Prevalence and Timing of Screening and Diagnostic Testing for Gestational Diabetes Mellitus: A Population-Based Study in Alberta, Canada

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OBJECTIVE

The extent to which pregnant women are screened for gestational diabetes mellitus (GDM) at the population level is not known. We examined the rate, type, and timing of GDM screening and diagnostic testing in the province of Alberta, Canada. Geographic and temporal differences in screening rates, and maternal risk factors associated with lower likelihood of screening, were also determined.

RESEARCH DESIGN AND METHODS

Our retrospective linked-database cohort study included 86,842 primiparous women with deliveries between 1 October 2008 and 31 December 2012. Multivariable logistic regression analysis was used to examine maternal factors associated with lower likelihood of GDM screening.

RESULTS

Overall, 94% (*n* = 81,304) of women underwent some form of glycemic assessment in the 270 days prior to delivery. The majority (91%) received a 50-g glucose screen (GDS). Women not screened were younger and more likely to smoke and had lower maternal weight and median household income. When a diagnostic 75-g oral glucose tolerance test (OGTT) was indicated, it occurred a median of 10 (interquartile range 7, 15) days after the screen.

CONCLUSIONS

GDS occurred widely in a system where it was universally recommended and paid for publicly. When indicated, a 75-g OGTT was completed within 15 days in 75% of cases. Our finding that this two-step approach was widely implemented in a timely fashion supports continued endorsement of a two-step approach to screening and diagnosis of GDM. Further research is merited to assess whether the one-step GDM diagnostic approach results in different rates and timing of the 75-g OGTT and affects pregnancy outcomes.

The 50-g oral glucose challenge test (GDS) is a common method of screening for gestational diabetes mellitus (GDM) in North America. This test is recommended for all women (1) or selectively for the vast majority (at least 90%) of pregnant women (2) who have at least one risk factor for GDM (i.e., older age, non-Caucasian, elevated BMI, history of adverse pregnancy outcomes, and personal or family history of

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glucose intolerance) (3). Typically this screening test is administered between 24 and 28 weeks' gestation, but it has been recommended earlier in gestation for those with multiple risk factors for GDM (1). If 1 h after the GDS the blood glucose level is greater than the selected cutoff (usually 7.2 or 7.8 mmol/L), a second step, an oral glucose tolerance test (OGTT) (with either 75- or 100-g glucose load) is performed to confirm the diagnosis of GDM. Sensitivity and specificity values of the GDS for predicting the outcome on an OGTT range from 70 to 99% and 66 to 89%, respectively, depending on the glucose thresholds selected for the positive screening result and diagnostic OGTT (4,5).

There are limited data on the extent to which current practice guidelines for the screening for GDM are implemented in clinical practice at the population level. Accordingly, we evaluated the prevalence, type, and timing of screening for GDM and examined temporal and geographic differences in a defined geographic area (the province of Alberta, Canada) with universal health care. Our secondary objectives were to identify maternal risk factors for not undergoing GDM screening.

RESEARCH DESIGN AND METHODS

Ethics Statement

Ethics approval for this study was obtained from the University of Alberta institutional review board (Pro00020230).

Data Sources and Linkage

Maternal personal health care number was used to link data from a provincial perinatal database, the Alberta Perinatal Health Program (APHP), with laboratory data made available by the Data Integration Measurement and Reporting (DIMR) unit of Alberta Health Services (http://www.albertahealthservices.ca) for the time period of 1 January 2008 to 31 December 2012. The APHP (www.aphp.ca) captures maternal, obstetrical, and neonatal clinical information from the provincial delivery record for all hospital and registered midwife-attended home births in the province of Alberta, Canada. DIMR holds a central repository of laboratory data for Alberta reported by four regional laboratories. The laboratory data record the time, type, and result of the test. The 2006 Census data were used to incorporate neighborhood-level information on median household income (MHI) as a measure of the socioeconomic status of the mothers in the cohort (6).

