Frequency of Gestational Diabetes Mellitus at Collaborating Centers Based on IADPSG Consensus Panel–Recommended Criteria

The Hyperglycemia and Adverse Pregnancy Outcome (HAPO) Study

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OBJECTIVE—To report frequencies of gestational diabetes mellitus (GDM) among the 15 centers that participated in the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) Study using the new International Association of the Diabetes and Pregnancy Study Groups (IADPSG) criteria.

RESEARCH DESIGN AND METHODS—All participants underwent a 75-g oral glucose tolerance test between 24 and 32 weeks' gestation. GDM was retrospectively classified using the IADPSG criteria (one or more fasting, 1-h, or 2-h plasma glucose concentrations equal to or greater than threshold values of 5.1, 10.0, or 8.5 mmol/L, respectively).

RESULTS—Overall frequency of GDM was 17.8% (range 9.3–25.5%). There was substantial center-to-center variation in which glucose measures met diagnostic thresholds.

CONCLUSIONS—Although the new diagnostic criteria for GDM apply globally, center-to-center differences occur in GDM frequency and relative diagnostic importance of fasting, 1-h, and 2-h glucose levels. This may impact strategies used for the diagnosis of GDM.

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The Hyperglycemia and Adverse Pregnancy Outcome (HAPO) Study found strong, positive, continuous associations of maternal glucose levels below those diagnostic of diabetes with birth weight, cord serum C-peptide, and newborn adiposity (each greater than 90th percentile) (1,2). Significant associations were observed for other outcomes, although these tended to be weaker. Associations between maternal glucose and perinatal outcomes were independent of maternal age, BMI, and family history of diabetes. Associations did not differ among centers, indicating that HAPO Study results are applicable to all centers. The HAPO data were used by the International Association of the Diabetes and Pregnancy Study Groups (IADPSG) Consensus Panel to develop "outcome-based" criteria for classifying glucose metabolism in pregnancy (3). In this article, we present center-by-center frequencies of gestational diabetes mellitus (GDM) using the IADPSG criteria and the contributions of each glucose measure to those frequencies.

RESEARCH DESIGN AND METHODS

—In HAPO, a 75-g oral glucose tolerance test (OGTT) was performed on a heterogeneous, multinational, ethnically diverse cohort of women at 24–32 weeks' gestation. The requirements for blinding and unblinding participants' results were previously reported (1). The 23,957 women followed through delivery, including blinded and unblinded participants (excluding 66 with overt diabetes [3]), are included in this article. The IADPSG Consensus Panel used the data from the 23,316 blinded study participants (1,2) to derive OGTT thresholds defining GDM (3).

Statistical analyses

Multiple logistic regression was used to compare differences in GDM frequencies across centers without and with adjustment for confounders. Additionally, direct standardization was used to adjust rates across quartiles of maternal age, BMI, and height. All analyses were conducted in Stata 11.2.

RESULTS—When the IADPSG diagnostic criteria (3) are applied to the total cohort (blinded plus unblinded), the combined prevalence of GDM in the 15 centers is 17.8%. Unadjusted frequencies of GDM

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at each center vary from 9.3–25.5% (Table 1) (χ^2 from logistic regression is 558.8, $P < 0.001$). Adjusting for maternal age, BMI, height, chronic hypertension, and frequency of family history of diabetes and hypertension reduced, but did not eliminate center-to-center differences (χ^2, fully adjusted is 372.8, $P < 0.001$). Supplementary Table A shows rates standardized across quartiles of age, BMI, and height, and Supplementary Table B presents center-to-center information on maternal age, height, BMI, chronic hypertension, family history of diabetes, and hypertension.

Table 1 (columns 4–6) shows the percent of GDM diagnosed by each glucose measure when fasting, 1-h, and 2-h values are considered sequentially. In HAPO overall, 55% had a fasting plasma glucose (FPG) meeting the threshold for GDM; the 1-h result was the diagnostic value in 33%, and the 2-h value made the diagnosis in only 12%. However, there was considerable center-to-center variation. A diagnostic FPG was present in only 24% of those with GDM in Bangkok and 26% in Hong Kong but accounted for over 70% in Barbados, Bellflower, and Providence. The proportion in which the 1-h OGTT value was diagnostic ranged from 9% in Barbados to 64% in Bangkok, and the proportion with only the 2-h value equal to or greater than threshold was just 6% in Bellflower but reached 29% in Hong Kong. Some centers in which FPG accounted for a high proportion of diagnostic values had higher average participant BMI, but this was not consistent (Supplementary Table B).

For each glucose measure (fasting, 1-h, and 2-h), there was substantial center-to-center variation in the proportion of all participants with values equal to or greater than threshold and in the proportion of those with GDM whose individual values met and/or exceeded the specific diagnostic thresholds (columns 7–9 and 10–12, respectively). The sum of percentages with values equal to or greater than threshold is more than the frequency of GDM in HAPO overall and at each center. Similarly, the sum of percentages of GDM with individual glucose values equal to or greater than threshold is more than 100%. This results from the fact that 25% and 11% of those with GDM, respectively, have two or three values equal to or greater than threshold.

