Efficacy and Cost of Postpartum Screening Strategies for Diabetes Among Women With Histories of Gestational Diabetes Mellitus

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OBJECTIVE — To compare the cost and time to diagnosis associated with several screening strategies for diabetes in women with histories of gestational diabetes mellitus (GDM).

RESEARCH DESIGN AND METHODS — We simulated screening for diabetes with fasting plasma glucose (FPG), a 2-h oral glucose tolerance test (OGTT), and A1C annually, every 2 years, and every 3 years over a period of 12 years. We assumed that women had negative screening tests 6 weeks after delivery, progressed to diabetes at 8% per year, and that each positive FPG and A1C was followed by a confirmatory FPG. For each strategy, we calculated the cost per case detected, cost per woman screened, the percent of cases detected, and the time elapsed with undiagnosed diabetes. In sensitivity analyses, we considered the inclusion of indirect costs, the impact of imperfect adherence to screening strategies, exclusion of confirmatory tests, and lower rates of progression to diabetes.

RESULTS — When annual, biannual, or every 3-year screening strategies were utilized, OGTTs resulted in lower costs per case detected than FPG or A1C. Testing every 3 years resulted in lower costs per case detected compared with more frequent testing. These patterns persisted in sensitivity analyses, except that FPG resulted in lower cost per case detected than OGTT, assuming annual screening and inclusion of indirect costs or assuming annual screening without a confirmatory FPG.

CONCLUSIONS — Screening every 3 years with OGTTs results in the lowest cost per case of detected diabetes.

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Gestational diabetes mellitus (GDM), or glucose intolerance first recognized during pregnancy, affects 4–12% of pregnancies in the U.S. (1). The incidence of GDM is increasing, fueled by maternal obesity and advancing maternal age (2–4). Whereas most women with GDM return to normal glucose tolerance after delivery, as many as 10–50% of women with GDM are diagnosed with diabetes within 5 years (5,6). Therefore, the Fourth International Workshop-Conference for Gestational Diabetes recommended that an oral glucose tolerance test (OGTT) be used to screen for diabetes at least 6 weeks after delivery. If glucose levels are normal, glycemia should be reassessed at a minimum of 3-year intervals with a screening test appropriate for the prevalence of diabetes in the population (1). A 2003 survey of American College of Obstetricians and Gynecologists fellows indicated that about three-quarters reported performing postpartum screening for diabetes in their patients with histories of GDM (7).

There are no long-term studies that compare the benefits of different screening strategies (8). Comparison of screening strategies for diabetes among women with histories of GDM is challenging for several reasons. First, a single screening strategy may not be appropriate across populations, as the performance and cost of screening strategies will vary with incidence of diabetes. A systematic review by Kim et al. (6) found that the 8% per year conversion rate to diabetes did not apply to non-Hispanic white populations, where the cumulative incidence could be as low as 10% at 10 years. Second, to our knowledge, no data exist on the incidence of complications or the cost-effectiveness of treatment for diabetes in women with histories of GDM. Such women are up to 2 decades younger than those modeled in other cost-effectiveness studies (9). Third, the benefit of interventions to prevent diabetes in women with impaired fasting glucose or impaired glucose tolerance has been demonstrated (10,11), but the availability of these interventions and the cost-effectiveness estimates vary (12,13). Finally, the frequency of screening for diabetes after delivery in women with histories of GDM has been reported to be low (14,15). Presumably, the adoption of strategies requiring fasting or more than a single blood draw might be optimal, but less applicable, in practice.