Study Design and Population

Our retrospective population-based cohort study included all primiparous births in the province of Alberta, Canada, between 1 October 2008 and 31 December 2012. Alberta is a large, diverse multicultural province in Canada with >3.9 million residents (7). A health insurance plan is paid for by the Alberta Government that covers all necessary medical service expenses in the province. Population-level laboratory data for the entire province except for one of the nine health regions were available as of 1 January 2008. We restricted the study cohort to birth events that occurred after 1 October 2008 to allow for a complete 9-month assessment for gestational screening prior to delivery for all patients. Since screening for GDM is recommended by 28 completed weeks of pregnancy, women who delivered prior to 29 gestational weeks were excluded. Women with preexisting diabetes, identified from the APHP antepartum risk assessment, were also excluded. We confined our primary analysis to primiparous women because we are aware that it is the practice of some health care providers in Alberta to treat women with a previous diagnosis of GDM without laboratory retesting in subsequent pregnancies, since there is a known high recurrence rate (8). However, with this caveat in mind, we did examine GDM screening rates for the entire population (both primiparous and multiparous) in a secondary analysis.

Outcome Measures

The primary outcome measure of interest was the incidence of laboratory screening testing for GDM. A woman was considered as having had a GDM screening test if she had any of the five types of tests for glycemic assessment (GDS, 75-g OGTT, HbA_{1c}, and fasting or random glucose) within 270 days before delivery date. At the time the study was conducted, national clinical practice guidelines recommended that all pregnant women be screened for GDM with a GDS at 24–28 weeks' gestation (first trimester, if multiple risk factors for GDM were present, followed by rescreening during subsequent trimesters if negative) (9). According to these recommendations, if a screening value of 10.3 mmol/L (185 mg/dL) or higher occurred, the woman was assumed to have GDM and no further diagnostic testing was required (10). A 2-h 75-g OGTT was recommended for all women whose GDS fell between 7.8 and 10.2 mmol/L (140 and 184 mg/dL). When women had GDS <7.8 mmol/L, no further glucose testing was recommended except in circumstances where the GDS was done prior to 24 weeks' gestation. According to these criteria, women were diagnosed with impaired glucose tolerance of pregnancy or GDM if they had exactly one, or two or more, glucose values, respectively, on the 75-g OGTT at or above the following glucose thresholds: fasting, 5.3 mmol/L; 1-h, 10.6 mmol/L; and 2-h, 8.9 mmol/L.

Statistical Analysis

We calculated the rates of GDM screening, overall and for each type of test (GDS, 75-g OGTT without GDS, HbA_{1c} without GDS or 75-g OGTT, and fasting or random glucose without GDS, 75-g OGTT, or HbA_{1c}), for our entire study cohort, as well as by maternal place of residence (urban or rural) and calendar year. Gestational time of GDS and 75-g OGTT was determined based on the gestational age at time of delivery, the collection date of the laboratory test, and the delivery date. When several GDS or 75-g OGTTs were collected, only the earliest GDS and earliest 75-g OGTT following GDS within 270 days prior to delivery were considered in the analysis. The year of pregnancy was selected as the calendar year of the delivery date. The delivery date was obtained from laboratory data. We examined temporal trends for screening between 2009 and 2012. Statistical significance of temporal trends was assessed using a logistic regression model with screening as outcome and year as the only predictor.

Descriptive statistics, specifically mean (SD) and median (interquartile range [IQR]) for continuous variables and percentages for categorical variables, were compared between screened and unscreened women using univariate Student *t* tests, Kruskal-Wallis test, and χ^2 test, respectively; all tests of significance were two sided, with *P* values of <0.05 considered significant. We used logistic regression to examine maternal factors associated with the likelihood of receiving any glycemic screening. The following variables were included in this analysis:

maternal age, urban residence, MHI, prepregnancy weight (≤45, 46–90, and ≥91 kg), comorbid medical disorders, and smoking at any time in pregnancy (yes/no). The comorbidity variable included in the logistic regression models was a yes/no dummy variable created based on whether the mother had any one of the following conditions: heart disease, hypertension, chronic renal disease, severe asthma, lupus, epilepsy, Crohn disease, or other medical disorders as recorded on antepartum risk assessment of APHP. The data analysis for this article was generated using SAS software, version 9.4 of the SAS system for Windows x64-based system.

