EFFECT OF VARYING THRESHOLD AND SELECTIVE VERSUS UNIVERSAL STRATEGIES ON THE COST IN GESTATIONAL DIABETES MELLITUS

Bagher Larijani MD¹, Arash Hossein-Nezhad MD, Ali-Reza Vassigh MD

Background – The prevalence of gestational diabetes mellitus (GDM) is increasing globally, and the major determinants of screening programs are cost-benefit and prevalence in the target population. We aimed at assessing the screening method best-suited for a selected population in Tehran.

Methods – A total number of 2,416 pregnant women were classified into high-, intermediate-, and low-risk groups, according to the American Diabetic Association (ADA) criteria. They were then screened for GDM at Tehran's teaching hospitals using the two-step approach with thresholds of 130 mg/dL and 140 mg/dL, and the diagnostic criteria advocated by Carpenter and Coustan.

Results – The prevalence of GDM in our sample was 4.7%. Switching from the 130 mg/dL to the 140 mg/dL threshold, decreased case-detection sensitivity by 12% (to 88%). With this approach, however, the cost of screening per pregnancy dropped from US $3.80 to US $3.20 (-15.6%), and the cost per detected case of GDM, from US $80.56 to US $77.43 (-3.9%).

Conclusion – We recommend a universal screening for populations in whom there is a significant prevalence of GDM and variable health-care coverage, leading to a significant proportion of cases being missed, but where the cost of universal screening is markedly lower than that in more developed economies.

Keywords: Cost analysis • developing country • diagnosis • gestational diabetes mellitus • screening

Introduction

There is a general consensus that the prevalence of gestational diabetes mellitus (GDM) is increasing globally. In spite of more than 30 years of research, however, there is no consensus as yet regarding the need for screening, diagnostic criteria, treatment, or even the validity of GDM as a meaningful diagnosis.

Until 1997, the position adopted by the American Diabetic Association (ADA) and the First Three International Workshop-Conferences on GDM, was to endorse universal screening. The report of the ADA Expert Committee on Diagnosis and Classification of Diabetes Mellitus in that year, however, switched its recommendation to selective, or risk factor-based screening, a decision endorsed by the Fourth International Workshop-Conference on Gestational Diabetes Mellitus in 1998.

The approach adopted by most obstetricians in the USA is that advocated by the National Diabetes Data Group (NDDG) and the American College of Obstetricians and Gynecologists (ACOG). The ACOG, being reluctant to recommend universal screening, instead endorsed screening protocols based on a variety of risk factors.

Universal screening or diagnostic testing is still recommended for women in ethnic groups in which the prevalence of carbohydrate intolerance during pregnancy, and the likelihood of developing diabetes later in life, are relatively high. This
would include people of Hispanic, African, Native American, and South or East Asian, Polynesian, and Australian aboriginal descent, especially if they lead a ‘western’ lifestyle or live in an urban setting.¹

In developing countries, Iran being an example, limited budget resources preclude the delivery of technology, or manpower-intensive care to the entire population. Cost-effectiveness and cost-benefit calculations are, therefore, intrinsic to the design and delivery of health-care in these countries. GDM in Iran has only been properly studied in the capital, Tehran, where the prevalence is around 5%.¹⁴,¹⁵

As the first step in determining the cost-effectiveness of GDM screening in Iran, we studied the cost of different screening approaches and thresholds.

**Patients and Methods**

A total number of 2,416 pregnant women were enrolled in an observational study of GDM at four university teaching hospitals in Tehran. The risk factors examined were known diabetes in first-degree relatives, a history of poor obstetric outcome (spontaneous abortion, neonatal death, intrauterine fetal death, anomaly, preterm labor), polyhydramnios, a history of having a macrosomic child, glycosuria, maternal age ≥ 35, and obesity. High-risk patients were screened during their first antenatal visit. If they were found not to have GDM at an initial screening, they were re-tested between the 24th and 28th weeks of their gestation. Remaining women (without risk factors) were also screened for GDM between the 24th and 28th weeks of their pregnancy. All women with impaired glucose tolerance and/or symptoms suggestive of hyperglycemia were followed up and re-tested between the 32nd and 36th weeks of pregnancy. The 50 g glucose challenge test (GCT) with a threshold of 130 mg/dL was used as screening test, and the 100 g oral glucose tolerance test (OGTT) as the diagnostic test. Two or more abnormal OGTT readings were considered diagnostic of GDM, based on the criteria proposed by Carpenter and Coustan.¹,¹⁶,¹⁷

