Increasing Prevalence of Gestational Diabetes Mellitus

A public health perspective

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Recent data show that gestational diabetes mellitus (GDM) prevalence has increased by ~10–100% in several race/ethnicity groups during the past 20 years. A true increase in the prevalence of GDM, aside from its adverse consequences for infants in the newborn period, might also reflect or contribute to the current patterns of increasing diabetes and obesity, especially in the offspring. Therefore, the public health aspects of increasing GDM need more attention.

The frequency of GDM usually reflects the frequency of type 2 diabetes in the underlying population (1,2). Established risk factors for GDM are advanced maternal age, obesity, and family history of diabetes (3). Unquestionably, there are ethnic differences in the prevalence of GDM (4–15). In the U.S., Native Americans, Asians, Hispanics, and African-American women are at higher risk for GDM than non-Hispanic white women (4–6,8–11,13–15). In Australia, GDM prevalence was found to be higher in women whose country of birth was China or India than in women whose country of birth was in Europe or Northern Africa (7). GDM prevalence was also higher in Aboriginal women than in non-Aboriginal women (12). In Europe, GDM has been found to be more common among Asian women than among European women (16). The proportion of pregnancies complicated by GDM in Asian countries has been reported to be lower than the proportion observed in Asian women living in other continents (17). In India, GDM has been found to be more common in women living in urban areas than in women living in rural areas (18).

The trend toward older maternal age (19), the epidemic of obesity (20) and diabetes (21), and the decrease in physical activity (22) and the adoption of modern lifestyles in developing countries (23) may all contribute to an increase in the prevalence of GDM. Because GDM is associated with several perinatal complications (3), and because women with GDM and their offspring are also at increased risk of developing diabetes later in life (3), it is critical to assess trends in GDM prevalence to allocate appropriate resources to perinatal management and postpartum diabetes prevention strategies. Characterizing trends in GDM might also help to understand possible mechanisms for the increase of obesity and type 2 diabetes, especially in children. Recent data (7,11–15) show that GDM prevalence has increased by ~16–127% in several race/ethnicity groups during the past 20 years. These variations may depend on differences in methodology and study populations across studies. Methodological issues are described below as well as studies of trends in GDM. Some studies (7,11) calculated the "cumulative incidence" (defined as the percentage of pregnancies in which GDM was recognized) because GDM frequency was calculated among screened pregnancies regardless of whether they delivered an infant. However, most of the studies (12–14,15) identified only women who delivered, and therefore they calculated the "prevalence" of GDM at delivery. For simplicity, the term "prevalence" of GDM will be used for all studies, since the GDM cumulative incidence estimates are similar to the prevalence estimates, given the small number of preggnancies that were screened but did not deliver an infant.

METHODOLOGICAL ISSUES IN ASSESSING TRENDS IN GDM PREVALENCE

— There are several important issues in studying trends in GDM. The first issue is the definition of GDM, which has been described as carbohydrate intolerance of varying degree of severity with onset or first recognition during pregnancy (24,25). This definition makes it difficult to distinguish between undiagnosed diabetes existing before pregnancy and hyperglycemia induced by pregnancy. Reasons for this difficulty are the facts that women in childbearing age are usually not screened for diabetes. Epidemiological studies that included an unselected large sample of women with blood glucose concentrations tested before pregnancy and followed through pregnancy have not been performed yet. Unrecognized diabetes before pregnancy could be ruled out in women with abnormal glucose tolerance during pregnancy if glucose tolerance was shown to return to normal at postpartum. However, studies of trends in GDM with systematic data on postpartum glucose tolerance status are lacking. When trends in GDM are examined, it is also important to know the penetration of screening for GDM over time to use the correct denominator. An increase in GDM screening from the beginning to the middle of the 1990s has been reported (11). If studies are not able to include in the denominator only women who were screened for GDM, increased prevalence of GDM over a time period might be the consequence of increased screening activity during that period of time. Finally, and most importantly, a difficulty in assessing true trends in GDM is represented by changes in the recommended diagnostic criteria. Studies

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Abbreviations: GDM, gestational diabetes mellitus.

