Early Prediction of Gestational Diabetes Mellitus in Vietnam

Clinical impact of currently recommended diagnostic criteria

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OBJECTIVE—We aimed to compare the discriminative power of prognostic models for early prediction of women at risk for the development of gestational diabetes mellitus (GDM) using four currently recommended diagnostic criteria based on the 75-g oral glucose tolerance test (OGTT). We also described the potential effect of application of the models into clinical practice.

RESEARCH DESIGN AND METHODS—A prospective cross-sectional study of 2,772 pregnant women was conducted at a referral maternity center in Vietnam. GDM was determined by the American Diabetes Association (ADA), International Association of the Diabetes and Pregnancy Study Groups (IADPSG), Australasian Diabetes in Pregnancy Society (ADIPS), and World Health Organization (WHO) criteria. Prognostic models were developed using the Bayesian model averaging approach, and discriminative power was assessed by area under the curve. Different thresholds of predicted risk of developing GDM were applied to describe the clinical impact of the diagnostic criteria.

RESULTS—The magnitude of GDM varied substantially by the diagnostic criteria: 5.9% (ADA), 20.4% (IADPSG), 20.8% (ADIPS), and 24.3% (WHO). The ADA prognostic model, consisting of age and BMI at booking, had the best discriminative power (area under the curve of 0.71) and the most favorable cost-effective ratio if implemented in clinical practice. Selective screening of women for GDM using the ADA model with a risk threshold of 3% gave 93% sensitivity for identification of women with GDM with a 27% reduction in the number of OGTTs required.

CONCLUSIONS—A simple prognostic model using age and BMI at booking could be used for selective screening of GDM in Vietnam and in other low- and middle-income settings.

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Gestational diabetes mellitus (GDM) has increased worldwide (1) and occurs in 1–28% of all pregnancies (2). This figure varies substantially between populations and the diagnostic criteria used. GDM is associated with adverse perinatal outcomes (3), future development of type 2 diabetes in the mother (4), and an increased risk of the offspring developing obesity and impaired glucose tolerance in childhood and early adulthood (5,6). Despite the recent publication of screening guidelines based on perinatal outcomes from the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) multinational large study, no international consensus for the screening of GDM has been reached (2).

The 75-g oral glucose tolerance test (OGTT) is accepted as the method of screening for GDM by the American Diabetes Association (ADA) (7), the International Association of the Diabetes and Pregnancy Study Groups (IADPSG) (8), World Health Organization (WHO) (9), and Australasian Diabetes in Pregnancy Society (ADIPS) (10). There has long been a debate about whether selective or universal screening for GDM should be performed. A universal approach to screening detects more women with GDM but requires greater resources (11,12). In low- and middle-income countries, universal screening poses particular challenges. High prevalence and limited resources available for management and health promotion may render universal screening impossible in under-resourced settings. Under these circumstances, a selective approach may be a reasonable alternative (13,14). Selective screening in women at high-risk for GDM can also result in a substantial decrease in the number of OGTTs performed compared with a universal screening, with acceptable sensitivity in case detection (14,15). Importantly, improved performance with a selective approach has been reported if the risk indicators are derived from the population where screening is being carried out (13–15). Unfortunately, which selective screening approach has the most favorable cost-effective profile if implemented in daily clinical practice has yet to be determined. These data are crucial in low- and middle-income countries where health care centers are overcrowded, understaffed, and insufficiently resourced.

This study aims to determine the sensitivity and specificity of prognostic models for the selective screening of GDM in a low-resource setting. We compare four major diagnostic criteria that use the 75-g OGTT at 28 weeks' gestation for diagnosis of GDM. We report the ability of different predictive models to identify GDM cases and the potential for reduction in the number of OGTTs needed. Using this information, we aim to determine the optimum selective screening model and diagnostic criteria for this setting.

