severity and incidence of the outcome (LBW), the availability of preventive measures, and the financial cost of the intervention offered—particularly in a situation involving high false positive values. It should also be remembered that by and large a change in the cutoff point will not improve the accuracy of prediction provided by the risk score; it will only take from one desired element (sensitivity or specificity) and give to the other. That is because improving the accuracy of prediction depends not on the cutoff value but upon developing a better risk score, devising better operations (providing superior information quality and data collection), or selecting a population with a higher incidence of LBW.

The sensitivity and specificity of the risk score employed here are similar to the sensitivities and specificities of other risk scores used to predict LBW or prematurity in several populations in both developing and developed countries (Table 4). Two of three studies shown in that table which predicted LBW yielded sensitivities and specificities closely resembling those of the present study, while most of those predicting preterm deliveries were within the same general range. This indicates that risk scores are fairly successful at taking a population of pregnant women and identifying a high-risk sample that includes between 40% and 75% of all the women who will deliver LBW infants.

Several reasons can be given to explain the level of predictability observed. Although risk scores can select a population with a high incidence of LBW, socio-demographic factors and obstetric history alone will tend to select large numbers of low-risk mothers (false positives) for inclusion in the high-risk group. Indicators of socioeconomic status were not good predictors in our study, probably because the population studied had a fairly homogeneous income. Furthermore, some variables with very high predictive values (e.g., previous delivery of an infant weighing less than 1,500 g at birth or the presence of maternal medical complications) are relatively rare and therefore responsible for a relatively low share of all the LBW infants delivered. Finally, our knowledge regarding the pathophysiology of early onset of labor and intrauterine growth retardation is limited; im-
proving our knowledge in these areas may allow us to select more specific indicators for predicting LBW.

An important question arises here. Could the risk factors found in our low-income Guatemalan population be used in another developing country? Or would every country have to invest a considerable amount of money to identify its own risk factors? The available evidence suggests it may not be necessary to implement longitudinal studies of risk factors in all health regions or countries. The biological association between risk factors and pregnancy outcome has been documented, and with some exceptions its magnitude appears to be relatively constant through the populations studied. Thus, determining the prevalence of a given risk factor and using that information to determine the attributable risk within and among populations could become an important epidemiologic tool for planning and organizing perinatal health interventions. The alternative—implementing a study like ours in Guatemala that requires establishment of a new structure parallel to the hospital bureaucracy—may entail excessive costs for a developing country.

We believe that our risk score could be used as a "basic" risk score for most of the urban populations in developing countries, and that those conducting the study should add "specific" risk factors for a given population only if the basic set proves not to have much discriminatory power to detect mothers in early pregnancy who are at high risk of delivering LBW infants. To improve the predict-
ability of LBW deliveries, we suggest that when an initial screening yields a high percentage of false positives but a low percentage of false negatives, some of the following activities should be implemented: By 32–34 weeks of gestation, all women who were previously classified as being at high risk could be systematically rescreened using techniques such as ultrasound examination to monitor fetal growth. Women with a history of preterm deliveries could be clinically evaluated for cervical dilatation and uterine contractibility, or could monitor their own uterine activity, or both. And women with a previous IUGR delivery could be evaluated by fetal movement counting. It is also true, of course, that some of these suggested activities would need to be systematically evaluated before being applied to large populations.

Acknowledgments. The authors are grateful to Dr. Brian McCarthy from the CDC/WHO Perinatal Collaborating Center Activity for his critique of the manuscript. We are also grateful to the staff and authorities of the Gynecology and Obstetric Hospital of the Guatemalan Social Security Institute for their collaboration, to all the clerks of the Guatemalan Perinatal Study for the assistance they provided, and especially to Mrs. Gloria García, Field Director of that study.

REFERENCES