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

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Table 1—*Studies of trends in the prevalence of GDM*

	n; race/ethnicity	Study period (years)	Change in GDM prevalence	Relative increase in GDM prevalence	Criteria for GDM definition	Age-adjusted
Northern California (U.S.) (11)	267,051; 45% non-Hispanic white	1991–2000	3.7% to 6.6% 5.1% to 6.9%	68% 35%	2000 ADA 2000 ADA or diagnosis	Yes
South Australia (12)	230,011; 96% non-Aboriginal	1988–1999	1.8% to 3.1% in non-Aboriginal 5.2% to 5.8% in Aboriginal	72% 12%	ADIPS and WHO	Yes
Colorado (U.S.) (13)	36,403; 61% non-Hispanic white	1994–2002	2.1% to 4.1%	95%	NDDG	Yes
Montana (U.S.) (14)	44,299; 86% white	2000–2003	2.0% to 2.2% in white; 2.4% to 2.9% in American Indian	10% 21%	GDM in infants' birth certificates	No
Melbourne (Australia) (7)	35,253; 66% Australian	1979–1983 and 1984–1988	3.3% to 7.5%	127%	Local criteria (7)	No
New York City (U.S.) (15)	236,003; 26% non-Hispanic white	1990 and 2001	2.6% to 3.8%	46%	GDM in infants' birth certificates	No

ADA, American Diabetes Association criteria (29); ADIPS, Australasian Diabetes in Pregnancy Society criteria (12); NDDG, National Diabetes Data Group criteria (27); WHO, World Health Organization criteria (30).

have shown that when the results of a 100-g 3-h oral glucose tolerance test were interpreted by using the lower Carpenter and Coustan (26) plasma glucose thresholds (recommended in 1998 by the Proceedings of the Fourth International Workshop-Conference of Gestational Diabetes [25]) instead of the National Diabetes Data Group (27) criteria (recommended until 1997), the frequency of GDM increased by ~50% (10,28). Therefore, it is critical that studies of trends in GDM have access to laboratory glucose results to apply uniform criteria to define GDM through all the study period.

TRENDS IN GDM PREVALENCE

— Despite the abovementioned difficulties in assessing trends in GDM prevalence, there are six studies from which we can learn about these trends (Table 1). The first four studies (11–14) in the table are studies that assessed the annual prevalence for all the study years. The last two studies (7,15) in the table estimated GDM frequency for two time periods. All studies reported an increase in GDM prevalence. However, increases varied widely across studies: from 16% in Montana to 127% in the study in a large maternity hospital in Melbourne. These variations may depend on differences in clinical surveillance for diabetes before pregnancy, length of the time of observation, the time period the study was conducted, the racial/ethnic composition of the study population, whether GDM prevalence was controlled for changes in maternal age (usually more advanced in the latest years), whether trends were analyzed only among women who were screened for GDM, and whether laboratory glucose results were available and GDM therefore was accurately defined by the same plasma glucose thresholds over time.

The Northern California Kaiser Permanente study (11) was the only study that accurately assessed variation in penetration of screening over time and used laboratory glucose results to apply the same plasma glucose thresholds for the definition of GDM over the entire study period. The 2000 American Diabetes Association criteria (29) were used to define GDM by hyperglycemia (95% of the cases defined by the Carpenter and Coustan [26] criteria). Among screened pregnancies, the age- and race/ethnicity-adjusted yearly prevalence of GDM defined by hyperglycemia increased by 68%: from 3.7% in 1991 to 6.6% in 1997, and lev-