RESEARCH DESIGN AND METHODS

RESEARCH DESIGN AND METHODS—The prospective cross-sectional study was conducted at Hung Vuong Hospital, a tertiary level, referral

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maternity hospital of Ho Chi Minh City, Vietnam. This hospital serves as a local and referral hospital for women in the city and surrounding provinces and conducted around 35,000 deliveries in 2010. Approximately one-quarter of the women who deliver in the hospital who are local women receiving routine antenatal care through the outpatient departments, and these women represented the target population of this study. We excluded women referred from other hospitals or private clinics for the management of antenatal complications or delivery because we felt they would not reflect population norms.

Women were approached in the antenatal outpatient clinic and given information about the study. Women were eligible if they were having antenatal care through the hospital outpatient departments, aged older than 18 years, had confirmed gestation between 24 and 32 weeks (by early ultrasound or certain menstrual period date), singleton pregnancy, planned to deliver in the hospital, and were not known to have diabetes.

Participants were recruited from 1 December 2010 to 31 March 2011. All women delivered by 21 August 2011, and the follow-up component of the study addressing consequences of GDM in an urban setting of Vietnam has been published elsewhere (16). All study participants underwent a 75-g OGTT between 24 and 32 weeks' gestation with testing as close to 28 weeks as possible. Women were given instructions to fast from midnight the night before and present in the morning for testing. Blood samples were collected fasting and at 1 and 2 h after ingestion of 75 g anhydrous glucose dissolved in 200 mL water.

To assess sociodemographic characteristics and medical risk factors for GDM, women completed a structured, 10-min interview at the time of OGTT testing conducted by one of three trained research midwives. Sociodemographic characteristics were collected, including age, occupation, education level, ethnicity, parity, and residency. Medical risk factors for GDM were collected, which included obstetric history of stillbirth, macrosomia (birth weight ≥4,000 g), induced abortion and previous caesarean delivery, prior history of GDM, and family history of diabetes or hypertension in the first-level relatives, as well as pregnancy characteristics at booking and at the OGTT. Weight, height, and blood pressure were determined from the antenatal record and measured again at the time of OGTT. Body weight was measured in light clothing without shoes, and height was determined without shoes on a portable stadiometer with a mandible plane parallel to the floor. Blood pressure was measured with the woman seated after having rested for at least 5 min. The interview was trialled on ~100 women for acceptability and applicability before commencement of the main study.

GDM status was assessed from blood samples collected from the antecubital fossa and processed within 1 h of collection using the glucose hexokinase enzymatic method (Roche/cobase c systems c501). Calibration was performed with each new batch of reagent or every 2 days, whichever was sooner, according to the manufacturer's instructions. If values were obtained outside the reference range, recalibration was performed and the samples were retested to confirm the result.

Sample size was estimated based on the number of events per predictor analyzed in the logistic regression analysis, and at least 10 events were needed for each independent predictor to ensure the confidence limits properly covered the estimated values (17). There were three (13,18), four (19), five (14,20), and six (21) independent predictors in the published prognostic models of GDM. Under an assumption of our models consisting of a maximum of six independent predictors and prevalence of GDM in Vietnam close to that in Japan (2.5%) (22), using the most stringent ADA criteria, at least 2,400 pregnant women should be recruited in the study. The study had a power of 90% at a significance level of 5% to determine an association between a predictor and GDM with an odds ratio of 1.6 or more.

The prevalence of GDM was calculated using four different criteria for the diagnosis of GDM (Table 1). Cohen's κ statistic (23) and the corresponding 95% CI for assessment of agreement between the criteria was calculated. The agreement was considered to be fair, moderate, substantial, and very good if the κ statistics were 0.21–0.40, 0.41–0.60, 0.61–0.80, and >0.80, respectively (24). The optimal prognostic model for GDM was selected by the Bayesian model averaging (BMA) approach (25), which searched for a model with minimum number of risk factors and maximum discriminatory power. We used the receiver operating characteristic curve analysis and its corresponding area under the curve to assess the discriminative performance of the prognostic models (26). Predicted probability of a woman at risk for development of GDM was estimated as:

$$\frac{1}{1 + e^{-y}}$$

where y is the logistic regression function of the selected prognostic model. We reported the number of OGTTs that would be performed, sensitivity (or number of GDM cases possibly identified), specificity, and positive and negative predictive value