Despite these obstacles, it is possible to compare the yield and costs associated with alternative screening strategies. Such "cost-per-diabetes-case-detected" analyses have been used in the assessment of other diabetes screening strategies (16). In these analyses, we sought to identify the screening strategy that would provide

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Abbreviations: FPG, fasting plasma glucose; GDM, gestational diabetes mellitus; OGTT, oral glucose tolerance test.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Cost estimates for resources used*

Cost categories	Screening strategy: OGTT	FPG	A1C	Costs per unit	Source (ref.)
Physician time	3/4 visit for initial visit	3/4 visit for initial visit; 1 visit for follow-up, if needed	3/4 visit for initial visit; 1 visit for follow-up if needed	$51.00/visit	(19,21)
Secretary time	1/12 h per visit	1/12 h per visit	1/12 h per visit	$15.96/h	(22)
Laboratory tests	1 OGTT	1 FPG; if positive, another FPG	1 A1C; if positive, an FPG	OGTT: $17.99 per test; FPG: $6.64 per test; A1C: $13.56 per test	(20)
Mailings	1 for initial visit	1 for initial visit; 1 for follow-up, if needed	1 for initial visit; 1 for follow-up, if needed	$1.00/mailing	(19)
Patient time	3 1/4 h	3/4 h; if positive, another 3/4 h	3/4 h; if positive, another 3/4 h	$16.24/h	(22)

good case yield, sufficient protection from false-negative and false-positive results, and acceptable cost.

RESEARCH DESIGN AND METHODS

— The study population for our simulation was a cohort representing women with histories of GDM who had normal 6-week postpartum OGTTs. Because not all women have glucose levels before pregnancy, GDM may be diagnosed in women with undiagnosed diabetes before pregnancy and in women who develop glucose intolerance during pregnancy. The OGTT performed 6 weeks postpartum primarily identifies women with undiagnosed diabetes that preceded pregnancy. We therefore chose to exclude this population (17).

Screening and diagnostic strategies

We examined several screening strategies. After the 6-week postpartum OGTT, we assumed that women could undergo *1*) an annual, biannual, or every 3-year 2-h 75-g OGTT, with a positive test defined as ≥126 mg/dl on the fasting level or ≥200 mg/dl on the 2-h level and a sensitivity of 1.0 and specificity of 1.0; *2*) an annual, biannual, or every 3-year fasting plasma glucose (FPG), with a cut point of 126 mg/dl and a sensitivity of 0.5 and a specificity of 0.98; or *3*) an annual, biannual, or every 3-year A1C, with a cut point of 6.3% and a sensitivity of 0.48 and a specificity of 1.0 (18). In the baseline analysis, we assumed that women would be referred for their initial test at an annual gynecological health maintenance visit and therefore would only be charged for the test and not for an entire additional physician visit and would not incur time lost from work. We assumed that a positive FPG or A1C was followed by confirmatory testing with an FPG and an additional physician visit, and we assumed that women with negative confirmatory tests would reenter the population available for testing. We assumed that women with an initial positive OGTT did not undergo another OGTT. In the scenarios requiring confirmatory testing, the false-positive was assumed to have minimal impact beyond the requirement for a follow-up test. Women were assumed to progress to diabetes at a rate of 8% per year (6). We then estimated the number of cases detected for each strategy after 12 years, the percent of cases detected, the time spent with undiagnosed diabetes, and the number of false-positives per strategy.

Cost analysis

The resources used for each strategy and associated costs are illustrated in Table 1. For all strategies, we considered the direct medical cost of screening to include costs incurred at the time of the initial test, including the cost of the screening test (FPG versus OGTT versus A1C); the cost of (three-quarters) of the physician visit for the initial visit (19); and administrative costs for scheduling the visit (19). Administrative costs were estimated by assuming a secretarial wage of $13.13 per hour and estimating that the secretarial time used was approximately one-twelfth of an hour (19). Direct medical costs also included costs incurred at the time of the follow-up visit, if warranted, but the cost of an entire physician visit was charged. Laboratory costs were based in 2005 Medicare reimbursement CPT codes (20); physician visit charges were obtained from 2000 estimates (19) then adjusted for inflation to 2005 (21). Cost estimates for secretarial wages were obtained from Bureau of Labor Statistics data from 2005 (19,22). We then estimated the cost for each woman after 12 years and the cost per case detected.