RESULTS

There were a total of 214,254 birth events between 1 October 2008 and 31 December 2012 in the province of Alberta, Canada (Fig. 1). One health region used a unique database that could not be integrated into the laboratory information system, and birth events from that region (n = 6,133, 3%) were excluded. Excluded patients were marginally younger, had lower MHI, were more likely to reside in rural areas, reported higher rates of smoking, and had lower rates of medical disorders (Supplementary Table 1). Excluding birth events with missing gestational age (n = 158), with <29 weeks of gestation (n = 2,159), or of women with preexisting diabetes (n = 1,494) resulted in 204,310 birth events. The primary analysis population consisted of 86,842 primiparous birth events and their corresponding pregnancies.

Overall, 94% (n = 81,304) of women underwent some form of glycemic assessment in the 270 days prior to delivery (Table 1). Not surprisingly, the most common type of screening was GDS, received by 91% (n = 78,552) of women. The rate of GDS among urban-dwelling women was higher (91.1%) than among rural women (86.1%, $P < 0.001$). An additional 3.1% of women who did not have a GDS had some other form of glycemic assessment alone (75-g OGTT, 0.9%; HbA_{1c}, 0.5%; and random or fasting glucose, 1.8%). The percentage of women undergoing some form of glycemic assessment increased significantly over time, from 92% in 2009 to 95% in 2012 ($P < 0.001$).

Women who did not receive any form of glycemic assessment were more likely to be younger (26 vs. 28 years, $P < 0.001$) and smoke (21.7 vs. 14.1%, $P < 0.001$) but less likely to reside in urban areas (82.7 vs. 87.4%, $P < 0.001$) (Table 2). They were also less likely to have maternal weight ≥91 kg (6.4 vs. 9.0%, $P < 0.001$) and had lower MHI ($61,176 vs. $65,147, $P < 0.001$). In multivariable analysis, older age, urban residence, higher MHI, high maternal weight (≥91 kg), and a history of medical disorders were all associated with higher odds, and smoking during pregnancy was associated with lower odds, of being screened for GDM (Table 2).

Of 78,552 women who underwent a GDS, 63,342 (80.6%) had the test between 24 and 28 gestational weeks (Fig. 2). Among women with a GDS, 12,894 (16.4%) had glucose values between 7.8 and 10.2 mmol/L, 877 (1.1%) had values between 10.3 and 11.0 mmol/L, and 779 (1%) had values ≥11.1 mmol/L. Women with glucose values between 7.8 and 10.2 mmol/L should have been recommended to have a 75-g OGTT in accordance with the national guidelines. A majority (n = 12,229, 94.8%) of them went on to complete it, and did so within a median of 10 days (IQR 7, 15) of their GDS collection date. Among women who completed the recommended 75-g OGTT, 3,011 (25%) had at least one and 1,019 (8.3%) had at least two abnormal values according to the 2008 Canadian Diabetes Association thresholds (fasting, 5.3 mmol/L; 1-h, 10.6 mmol/L; 2-h, 8.9 mmol/L). Thus, based on the diagnostic criteria used during the time period of the study, the impaired glucose tolerance rate (defined as exactly one abnormal OGTT value) was 2.5% (1,992 of 78,552) and the GDM rate was 3.4% (2,675 of 78,552).

We excluded multiparous women from the primary analysis population, as screening for GDM may be influenced by their GDM status during a previous pregnancy and could result in biased estimates. However, we conducted a secondary analysis, extending the population to include both primiparous and multiparous women (n = 204,310). Screening patterns were very similar, although, as anticipated, GDS rate in the combined cohort was slightly lower (87.6%) than in the primiparous cohort (Supplementary Table 2).