Table 1—*Current diagnostic criteria of GDM based on 75-g OGTT*

Criteria	Diagnosis
ADA (7)	GDM defined as at least two values meeting the thresholds: Fasting plasma glucose ≥5.3 mmol/L 1-h plasma glucose ≥10.0 mmol/L 2-h plasma glucose ≥8.6 mmol/L
IADPSG (8)	GDM defined as at least one value meeting the threshold: Fasting plasma glucose ≥5.1 mmol/L 1-h plasma glucose ≥10.0 mmol/L 2-h plasma glucose ≥8.5 mmol/L
WHO (9)	GDM defined as diabetes or impaired glucose tolerance Diabetes defined as at least one value meeting the threshold: • Fasting plasma glucose ≥7.0 mmol/L • 2-h plasma glucose ≥11.1 mmol/L Impaired glucose tolerance defined as: • Fasting plasma glucose <7.0 mmol/L • 2-h plasma glucose ≥7.8 mmol/L
ADIPS (10)	GDM defined as at least one value meeting the threshold: Fasting plasma glucose ≥5.5 mmol/L 2-h plasma glucose ≥8.0 mmol/L

for different thresholds of predicted probability of GDM risk under an assumption that only a woman whose GDM risk for development of GDM is at the threshold or higher would undergo the OGTT. A value of $P = 0.05$ indicated statistical significance; all P values were two-sided. A predictive nomogram was developed from the model with the best discriminative power to facilitate early prediction of a woman at risk for development of GDM. All analyses were performed using R 2.13.2 software (The R Foundation for Statistical Computing, 2011).

Ethical approval was obtained from the University of Sydney (HREC approval number 13200) and the Hung Vuong Hospital Ethics Approval Board (approval number 725/QĐ-BVHV) before commencement of the study. All study participants were given written and oral information about the study and provided written informed consent to participate.

RESULTS—During a 4-month period, 4,802 potentially eligible women presenting for routine antenatal care at Hung Vuong Hospital were screened for eligibility, with 2,952 women found eligible. The most common reason for ineligibility was planning to deliver elsewhere, with many city workers planning to return to their home province for delivery. Of those eligible women, 2,824 consented to participate in the study. There were 43 women who were unable to complete the OGTT, and 9 withdrew from the study, leaving 2,772 with baseline data and OGTT results (94% of eligible women).

There were 164 women diagnosed with GDM by the ADA criteria, 5.9% (95% CI 5.0–6.8); 565 by the IADPSG criteria, 20.4% (18.9–21.9); 577 by the ADIPS criteria, 20.8% (19.3–22.3); and 674 by the WHO criteria, 24.3% (22.7–25.9). The ADA criteria had fair agreement with the other criteria, Cohen's κ statistic of 0.39 (0.36–0.42) to the IADPSG, of 0.37 (0.34–0.39) to the ADIPS criteria, and of 0.30 (0.25–0.35) to the WHO criteria. The IADPSG criteria substantially agreed with the WHO criteria (0.59 [0.56–0.63]) and the ADIPS criteria (0.66 [0.63–0.70]). Agreement between the WHO criteria and ADIPS criteria agreement was however very high (0.87 [0.83–0.91]).