All borderline or suspicious test results were repeated. Every blood sample was centrifuged for a maximum of two hours after it was drawn. The supernatant plasma were kept in a cold state and transported to Shariati Hospital Laboratory where they were tested. Plasma glucose was measured by the glucose oxidase method, using a Hitachi 704 autoanalyzer. After universal testing was completed, samples were re-tested as if selective or risk factor-based screening had been used. We estimated the direct costs incurred by the hospital laboratory in the screening and diagnosis of GDM in consecutive pregnant women with historical and clinical risk factors by proration of component unit costs. The results obtained with the two screening approaches were analyzed and compared. The cost of universal and selective screening methods were calculated based on both public and private sector tariffs, as was the cost of each portion of the GCT and OGTT tests, assuming use of standard material and services, under the heading of calculated tariffs. The estimated unit cost in 2002 was $0.35 for serum glucose determination, $0.65 for test solution for the GCT, $1.31 for test solution for the OGTT, and $0.32 for each phlebotomy. Finally, for a more realistic calculation of costs, the mean value of the public sector and private sector were calculated and used as the basis of cost analysis studies (Table 1). The cost of each screening method was calculated as follows: cost per pregnant woman = [(number of performed GCT* average cost of GCT) + (number of performed OGTT* average cost of OGTT)] /total pregnant women enrolled; and cost per GDM case detected = [(number of performed GCT* average cost of GCT) + (number of performed OGTT* average cost of OGTT)]/total GDM patients detected. The figures obtained were converted into US dollars to allow comparison with studies done elsewhere (Tables 2 and 3).

**Results**

A total number of 2,416 women underwent universal screening for GDM using the two-step

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**Table 1. Average cost of diagnostic and screening tests for gestational diabetes mellitus in Tehran, Iran.**

<table>
<thead>
<tr>
<th>Test</th>
<th>Public sector tariff</th>
<th>Private sector tariff</th>
<th>Calculated cost</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rials</td>
<td>US$</td>
<td>Rials</td>
<td>US$</td>
</tr>
<tr>
<td>GCT</td>
<td>8,500</td>
<td>1.06</td>
<td>11,000</td>
<td>1.38</td>
</tr>
<tr>
<td>OGTT</td>
<td>13,100</td>
<td>1.63</td>
<td>24,500</td>
<td>3.06</td>
</tr>
</tbody>
</table>

GCT = 50-gram 1-hour glucose challenge test; OGTT = 100 g 3-hour oral glucose tolerance test; Exchange rate = 8,000 Rials = US $1.00; Calculated cost = cumulative cost of each portion of the test, assuming standard material and services.
approach with a 130 mg/dL threshold, based on the Carpenter and Coustan criteria. Of these, 114 (4.7%) were diagnosed with GDM. Screening was performed before the 24th week of pregnancy in 1,209 women, of whom 392 had an abnormal GCT and, therefore, underwent a diagnostic OGTT. GDM was eventually diagnosed in 28 of the 392 patients with initial abnormal GCT. Between the 24th and 28th weeks of pregnancy, 2,388 women were screened: 517 went on to have a diagnostic OGTT and 44 were eventually diagnosed with GDM. At 29th week of gestation, 906 women had either symptoms of hyperglycemia or a single abnormal OGTT reading, but were otherwise normal. They were followed up and re-tested; 251 had an abnormal GCT during the second test. Forty-two were eventually diagnosed with GDM.

Table 2 shows the total number of GCT and OGTT performed with each screening protocol. Therefore, out of 114 patients diagnosed with GDM, 24.56% were diagnosed before the 24th week of pregnancy, 38.59% were diagnosed between the 24th and 28th weeks of pregnancy, and 36.8% after the 29th week of pregnancy. Using a threshold of 140 mg/dL, the number of OGTT performed would have decreased by 39.8%, at the expense, however, of 12% of GDM cases being missed.

Using selective screening with a 130 mg/dL threshold, 748 women were assessed before the 24th week of pregnancy, 1,689 women between the 24th and 28th weeks of pregnancy, and 698 women during the 32nd week of pregnancy. Overall, 98 women with GDM were eventually screened. This approach missed 14% of the cases but reduced the number of GCTs by 21%, and OGTTs by 21.72%. Universal screening with a 140 mg/dL threshold reduced the number of GCTs by 43.5%, but also missed 23% of GDM cases.

Analysis of the direct cost of diagnostic/screening tests for the ‘universal 130’ approach yields a cost of US $3.80 (30,410 Rials) per patient screened and US $80.56 (644,488 Rials) per case of GDM detected. The corresponding values for the ‘universal 140’ approach are US $3.20 (25,641 Rials) and US $77.43 (619,500 Rials), respectively, but, as mentioned already, with 12% of cases being missed. Therefore, a 15.6% reduction in per capita screening cost and a 3.9% reduction in cost per case detected may be achieved with a 12% decrease in screening sensitivity (Tables 2 and 3). The ‘selective 130’ and ‘selective 140’ methods yield per capita screening costs of US $2.71 (21,703 Rials) and US $2.39 (19,124 Rials), respectively, and cost per case detected of US $66.88 (535,052 Rials), and US $65.53 (525,044 Rials), respectively. The sensitivity and required expenditure for each approach are shown in Table 3. Demographic and reproductive characteristics of GDM and normal pregnant women are shown in Table 4.