Sensitivity analyses

We conducted multiple sensitivity analyses examining different screening scenarios. First, we calculated indirect costs in addition to the direct costs noted above. Indirect costs included the cost of lost work hours (0.75 h for an FPG or A1C and 3.25 h for an OGTT); the lost time was valued based on median wages from 2005 Bureau of Labor Statistics data (22). We also included costs of travel ($7.00 per trip) based on a prior analysis (19). Second, we examined a scenario in which women referred for OGTTs actually underwent testing only 50% of the time, in which women referred for FPGs actually underwent testing only ~75% of the time, and in which women referred for A1C testing underwent testing all of the time (19). The rationale for 100% adherence for the A1C test was that this test does not have to be done fasting and can be performed in the office. We did assume that the repeat FPG after an initial positive screen would have an adherence of 100% because of the concern caused by the first positive test result. Third, we examined a scenario that accounted for both indirect costs and differential adherence. Fourth, we examined a scenario that did not require a confirmatory FPG for a positive FPG and the associated false-positive rate. In these scenarios, we did not estimate

Table 2—*Comparison of screening strategies for diabetes among women with histories of GDM*

	OGTT every year	FPG every year	A1C every year	OGTT every 2 years	FPG every 2 years	A1C every 2 years	OGTT every 3 years	FPG every 3 years	A1C every 3 years
Cost per case detected	$860	$1,145	$1,288	$502	$924	$1,047	$388	$895	$1,018
Cost per person screened	$513	$543	$603	$283	$310	$342	$205	$219	$241
Percent of cases detected	97.5%	77.4%	76.5%	92.1%	54.8%	53.4%	86.2%	39.9%	38.6%
Duration (years) of undiagnosed diabetes	0.29	1.73	1.79	0.58	2.51	2.57	0.88	2.95	2.99

Base case assumptions: costs include cost of tests and visit but not time lost from work; tests are obtained whenever ordered; rate of progression to diabetes is 8% per year. OGTT = 2-h glucose tolerance test with 75-g challenge.

any further effects of the false-positive because of the nature of the cost per case calculation, which limits estimation of downstream effects. Fifth, we examined a scenario in which some women underwent screening for other causes, such as symptoms. We varied this "background detection" screening between 0 and 7.5% of cases detected per year. Sixth, we examined confirmation of an initial positive A1C or FPG using an OGTT instead of an FPG. Seventh, we removed the costs for administrative charges from the base case and reduced the lost productivity hours associated with an OGTT to 2 h. Finally, we decreased the rate of progression of diabetes from 8 to 2% in order to reflect the lower rates of progression reported in predominantly white populations (6). We extrapolated the base case results to a cohort of 1,000 women and calculated incremental cost per case for annual, biannual, and every 3-year OGTT screening (23).

RESULTS

Base case

The cost per person, cost per case of diabetes detected, the percent of cases detected, and the time with undiagnosed diabetes for each screening interval for each strategy are illustrated in Table 2. OGTTs resulted in a lower cost per case of diabetes detected than FPG whether annual, biannual, or every 3-year testing was used. In general, the longer the screening interval, the lower the cost per case of diabetes detected and the lower the cost per woman screened, with only a 6- to 14-month increase in the duration of undiagnosed diabetes. Testing with A1C was inferior to the OGTT at every screening interval, both in terms of cost per case detected and in cost per woman screened.

Sensitivity analyses

In most sensitivity analyses, OGTTs still resulted in lower costs per case detected than either FPG or A1C (Table 3). When adherence to OGTT testing was assumed to be 50%, adherence to FPG was assumed to be 75%, and adherence to A1C was assumed to be 100%, OGTT still resulted in lower cost per case detected at each screening interval. When we combined indirect costs and differential adherence to tests, a scenario that may more closely mimic the "real-world" situation, the results were similar. When the administrative charges were removed from the base case and the lost productivity associated with OGTT was reduced to 2 h rather than 3.25 h, OGTT still was favored. When we varied the rate of progression to diabetes by assuming a 2% progression per year rather than an 8% progression per year, the cost per diabetes case detected was higher than in the base case analyses, but similar patterns of lower costs with longer screening intervals were observed, and the OGTT still led to lower cost per case detected at each screening interval (Fig. 1). Varying the background detection rate between 0 and 7.5% of cases still resulted in lower costs per case detected for OGTT compared with FPG and A1C (results not shown). Substituting an OGTT as a confirmatory test instead of the FPG did not significantly alter the results (results not shown).