Table 2 illustrates the baseline characteristics of the participants by GDM status as determined by diagnostic criteria. Regardless of criteria, women with GDM were more likely to be older, of higher

Table 2—*Baseline characteristics of the participants*

	ADA criteria		IADPSG criteria		WHO criteria		ADIPS criteria		
	GDM	Non-GDM	GDM	Non-GDM	GDM	Non-GDM	GDM	Non-GDM	
Variables	n = 164	n = 2,608	n = 565	n = 2,207	n = 674	n = 2,098	n = 577	n = 2,195	Total
Age (years)	31.2 ± 4.2	28.1 ± 4.8*	29.9 ± 4.8	27.8 ± 4.7*	29.7 ± 4.6	27.8 ± 4.8*	29.9 ± 4.7	27.8 ± 4.8*	28.2 ± 4.8
At booking									
Gestational age (weeks)	12.3 ± 7.0	12.1 ± 6.6	12.4 ± 6.8	12.1 ± 6.5	12.1 ± 6.9	12.1 ± 6.5	12.2 ± 7.0	12.1 ± 6.5	12.1 ± 6.6
BMI (kg/m^2)	21.8 ± 3.1	20.6 ± 2.7*	21.3 ± 3.0	20.5 ± 2.6*	21.1 ± 3.0	20.5 ± 2.6*	21.2 ± 3.0	20.5 ± 2.7*	20.6 ± 2.7
At OGTT									
Arterial pressure (mmHg)	78.5 ± 6.6	77.7 ± 6.4	78.3 ± 6.7	77.6 ± 6.3*	77.9 ± 6.6	77.7 ± 6.3	78.0 ± 6.7	77.7 ± 6.3	77.9 ± 6.4
Gestational age (weeks)	28.4 ± 1.8	28.7 ± 1.7	28.5 ± 1.7	28.7 ± 1.7*	28.6 ± 1.8	28.7 ± 1.7	28.6 ± 1.8	28.7 ± 1.7	28.7 ± 1.7
Ethnic Vietnamese	158 (96.3)	2,484 (95.3)	543 (96.1)	2,099 (95.1)	651 (96.6)	1,991 (94.9)	556 (96.4)	2,086 (95.0)	2,642 (95.3)
Education attained									
Primary	14 (8.6)	195 (7.5)	46 (8.1)	163 (7.4)	51 (7.6)	158 (7.5)	46 (8.0)	163 (7.4)	209 (7.5)
Secondary	99 (60.4)	1,684 (64.6)	351 (62.1)	1,432 (64.9)	418 (62.0)	1,365 (65.1)	361 (62.6)	1,422 (64.8)	1,783 (64.3)
Tertiary	51 (31)	729 (27.9)	168 (29.8)	612 (27.7)	205 (30.4)	575 (27.4)	170 (29.4)	610 (27.8)	780 (28.2)
Nulliparity	76 (46.3)	922 (35.4)*	240 (42.5)	758 (34.4)*	266 (39.5)	732 (34.9)*	235 (40.7)	763 (34.8)*	998 (36)
History of									
Caesarean delivery	28 (17.1)	206 (7.9)*	63 (11.2)	171 (7.8)*	68 (10.1)	166 (7.9)	60 (10.4)	174 (7.9)	234 (8.4)
GDM	3 (1.8)	7 (0.3)*	4 (0.7)	6 (0.3)	6 (0.9)	4 (0.2)*	6 (1.0)	4 (0.2)*	10 (0.4)
Stillbirth	12 (7.3)	76 (2.9)*	22 (3.9)	66 (3.0)	33 (4.9)	55 (2.6)*	27 (4.7)	61 (2.8)*	88 (3.2)
Macrosomia	5 (3.1)	25 (1.0)*	10 (1.8)	20 (0.9)	9 (1.3)	21 (1.0)	8 (1.4)	22 (1.0)	30 (1.1)
First-level relatives									
With diabetes	24 (14.6)	167 (6.4)*	62 (11.0)	129 (5.9)*	66 (9.8)	125 (6.0)*	61 (10.6)	130 (5.9)*	191 (6.9)
With hypertension	48 (29.3)	452 (17.3)*	122 (21.6)	378 (17.1)*	130 (19.3)	370 (17.6)	114 (19.8)	386 (17.6)	500 (18.0)

Data are presented as mean ± SD or as n (%). *$P < 0.05$ (χ^2 test for categorical variables, and Student t test for continuous variables).