**Discussion**

Many authors have evaluated the direct costs of different screening approaches for GDM. Several investigators have examined the efficiency of historical risk factors at narrowing the group to be screened. They have found these risk factors only in roughly half of the women known to have GDM. Reed showed that 50% of all referrals had risk factors for GDM; 48% of these had one risk factor and were older than 25 years; 85% of patients with GDM belonged to this group. The per capita cost of this approach was US $6.83, compared with US $24.40 for universal screening. If only women over the age of 25 had been screened, the per capita cost would have risen to

<table>
<thead>
<tr>
<th>Approach</th>
<th>Threshold</th>
<th>GCT</th>
<th>OGTT</th>
<th>GDM cases detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universal</td>
<td>130 mg/dL</td>
<td>4,499</td>
<td>1,160</td>
<td>114</td>
</tr>
<tr>
<td>Universal</td>
<td>140 mg/dL</td>
<td>4,443</td>
<td>698</td>
<td>100</td>
</tr>
<tr>
<td>Selective</td>
<td>130 mg/dL</td>
<td>3,025</td>
<td>908</td>
<td>98</td>
</tr>
<tr>
<td>Selective</td>
<td>140 mg/dL</td>
<td>3,002</td>
<td>655</td>
<td>88</td>
</tr>
</tbody>
</table>

GCT = 50-gram 1-hour glucose challenge test; OGTT = 100-gram 3-hour oral glucose tolerance test; Threshold = 1-hour blood glucose value on GCT at or above which patients are referred for diagnostic (OGTT) testing.

<table>
<thead>
<tr>
<th>Approach</th>
<th>Threshold</th>
<th>Sensitivity</th>
<th>Cost per pregnant woman</th>
<th>Cost per GDM case detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universal</td>
<td>130 mg/dL</td>
<td>100</td>
<td>30,410</td>
<td>644,488</td>
</tr>
<tr>
<td>Universal</td>
<td>140 mg/dL</td>
<td>88</td>
<td>25,641</td>
<td>619,500</td>
</tr>
<tr>
<td>Selective</td>
<td>130 mg/dL</td>
<td>86</td>
<td>21,703</td>
<td>535,052</td>
</tr>
<tr>
<td>Selective</td>
<td>140 mg/dL</td>
<td>77</td>
<td>19,124</td>
<td>525,044</td>
</tr>
</tbody>
</table>

| Threshold | 1-hour blood glucose value on GCT at or above which patients are referred for diagnostic (OGTT) testing; Exchange rate = 8,000 Rials = US $1.00; Sensitivity = true positives/(true positives + false negatives).
Effect of varying threshold and selective versus universal strategies on the cost in GDM

In their study, Metzger et al.24 assessed the effect of different screening strategies on the cost and sensitivity. Universal screening with a 130 mg/dL threshold was 100% sensitive and cost US $249.00 per case of GDM detected, whereas limiting screening to women over the age of 25, with a 140 mg/dL threshold reduced the cost per case of GDM to US $192.00 (22.8% reduction) and sensitivity to 85%. In this study, a 15.6% reduction in per capita screening cost and a 3.9% reduction in cost per case detected may be achieved with a 12% decrease in screening sensitivity for using 140 mg/dL threshold instead of 130 mg/dL threshold in universal screening.

Kitzmiller reported that risk factor-based screening leads to a 22% overall reduction in the number of screening tests performed and has a sensitivity of 95% with a 130 mg/dL threshold. The cost per case of GDM detected was US $215 in his study.24

In spite of the wealth of data, no clear picture emerges from the most appropriate screening strategy for GDM. The variety of thresholds and selection protocols used, as well as the wide range of GDM prevalence in the populations studied, make direct comparison very difficult. The present lack of consistency regarding different practice guidelines/recommendations of the major professional/advocacy bodies in this field has not helped resolve the controversy. In addition, few studies have measured the cost-effectiveness or cost-benefit of screening for GDM, especially with pregnancy outcomes as a major end-point.25 – 27 The purchasing power of the client further makes the interpretation of simple cost saving difficult.

In this study, the prevalence of GDM was 4.7%, which is higher than many of the populations in whom cost analysis studies have been carried out.

The cost of GDM screening strategies is a function of the testing protocol used, patient selection criteria, the blood glucose value at or above which OGTT is performed, the demographic and fertility characteristics of the population under consideration, and the baseline prevalence of GDM in this population.

Studies that advocate a selective screening approach tend to be conducted in populations with a low prevalence of GDM, hence the low number of missed cases—the sensitivity of a test (screening) does depend on the baseline prevalence of positive (GDM) cases in the population.

In our population and any other populations with similar demographic and socioeconomic conditions, where the baseline prevalence of GDM is moderate to high and a significant number of cases are missed with selective screening, universal screening is the better option. Finally, risk factor screening is not the recommended method of screening for GDM in our antenatal population when the GDM prevalence, number of mothers with identified risk factors, cost effectiveness, and the risk of missing cases are taken into consideration.

References

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