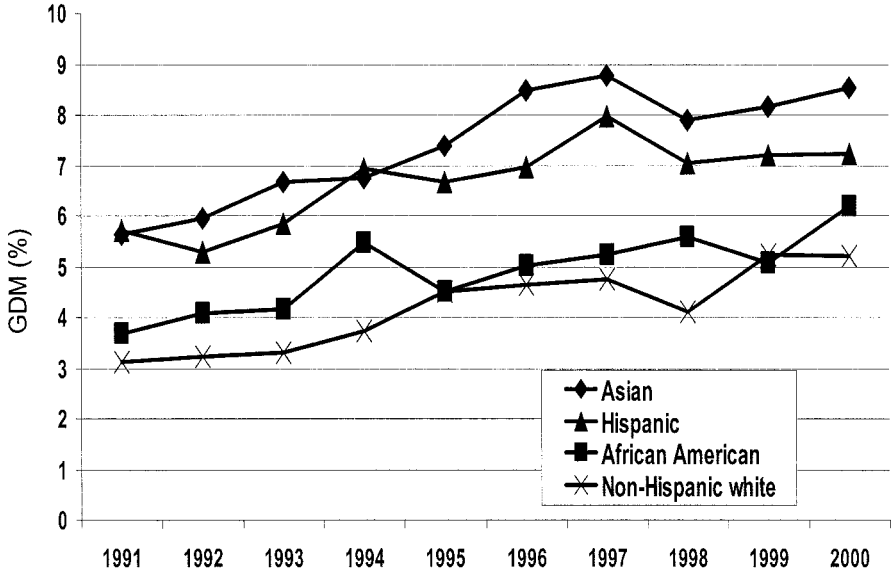

Figure 1—*Age-adjusted prevalence of GDM by race/ethnicity and years: Northern California Kaiser Permanente, 1991–2000. GDM was defined according to documented laboratory hyperglycemia identified during pregnancy according to the American Diabetes Association recommendation (29), a hospital discharge diagnosis* (International Classification of Diseases, Ninth Revision, *code 648.8), or both.*

eled off through 2000 (6.2%). The prevalence of GDM defined by hyperglycemia, a hospital discharge diagnosis, or both increased from 5.1% in 1991 to 7.4% in 1997 and then leveled off through 2000 (6.9%). Similar increases in the prevalence of GDM were observed in all ethnic groups (Fig. 1). The prevalence of GDM (defined by American Diabetes Association criteria [29] or physician diagnosis) was higher among Asians and Hispanics, intermediate among African-Americans, and lower among non-Hispanic whites. The prevalence of GDM increased in all age-groups with the highest proportional increase in the youngest group, where the prevalence almost doubled from 1991 (1.4%) to 2000 (2.7%). A cohort effect on the prevalence of GDM appeared to vary by race/ethnicity. Figure 2 shows the age-specific prevalence of GDM for four cohorts of women grouped according to their birth period within each race/ethnicity group. Among non-Hispanic white women and Asians, for a given age