CONCLUSIONS

Our population-level analysis of 86,842 primiparious women in a publicly funded health care system found that 94% were screened for GDM. Screening rates have increased over time, with rates reaching 95% in 2012. A majority of the screening was based on a 50-g GDS, although some (3.1% of women) who did not undergo the GDS had an alternative glycemic assessment during pregnancy in the form of a 75-g OGTT, HbA_{1c}, or fasting or random glucose. Although slightly higher in urban women, GDM screening rates were high even among rural-dwelling women

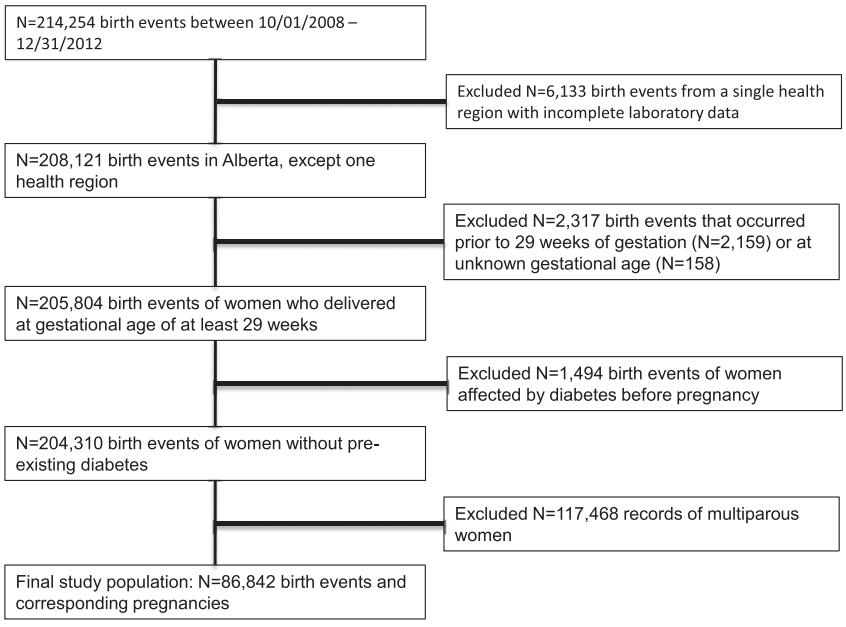

Figure 1—Flow diagram of study inclusion criteria.

Table 1—Rates of GDM screening by type of test, urban/rural dwelling status, and delivery year

		GDS		75-g OGTT without GDS		HbA_{1c} without GDS or 75-g OGTT		Fasting/random without GDS, 75-g OGTT or HbA_{1c}		Any diabetes screening	
	n	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Overall	86,842	78,552	90.5	811	0.9	414	0.5	1,527	1.8	81,304	93.6
Residence											
Urban	75,617	68,884	91.1	709	0.9	306	0.4	1,137	1.5	71,036	93.9
Rural	11,225	9,668	86.1	102	0.9	108	1	390	3.5	10,268	91.5
Delivery year											
2008	5,008	4,304	86	53	1.1	18	0.4	85	1.7	4,460	89.1
2009	20,835	18,530	89	177	0.9	79	0.4	419	2	19,205	92.2
2010	20,102	18,319	91.1	203	1	64	0.3	371	1.9	18,957	94.3
2011	20,110	18,407	91.5	180	0.9	121	0.6	316	1.6	19,024	94.6
2012	20,787	18,992	91.4	198	1	132	0.6	336	1.6	19,658	94.6

(94 vs. 92%, $P < 0.001$). This is reassuring and should reduce the concern that access to services may be compromised in a very large, geographically diverse province such as Alberta, Canada.

Screened women were older, had a higher MHI, were less likely to be smokers, and were more likely to have high maternal weight. Some of these characteristics mirror known risk factors for GDM (age and maternal weight); however, women with lower MHI would in many populations be at higher risk of obesity, GDM, and type 2 diabetes. Over 90% of women who had the GDS did so before 29 gestational weeks of pregnancy.