BMI at booking, nulliparous, and to have a first-level relative with diabetes. History of previous GDM and stillbirth were not different between GDM and non-GDM groups identified by the IADPSG criteria, but did differ according to the ADA, WHO and ADIPS criteria.

BMA analysis was performed to determine the optimal prognostic model for GDM by each different diagnostic criterion. Age and BMI at booking strongly predicted the risk for development of GDM identified by the ADA criteria, with an adjusted relative risk (95% CI) of 1.70 (1.46–1.98, $P < 0.0001$) for every 5-year increase in the mother's age, and 1.33 (1.15–1.54, $P < 0.0001$) for every 3-unit increase in BMI at booking. This was also demonstrated for the ADIPS criteria (1.47 [1.34–1.61], $P < 0.0001$ for age; 1.18 [1.08–1.30], $P < 0.0001$ for BMI), and WHO criteria (1.42 [1.30–1.56], $P < 0.0001$; 1.14 [1.04–1.24], $P = 0.005$, respectively). The optimal model for the IADPSG criterion included age (1.44 [1.31–1.58], $P < 0.0001$ for every 5-year increase), BMI at booking (1.23 [1.12–1.35], $P < 0.0001$ for every 3-unit increase), and a first-level relative with diabetes (1.65 [1.19–2.28], $P = 0.003$). The model predicting GDM identified by the ADA criteria had the best prognostic performance with the area under the curve of 0.71 (0.68–0.75), compared with 0.65 (0.62–0.67), 0.64 (0.62–0.67), and 0.63 (0.60–0.65) for IADPSG, ADIPS and WHO criteria, respectively.

The ADA predictive model also demonstrated the greatest sensitivity for the detection of GDM with the lowest number of OGTTs that would be required (Table 3). If the threshold of GDM risk was 3%, selective screening of GDM using the ADA prognostic model would have 93% GDM cases identified with a 27% reduction in the number of OGTTs required. A risk threshold of 4% would enable the model to halve the number of OGTTs needed; however, 20% of women with GDM would remain undiagnosed. To get ~93% GDM cases diagnosed, the prognostic models from other criteria would be able to reduce only 10% of the OGTTs needed. Figure 1 presents the prognostic model developed from the ADA model, which will be used for early prediction of development of GDM in a Vietnamese pregnant woman. The nomogram consists of two axes of age and BMI at booking, and a vertical line connecting two axes indicates the predicted risk of development of GDM. The risk of development of GDM for a 28-year-old pregnant woman with BMI at booking of 22 kg/m^2 will be estimated at ~5%, which is the intersection point between the line connecting the age axis at 28 to the BMI axis at 22 and the middle axis of GDM risk at 5%.

CONCLUSIONS—The prevalence of GDM in Ho Chi Minh City, Vietnam, varies substantially by the diagnostic criteria used, from ~6% by the ADA criteria up to 20% by other criteria. A prognostic model for the ADA criteria consisting of age and BMI at booking had the greatest sensitivity for detection of cases, 93%, and would be the most efficient in reducing the number of OGTTs that would need to be performed compared with universal screening (reduction of 27%). The thresholds required for the ADA criteria are the highest of the criteria we tested, indicating that these women are likely to have more severe glucose intolerance and

Table 3—*Potential clinical impacts of different selective screening strategies with different thresholds of predicted probability of risk for development of GDM applied*