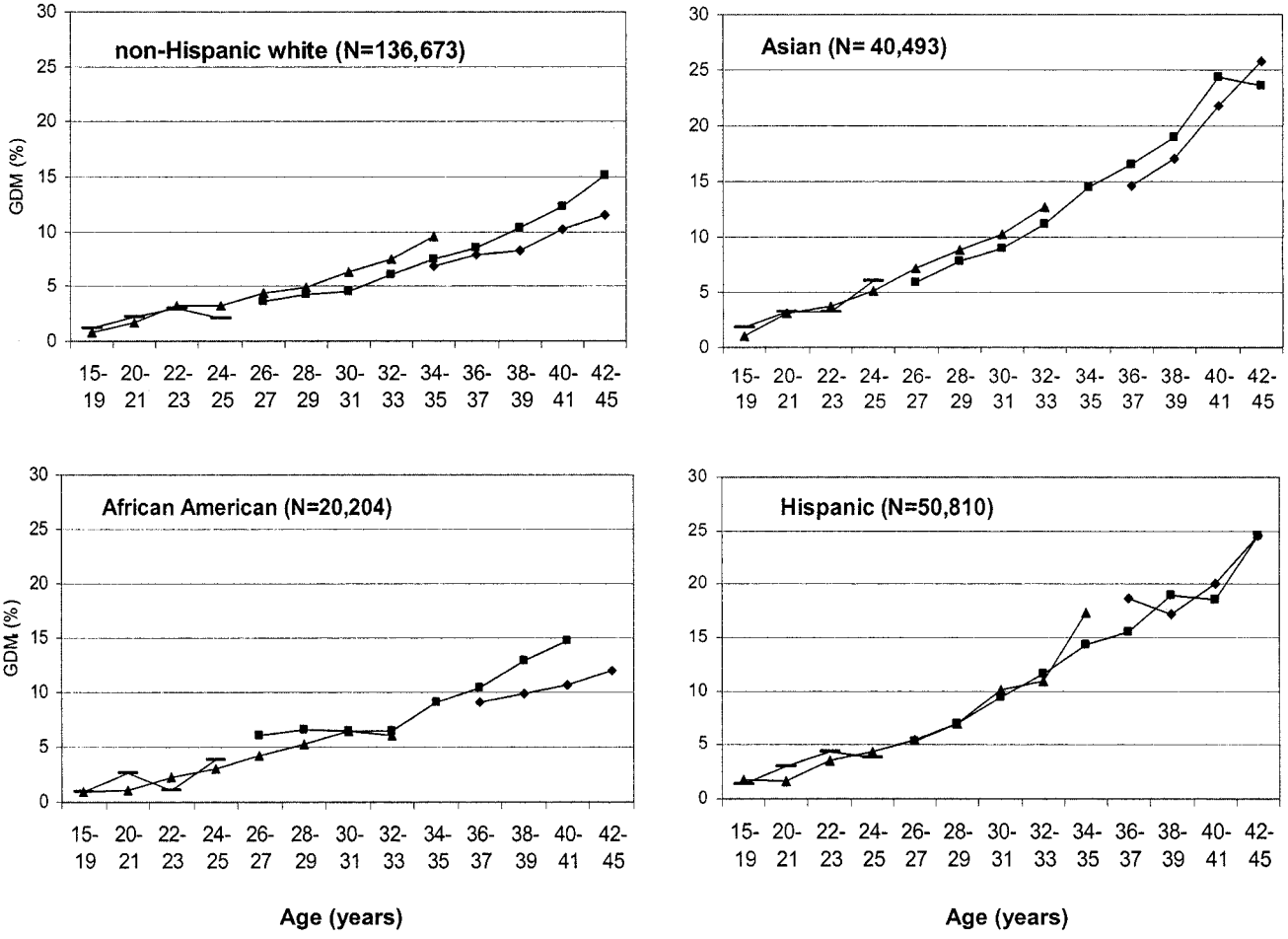

Figure 2—*Age-specific prevalence of GDM by birth cohort and race/ethnicity: Northern California Kaiser Permanente, 1991–2000. Birth cohort years: ♦, 1946–1955; ■ 1956–1965; ▲, 1966–1975; —, 1976–1985.*

at delivery, the prevalence was higher in younger cohorts than in older cohorts, although the prevalence was similar in the two most recent cohorts (birth years 1966–1975 and 1976–1985). Among African-American women, a cohort effect was observed only between the two older birth cohorts: for a given age, the prevalence of GDM was higher in the older birth cohort (birth years 1946–1955). A cohort effect was not present at all among Hispanic women.

The South Australia study (12) examined the prevalence of GDM between 1988 and 1999. An increase of 72% in GDM prevalence among non-Aboriginal women was observed, whereas a smaller increase of 12% was observed among Aboriginal women. The penetration of screening over time was unknown and the yearly denominator included all pregnancies, regardless of screening. Results from the 75-g 2-h oral glucose tolerance test were not available; therefore, the authors were not able to use the same glucose thresholds for the definition of GDM over time. The authors estimated that GDM was diagnosed according to the Australasian Diabetes in Pregnancy Society criteria during the first 5 years of the study and by the slightly lower 1985 World Health Organization (30) plasma glucose thresholds from 1993 through 2000. Therefore, some of the observed increases in GDM prevalence might be a result of the changes in the criteria for GDM diagnosis or variations in the penetration of screening over time.

The Colorado Kaiser Permanente study (13) observed an increase in GDM prevalence of ~95% between 1994 and 2002. However, this large increase should be interpreted with caution. The pregnancy cohort was identified through a clinical perinatal database that did not include laboratory data. It was assumed that during the entire study period, the clinical database classified women as having GDM if they met the National Diabetes Data Group (27) criteria. It is possible that the large increase in GDM prevalence was in part because, after 1998, some clinicians may have diagnosed GDM according to the Carpenter and Coustan criteria, as recommended by the Proceedings of the Fourth International Workshop-Conference on GDM (25) published in August 1998. The penetration of screening over time was not well documented. Nevertheless, the Colorado study showed a similar increase in GDM in all race/ethnicity groups and found a higher prevalence among Asian women. The Colorado study first reported a cohort effect on GDM prevalence. Women who were born more recently were at increased risk for GDM diagnosis than women born earlier; however, no difference in GDM diagnosis was found between the two most recent birth cohorts.

A recent report from Montana showed that the prevalence of GDM, as reported in the birth certificate records, increased by ~10% among white women and by ~21% among American Indian women between 2000 and 2003. Variation of penetration of screening over time and criteria for GDM diagnosis were not available.

An early report from Melbourne (7) compared the prevalence of GDM in one large maternity hospital in 1979–1983 and 1984–1988. The authors demonstrated a doubling in the GDM prevalence that appeared to apply similarly to mothers who were born in many different countries and currently living in Australia. However, the authors did not adjust for the changing age distribution among the pregnant women over the time period, and possible variation in penetration of screening was not assessed. Therefore, the doubling in GDM prevalence should be interpreted with caution.