The rate of screening for GDM in our population was similar to that seen in a large Israeli study, where universal screening is also recommended (11). However, our screening rate was much higher than that observed in a large national sample of health care–insured pregnant women 25 years old or greater in the U.S., where only 68% received some form of screening (12). Also, our screening rate was much greater than the 30% rate of GDM screening observed in an Italian region from 2007 to 2010, when GDM screening in Italy was recommended only for women at increased risk based on selected risk factors. At the time the Italian study was conducted, age alone was not considered a risk that prompted GDM screening. Unlike our study, the Italian study demonstrated wide variability in screening between health regions from 20 to 68%. Independent predictors of GDM screening

Table 2—Characteristics of GDM-unscreened and -screened women

	Descriptive analysis			Multivariable logistic regression model for GDM screening	
Variable	GDM-unscreened pregnancies	GDM-screened pregnancies	*P**	Odds ratio (95% CI)	*P***
Birth events, *n*	5,538	81,304			
Demographics					
Maternal age, 1-year increments				1.05 (1.05, 1.06)	<0.001
Mean (SD)	25.8 (5.6)	27.6 (5.4)	<0.001		
Median (IQR)	26 (21, 30)	28 (24, 31)	<0.001		
≥35 years	384 (6.9)	8,433 (10.4)	<0.001		
Urban residence	4,581 (82.7)	71,036 (87.4)	<0.001	1.08 (1, 1.17)	0.041
MHI, $10,000 increments				1.07 (1.05, 1.08)	<0.001
Mean (SD)	$66,285 ($19,376)	$69,709 ($19,947)	<0.001		
Median (IQR)	$61,176 ($54,929, $77,410)	$65,147 ($55,510, $81,276)	<0.001		
Prepregnancy weight			<0.001		
≤45 kg	42 (0.8)	644 (0.8)		1.15 (0.84, 1.58)	0.372
46–90 kg	5,142 (92.8)	73,322 (90.2)		1	
≥91 kg	354 (6.4)	7,338 (9.0)		1.43 (1.28, 1.60)	<0.001
Risk factors as reported on antepartum risk assessment (APHP)					
Any medical disorders	368 (6.6)	7,536 (9.3)	<0.001	1.34 (1.2, 1.49)	<0.001
Heart	19 (0.3)	383 (0.5)	0.175		
Hypertension	31 (0.6)	690 (0.8)	0.022		
Chronic renal disease	2 (0.0)	88 (0.1)	0.107		
Other medical disorders	324 (5.9)	6,610 (8.1)	<0.001		
Smoking	1,200 (21.7)	11,464 (14.1)	<0.001	0.75 (0.70, 0.80)	<0.001

**P* value for comparison of GDM-screened and -unscreened pregnancies. ***P* value for testing that odds ratio equals one.

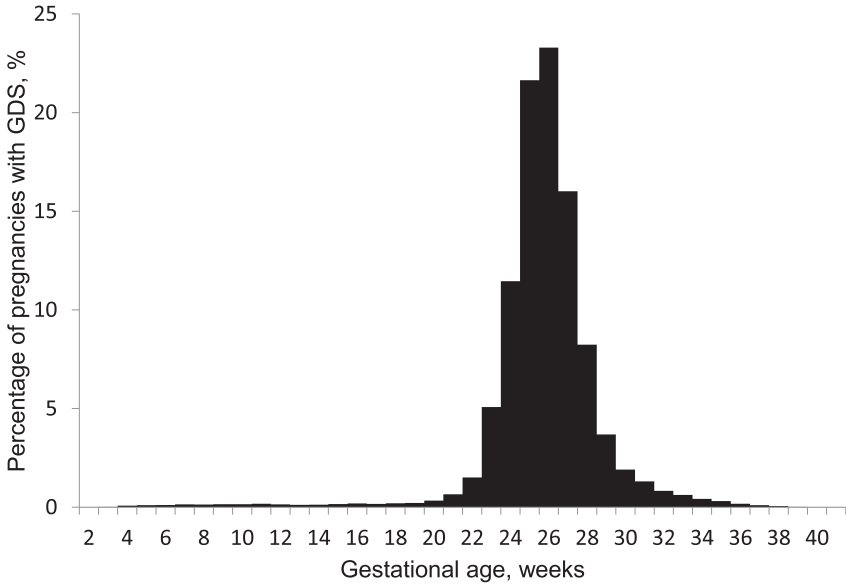

Figure 2—Histogram of gestational timing of first completed GDS.

observed in these other studies included socioeconomic indicators (2), age (12), and ethnicity. Contrary to our findings, weight >200 lb (>91 kg) was not associated with an increased chance of being screened in the U.S. study, and surprisingly those weighing >275 lb were less likely to be screened (12).