	Selective 1	Selective 2	Selective 3
ADA 2010 criteria, threshold (%)	2	3	4
Women to be tested with OGTT	2,541 (91.7)	2,018 (72.8)	1,473 (53.1)
Sensitivity	99.4 (96.6–100)	93.3 (88.3–96.6)	79.9 (72.9–85.7)
Specificity	8.8 (7.8–10.0)	28.5 (26.8–30.3)	48.5 (46.6–50.5)
Positive predictive value	6.4 (5.5–7.4)	7.6 (6.5–8.8)	8.9 (7.5–10.5)
Negative predictive value	99.6 (97.6–100)	98.5 (97.4–99.3)	97.5 (96.5–98.2)
IADPSG 2010 criteria, threshold (%)	12	14	18
Women to be tested with OGTT	2,459 (88.7)	2,148 (77.5)	1,446 (52.2)
Sensitivity	94.5 (92.3–96.2)	88.1 (72.9–85.7)	70.4 (66.5–74.2)
Specificity	12.8 (11.4–14.2)	25.2 (23.4–27.1)	52.5 (50.4–54.6)
Positive predictive value	21.7 (20.1–23.4)	23.2 (21.4–25)	27.5 (25.2–29.9)
Negative predictive value	90.1 (86.2–93.2)	89.3 (86.6–91.6)	87.4 (85.5–89.1)
WHO 1999 criteria, threshold (%)	16	18	22
Women to be tested with OGTT	2,455 (88.6)	2,139 (77.2)	1,411 (50.9)
Sensitivity	94.2 (92.2–95.9)	87.2 (84.5–89.7)	65.1 (61.4–68.7)
Specificity	13.3 (11.8–14.8)	26.1 (24.2–28)	53.7 (51.5–55.8)
Positive predictive value	25.9 (24.1–27.6)	27.5 (25.6–29.4)	31.1 (28.7–33.6)
Negative predictive value	87.7 (83.6–91.1)	86.4 (83.5–89)	82.7 (80.6–84.7)
ADIPS 1998 criteria, threshold (%)	12	15	19
Women to be tested with OGTT	2,514 (90.7)	2,054 (74.1)	1,318 (47.6)
Sensitivity	95.7 (93.7–97.2)	86.7 (83.6–89.3)	64.1 (60.1–68)
Specificity	10.6 (9.4–12)	29.2 (27.3–31.2)	56.8 (54.7–58.9)
Positive predictive value	22.0 (20.4–23.6)	24.3 (22.5–26.3)	28.1 (25.7–30.6)
Negative predictive value	90.3 (86–93.6)	89.3 (86.8–91.4)	85.8 (83.9–87.5)

Data are presented as *n* (%) or % (95% CI), unless otherwise indicated.