FPG testing led to a lower cost per case detected in two scenarios. The first scenario included indirect costs and assumed annual testing. However, with longer screening intervals, OGTT testing resulted in lower cost per case detected (Table 2, sensitivity analysis 1). In the second scenario, a confirmatory FPG was not required and annual testing was assumed. Again, with longer screening intervals, OGTT testing resulted in lower cost per case detected (Table 2, sensitivity analysis 4). When a confirmatory FPG was not required, false-positive rates increased dramatically over the 12-year period; the false-positive rate for annual FPG testing was 17%, biannual FPG testing was 9.5%, and every 3-year testing was 6.7%.

CONCLUSIONS — Women with histories of GDM represent a unique population in that screening for type 2 diabetes already is generally endorsed because of their high risk (8,24). Therefore, screening already is recommended, if not performed (14). Current recommendations for screening for type 2 diabetes in women with histories of GDM have been guided by considerations of the increased cost and inconvenience of the OGTT balanced by the concern for the sequelae of undiagnosed diabetes. In this analysis, we found that the increased sensitivity and specificity of the OGTT led to lower cost per diabetes case detected compared with other diagnostic tests. Moreover, we found that less frequent testing led to lower cost per case detected, with relatively small increments in the time spent with undiagnosed diabetes. These findings persisted despite assumptions of lower rates of progression, increased indirect costs for OGTT-based screening strategies, and decreased adherence to OGTT because of its need for multiple blood draws and increased patient time. FPG was a superior testing strategy only when annual testing was performed and indirect costs were included or when annual testing was performed and there was no confirmatory testing.

We considered multiple testing scenarios in our construction of these models. The base case results favored OGTTs, so we tried to construct sensitivity analyses with assumptions that would favor FPG or A1C. Therefore, sensitivity analyses favored FPG and A1C by lower adher-

Table 3—*Sensitivity analyses of base case assumptions*

	OGTT every year	FPG every year	A1C every year	OGTT every 2 years	FPG every 2 years	A1C every 2 years	OGTT every 3 years	FPG every 3 years	A1C every 3 years
1) Sensitivity analysis assumptions: costs include base case costs and costs of time lost from work; otherwise similar to base case									
Cost per case detected	$1,771	$1,621	$1,764	$1,033	$1,308	$1,435	$799	$1,267	$1,395
Cost per person screened	$1,057	$768	$826	$583	$439	$469	$422	$309	$330
2) Sensitivity analysis assumptions: OGTT obtained only 50% after ordering and FPG obtained 75% after ordering; otherwise similar to base case									
Cost per case detected	$487	$1,013	$1,288	$321	$870	$1,047	$279	$865	$1,018
Cost per person screened	$272	$428	$603	$154	$240	$342	$111	$167	$241
Percent of cases detected	91.5%	69.0%	76.5%	78.1%	45.0%	53.4%	64.7%	31.5%	38.6%
3) Sensitivity analysis assumptions: indirect costs (sensitivity analysis 1) and imperfect adherence to tests (sensitivity analysis 2)									
Cost per case detected	$1,003	$1,434	$1,764	$662	$1,232	$1,435	$575	$1,224	$1,395
Cost per person screened	$562	$605	$826	$316	$339	$469	$228	$236	$330
4) Sensitivity analysis assumptions: no confirmatory test needed for a positive FPG; otherwise similar to base case									
Cost per case detected	$860	$798	$1,288	$502	$528	$1,047	$388	$460	$1,018
Cost per person screened	$513	$399	$603	$283	$239	$342	$205	$175	$241
Percent of cases detected	97.5%	81.8%	76.5%	$92.1%	73.8%	53.4%	86.2%	62.2%	38.6%
Duration (years) of undiagnosed diabetes	0.29	0.81	1.79	0.58	1.44	2.57	0.88	1.93	2.99