CONCLUSIONS—The IADPSG Consensus Panel analyzed HAPO results and other data showing glucose-outcome associations and used HAPO Study findings to define thresholds for diagnosis of GDM based on a 75-g OGTT (3). Center-to-center variations were seen in several characteristics of the HAPO Study cohort including maternal age, BMI, family history of diabetes, and mean OGTT glucose values (1). However, glucose-outcome associations were found in all centers and apply to all centers and therefore justified the development of global criteria for GDM based on data from all centers (3).

This article shows center-to-center differences in prevalence of GDM and in the specific glucose measures accounting for the diagnosis of GDM. As the RESULTS indicate, adjusting for maternal age, BMI, frequency of family history of diabetes, and hypertension in each field center reduced, but did not eliminate, center-to-center differences. The reasons for differences are not clear and may partially relate to frequencies of obesity and degree of abnormal glucose metabolism in the general populations where HAPO centers were located. However, data on population characteristics are not available for many of the HAPO centers.

Although the new diagnostic criteria apply globally, differences in frequency of the diagnosis and the individual glucose measures that fulfill the diagnostic criteria may impact the choice of strategies used for GDM detection and diagnosis in different regions or populations. For example, in populations in which FPG is diagnostic in more than half of those with GDM, it may be reasonable to perform an accurately measured FPG as an initial step, reserving a full OGTT for those with a nondiagnostic FPG. Alternatively, experience with use of

Table 1—*Frequency of GDM by field center (IADPSG criteria) and participants with elevated FPG, 1-h PG, and 2-h PG*

Center*	Participants/ center	Percent GDM	Percent of GDM diagnosed by each glucose measure			Percent of all women with individual glucose measures ≥ threshold			Percent of women with GDM with individual glucose measures ≥ threshold		
			FPG†	1-h PG‡	2-h PG§	FPG	1-h PG	2-h PG	FPG	1-h PG	2-h PG
HAPO overall	23,957	17.8	55	33	12	9.8	9.7	6.7	55	55	38
Bellflower, CA	1,981	25.5	73	21	6	18.7	12.4	6.9	73	49	27
Singapore, Singapore	1,787	25.1	47	39	14	11.9	16.3	11.7	47	65	47
Cleveland, OH	797	25.0	64	27	10	15.9	12.0	9.4	64	48	38
Manchester, U.K.	2,376	24.3	67	26	7	16.2	13.8	8.5	67	57	35
Bangkok, Thailand	2,499	23.0	24	64	12	5.5	17.4	10.0	24	76	43
Chicago, IL	753	17.3	53	28	19	9.2	8.0	8.0	53	46	46
Belfast, U.K.	1,671	17.1	63	30	7	10.7	7.8	4.2	63	46	25
Toronto, Canada	2,028	15.5	66	24	9	10.3	7.5	5.2	66	48	34
Providence, RI	757	15.5	73	19	9	11.2	5.9	5.3	73	38	34
Newcastle, Australia	668	15.3	64	25	11	9.7	7.2	5.7	64	47	37
Hong Kong, PRC	1,654	14.4	26	45	29	3.8	8.9	9.4	26	62	65
Brisbane, Australia	1,444	12.4	50	31	18	6.2	5.9	4.8	50	47	39
Bridgetown, Barbados	2,093	11.9	74	9	17	8.8	3.8	5.1	74	32	43
Petah-Tiqva, Israel	1,818	10.1	43	45	13	4.3	6.3	3.4	43	62	33
Beersheba, Israel	1,631	9.3	57	28	15	5.3	3.8	2.4	57	41	26

PG, plasma glucose; PRC, People's Republic of China. *Centers listed from highest to lowest unadjusted frequency of GDM. †Includes all with FPG ≥ threshold without regard to 1-h and 2-h value. ‡Includes all with FPG < threshold and 1-h ≥ threshold without regard to 2-h value. §Only 2-h value is ≥ threshold.

these criteria in centers in which the 2-h OGTT value is needed for diagnosis in less than 10% of cases (e.g., Bellflower, Manchester, Belfast, Toronto, and Providence), performing only a 1-h OGTT might be justified, whereas that strategy would not be appropriate in Hong Kong where the 2-h sample provided the diagnostic value in 29% of those with GDM.

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Center-to-center variation in the frequency of GDM in the blinded cohort was previously presented: Hadden DR, Metzger BE, Lowe LP, et al.; HAPO Study Cooperative Research Group. Hyperglycemia and Adverse Pregnancy Outcome (HAPO) Study: frequency of gestational diabetes mellitus (GDM) at collaborating centers based on IADPSG Consensus Panel recommended criteria. Diabetologia 2010;53 (Suppl. 1):S9.

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