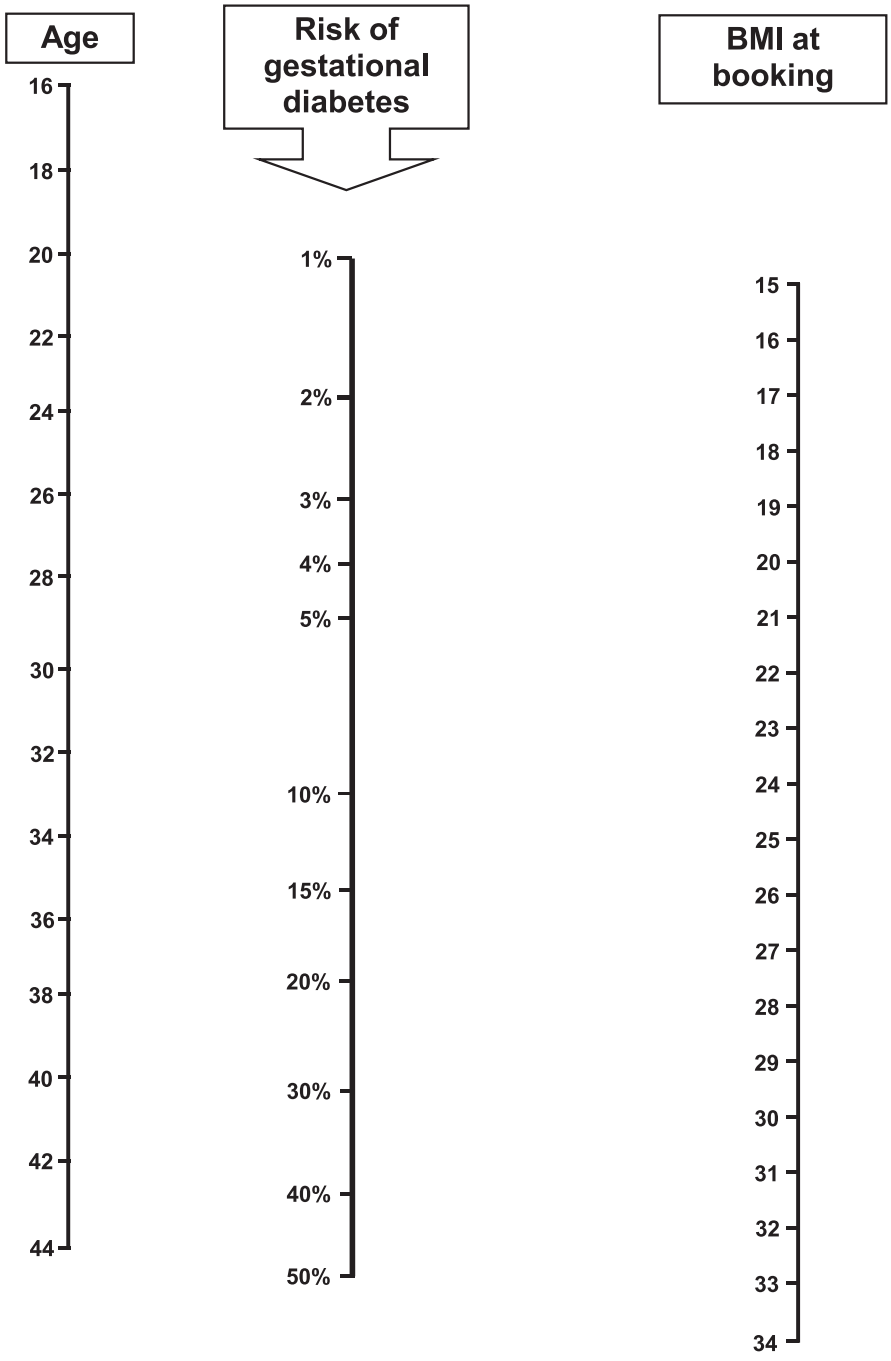

Figure 1—*Nomogram for early prediction of the risk of development of GDM in Vietnam. The left and right columns represent age and BMI at booking, respectively, and the middle line indicates the risk of development of GDM. The GDM risk (5%) of a 28-year-old pregnant woman with BMI of 22 kg/m^2 is the intersection point between the line connecting the age axis at 28 to the BMI axis at 22 and the middle axis.*

thus more at risk for adverse perinatal outcomes, which is supported by the findings in our previous publication (16). In a limited resource setting, it is vital to identify the women most at risk for the lowest cost. This prognostic method is conceptually simple to use and could easily be incorporated into clinical practice.

Despite a substantial variation resulting from diversity of the criteria used, the magnitude of GDM in Vietnam was comparable to previous reports (13,27). The prevalence of GDM in an Iranian population was reported as 6.1%, 12.1%, and 18.8% by the ADA, WHO, and ADIPS criteria, respectively (13). The rates of GDM by the new IADPSG criteria in Asian populations have been found to be very close to ours, with a GDM prevalence using these criteria of 23.0% in Thailand and 25.1% in Singapore (27). Our study reports a similar trend by which the new IADPSG criteria result in a tripling of the GDM prevalence, such as in Japan (22), United Arab Emirates (28), and Mexico (29).

In Vietnam, we found that age and BMI at booking were the strongest predictors of developing GDM. Advanced age and BMI, among the well-known predictors of development of GDM, were also reported in other prognostic models developed from high-income (18–21,30) and low-income countries (13,14). The discriminative power of these prognostic models, consisting of at least four predictors, varied from 0.70 in Australia (20) to 0.75 in the U.K. (21) and to 0.77 in the Netherlands (19). The Canadian prognostic model, with discriminative power of 0.68, consisted of age ≥30 years, ethnicity, and BMI ≥22 kg/m^2 (18). Our two-predictor prognostic model had comparable discriminating power to that of other models with more predictive variables.