OGTT = 2-h glucose tolerance test with 75-g challenge.

ence for OGTTs (resulting in fewer cases detected for OGTT strategies) and confirmatory tests using FPG rather than OGTTs (resulting in lower costs for FPG and A1C strategies). However, cost per case detected patterns remained fairly consistent. Moreover, lack of confirmatory testing for FPG led to high false-positive rates. Although not calculable in our cost-per-case approach, the false-positive rates likely have significant downstream effects. In a standard cost-effectiveness analysis, the false-positive results would incur multiple repeat glucose measurements and physician visits, as well as testing for other cardiovascular risk factors.

Our report examines the optimal

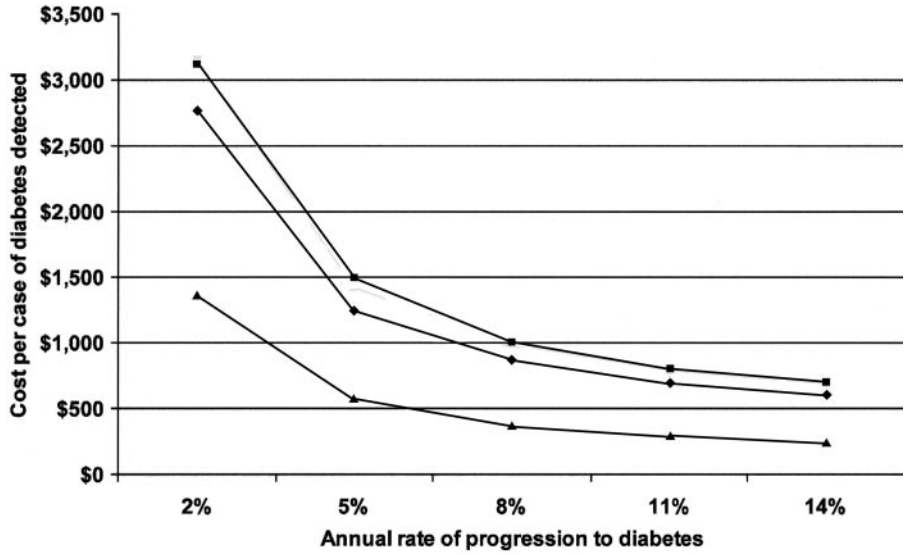

Figure 1—*Cost per case detected by annual rate of progression to diabetes, assuming screening every 3 years.* ♦*, FPG;* ■*, A1C;* ▲*, OGTT.*

method and frequency of screening but does not establish the benefit of screening itself. Our report also is limited by the fact that we did not examine all potential screening tests of strategies but instead tried to target the ones that are recommended or performed most frequently. Finally, we did not attempt to incorporate prevention strategies for glucose intolerance. Although one cost-effectiveness analysis found that such interventions could be cost-saving, (12), another cost-effectiveness analysis did not (13). These assessments differed primarily because of their different assumptions of the rate of progression from glucose intolerance to diabetes. It is possible that such programs would be cost-effective in populations that rapidly progressed but less effective in populations that progressed more slowly. In addition, using other diabetes disease management programs as a proxy, the availability and cost of such programs probably varies dramatically. Given these variations, it may not be possible to calculate a single cost-effectiveness estimate for the entire population of women with GDM.

We conclude that testing strategies utilizing OGTTs at 3-year intervals may yield the lowest cost per diabetes case detected. Such analyses should guide future recommendations about optimal diabetes screening strategies among women with GDM. More detailed, long-term assessments of the cardiovascular complications among women with a history GDM and their compliance with treatment, as well as the benefits of early treatment, are needed.

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