Finally, a recent study (15) examined GDM prevalence as reported in the New York City birth certificate records in 1990 and again in 2001. The prevalence of diagnosed GDM increased by ~46%, and increments were observed in all race/ethnicity groups. However, possible variations in penetration of screening or in criteria used to diagnose GDM were not documented. Also in this study, the prevalence of GDM was higher among Asian women.

WHY IS GDM INCREASING? — All six studies of trend in GDM conducted in different populations and with different methodologies consistently reported an increase in GDM in all race/ethnicity groups, suggesting that the observed increase in GDM prevalence may be true. However, none of the six studies could distinguish between women who have been reclassified postpartum as having underlying diabetes from those who returned to normal glucose tolerance. Higher relative increases in younger women suggest that the prevalence of risk factors for GDM may have increased more in younger women than in older women. However, none of the studies had information on maternal obesity, the most important modifiable risk factor for GDM (3), and therefore none of the studies was able to assess whether the observed increases in GDM prevalence were explained by concomitant increases in maternal obesity. It is worth noting some results that might suggest a possible plateau in the increase of GDM prevalence. The Northern California Kaiser Permanente study (11) showed that the increase in GDM prevalence leveled off after 1997. Although women who were born more recently had a higher prevalence of GDM than women who were born later, no differences in the prevalence of GDM between the two most recent birth cohorts were observed. The lack of data on maternal obesity make it impossible to explain whether these findings would be explained by a plateau of maternal obesity after 1997, or whether maternal obesity has increased less in the younger generations, or whether the increasing prevalence of GDM in women from younger birth cohorts is independent of the effect of obesity. In summary, there is a need for large epidemiological studies that assess prepregnancy and/or postpartum glucose tolerance status to evaluate the contribution of underlying glucose intolerance in the development of GDM. There is also the need of additional studies that assess prepregnancy obesity and possible GDM risk factors operating before childbearing to better understand trends in the prevalence of GDM and plan prevention strategies. The higher prevalence of GDM among Asian women needs further investigation. Epidemiological data on modifiable risk factors of GDM are sparse. Besides obesity, a major GDM risk factor, there is a suggestion that physical inactivity (31), diets high in saturated fat (32), and smoking (33) are associated with increasing risk for GDM or recurrent GDM. It is critical to know the risk factors for GDM not only to better understand trends in GDM, but also to allow early identification of women at risk and prevention of this common pregnancy complication.

GDM INCREASE IS A PUBLIC HEALTH CONCERN — Whatever the underlying reason for the observed increases in the prevalence of GDM, the health care system is faced with an increase in GDM. Therefore, this pregnancy complication will require increased re-

sources to manage appropriate glycemic control during pregnancy and reduce adverse perinatal outcomes (34). In addition, ~50% of women with GDM are expected to develop type 2 diabetes within 5 years of the index pregnancy (35). Recent clinical trials have shown that health behaviors such as diet and physical activity prevent or delay the onset of diabetes (36,37). Such behavioral interventions have been shown to be cost-effective at a higher level than a pharmacological intervention (38). Therefore, clinicians will increasingly have to promote plasma glucose testing and improved health behaviors at postpartum visits of women who had GDM to prevent development of diabetes and recurrent GDM. However, discontinuities in health care may lead to inadequate postpartum follow-up and care. Women with GDM are diagnosed by an obstetrician during pregnancy but often are referred to the primary care provider after delivery. Also, some physicians may not recognize that women with GDM are at risk of diabetes. As reported in a survey conducted in 1998, only 62% of the American College of Obstetrics and Gynecology members believed that women with GDM were at increased risk of diabetes (14). Probably more evidence on the efficacy of postpartum behavioral intervention in preventing diabetes in women with GDM is needed to increase the awareness of physicians about the importance of counseling GDM women about their risk of diabetes and behavioral changes (39). In addition, GDM may play a crucial role in the increasing prevalence of diabetes and obesity. Infants of women with GDM or diabetes are at increased risk of developing obesity, impaired glucose tolerance, and diabetes as children or young adults (40–42), and the increased risk may be independent of genetic factors (43).

In conclusion, a true increase in the prevalence of GDM, aside from its adverse consequences for infants in the newborn period, might reflect or contribute to the ongoing pattern of increasing diabetes and obesity. The possible long-term effects of the increase in GDM on the immediate offspring will not be known for decades. Access to health care and quality care for GDM women and their offspring need to be more widely available. Therefore, coordinated efforts are required to alter these trends in GDM and to prevent chronic diabetes in GDM patients and their offspring.

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