A simpler model with fewer variables would facilitate its implementation into daily practice, especially in under-resourced and overcrowded settings. In addition, our model was selected by the BMA method, whereas the stepwise-selection procedure was used to select other prognostic models (13,14,18–21), or even no method was applied to take potential confounding effects into account (30). The stepwise model-building procedure has been reported to be associated with higher probability of selecting a redundant variable but with similar chance of selecting the true predictors, which then lead to poorer discriminating performance of the prognostic model than the BMA approach (31,32). Moreover, the BMA but not the stepwise method was able to take the model uncertainty into consideration, improving its prognostic ability (32). We also preserved the continuous nature of predictors included in the prognostic model whereas they were categorized in the other models with a relatively arbitrary cutoff value (13,14,18–20,30). Categorization of a continuous variable was known to lead to a substantial loss of power (33) and an introduction of remarkable interactions (34) and residual confounding (33).

A predictive nomogram constructed from the ADA model, with the risk indicators

easily assessed at the booking visit by a health care provider, facilitates early differentiation of a woman at risk for development of GDM who would subsequently undergo the OGTT at 28 weeks' gestation from a low-risk population to whom the OGTT should not be routinely given. A 28-year-old woman with BMI of 22 kg/m^2 whose GDM risk is estimated to be 5% should be therefore counseled to undergo the OGTT at close to 28 weeks' gestation.

It is well recognized that the treatment provided to women with GDM would be able to improve the pregnancy outcomes (35). From a public health perspective, the selective screening for GDM using the ADA prognostic model would be the promising practical approach for management of GDM in under-resourced settings where universal screening is not always possible. It would have more than 90% of GDM cases diagnosed and reduce a quarter of OGTTs performed if the OGTT were given to women with a risk of GDM at 3% or more. Given similar discriminative power between their four-predictor model and ours, van Leeuwen et al. (19) reported a sensitivity of 75% with 60% reduction of OGTTs performed if a predicted probability of 4% was used as a threshold to consider women at risk for GDM.

Strengths of the study included the large sample size with rigorous methodology. The study, to our knowledge is the largest study addressing a prognostic model of GDM in the context of low- and middle-income countries where the prognostic models from high-income countries are not directly applicable. The robust and sophisticated statistical approach applied in the study enabled us to minimize the chance of selection of a redundant predictor for the prognostic model, ensuring the selected model reliably predicts the risk of a woman developing GDM in under-resourced settings. The study was able to not only compare the predictive ability of all currently recommended criteria for GDM diagnosis but also describe the potential impact for implementation of these prognostic models into clinical practice.

A limitation of the study is that it was a hospital-based study in an urban setting; thus, results may not be replicable in the general population of Vietnam or populations in other high-income countries. Secondly, the discriminative power of the prognostic model determined from our study needs to be validated. The validation of the potential clinical impact of our prognostic model using data of adverse health outcomes associated with undiagnosed GDM cases and corresponding costs will be described in a subsequent report.

In conclusion, the prevalence of GDM in an urban setting of Vietnam substantially varied by the diagnostic criteria. The selective screening approach using the ADA model, aided by a predictive nomogram, would have more than 90% of GDM cases diagnosed and reduce a quarter of OGTTs performed if the OGTT were given to women with a risk of GDM at 3% or more. We propose that this approach would be feasible in an under-resourced context.

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T.S.T. devised and implemented the study, managed the database, performed statistical calculations, wrote the first draft of the manuscript, and read and approved the final draft of the manuscript. J.E.H. devised and implemented the study, managed the database, contributed to writing the manuscript, and read and approved the final draft of the manuscript. M.A.T.D. implemented the study, managed the database, performed statistical calculations, contributed to writing the manuscript, and read and approved the final draft of the manuscript. J.M.M. and H.E.J. devised the study, contributed to writing the manuscript, and read and approved the final draft of the manuscript. T.S.T. is the guarantor of the study, 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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