In our study, 95% of women with a positive GDS completed the recommended 75-g OGTT in a timely fashion. This rate is much higher than the one reported by Sievenpiper et al. (13) (36%). However, whereas our study is truly population based, this previous study was performed at a single university hospital center (Hamilton, Ontario) and the authors were unable to determine if women attended other hospital or laboratory sites for their follow-up OGTT. It should also be noted that the number of patients requiring 75-g OGTT may increase in the future given the change in 2013 Canadian Diabetes Association guidelines recommending a higher threshold of 11.1 mmol/L, as opposed to 10.3 mmol/L, to presume GDM based on the GDS alone (1). This higher threshold would have resulted in an additional 877 (1.1%) patients requiring a 75-g OGTT in our study.

Although women express concern about the complexity of screening and diagnosis for GDM, the vast majority seem to tolerate the inconveniences of the screening and diagnostic tests in our system, where it is universally recommended and publicly funded. It is possible that some of the women in our study were not screened because their physicians, or the women themselves, perceived a low risk of GDM. The unscreened women in our study did, indeed, have fewer high-risk indicators for GDM, supporting this hypothesis (14).

The timing of the GDS was appropriate for most of the women. Although some may argue that the median 10-day delay between positive GDS and the 75-g OGTT is a reason to endorse a one-step screening and diagnostic strategy for GDM, it is impossible to draw such a conclusion without more rigorous evidence, such as randomizing women to a one- or two-step protocol. It may be possible, for example, that a one-step screening and diagnostic protocol with an OGTT might actually delay the diagnosis of GDM later in gestation, simply because it could be harder for women to schedule a laboratory appointment in the fasting state and to commit time to a test of longer duration and restricted activity. Furthermore, the use of a high threshold for diagnosing GDM on a screening test eliminates a diagnostic delay for women with the highest GDS, who would be expected to have poorer pregnancy outcomes if untreated or if treatment was delayed (15). The use of a high GDS threshold for a diagnosis of GDM has high specificity (16) and is associated with unfavorable perinatal outcomes (17) and thus could reduce the time and cost of a two-step approach for GDM screening and diagnosis. The additional time and expense of performing an OGTT (and fasting) was averted for the overwhelming majority of women in our population. The International Association of the Diabetes and Pregnancy Study Groups (18) has recommended that the GDS be abandoned in favor of a one-step diagnostic 75-g OGTT. However a two-step approach has been shown to be more cost effective (19). A recent National Institutes of Health Consensus Conference Statement on Diagnosing GDM concluded that there was currently insufficient evidence to adopt a one-step OGTT diagnostic approach for GDM (20).

Our study has several strengths and some limitations. Its strengths include the true population-based assessment and the use of laboratory linkages to confirm screening and diagnostic testing for GDM. These factors enhance the generalizability of our results to other publicly funded settings. We also report the novel findings of rate and timing of indicated diagnostic testing following the GDS in a "real world" setting. Some limitations of our study include the unavailability of ethnicity data or maternal BMI, as prepregnancy weight was collected only as a categorical variable (≤45 and ≥91 kg).

In conclusion, GDM screening is widely performed in a system where it is universally recommended and paid for publicly. The most commonly used screening test was the 50-g GDS. Follow-up assessment of women with abnormal GDS screens was conducted in a timely fashion. Our finding that a two-step approach to screening and diagnosis of GDM is widely accepted and implemented in a timely fashion may assist professional organizations as they consider whether to continue to endorse a two-step approach to screening and diagnosis of GDM.

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and approved the final version of the manuscript. A.L.E. interpreted the data, edited the manuscript, and approved the final version of the manuscript. J.A.J. and P.K. conceived and designed the study, obtained the funding, interpreted the data, edited the manuscript, and approved the final version of the manuscript. P.K. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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