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**Gestational diabetes mellitus: Challenges for different ethnic groups**

Yuen L *et al.* GDM: Ethnic differences

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## Abstract

Ethnicity is defined as “belonging to a social group that has a common national or cultural tradition”. Membership of certain ethnic groups has long been associated with increased risk of gestational diabetes mellitus (GDM). Studies that examined ethnic differences amongst women with GDM were often conducted in western countries where women from various ethnic backgrounds were represented. The prevalence of GDM appears to be particularly high among women from South Asia and South East Asia, compared to Caucasian, African-American and Hispanic communities. For some, but not all ethnic groups, the body mass index is a risk factor for the development of GDM. Even within a particular ethnic group, those who were born in their native countries have a different risk profile for GDM compared to those born in western countries. In terms of treatment, medical nutrition therapy (MNT) plays a key role in the management of GDM and the prescription of MNT should be culturally sensitive. Limited studies have shown that women who live in an English-speaking country but predominantly speak a language other than English, have lower rates of dietary understanding compared with their English speaking counterparts, and this may affect compliance to therapy. Insulin therapy also plays an important role and there appears to be variation as to the progression of women who progress to requiring insulin among different ethnicities. As for peri-natal outcomes, women from Pacific Islander countries have higher rates of macrosomia, while women from Chinese backgrounds had lower adverse pregnancy outcomes. From a maternal outcome point of view, pregnant women from Asia with GDM have a higher incidence of abnormal glucose tolerance test results post-partum and hence a higher risk of future development of type 2 diabetes mellitus. On the other hand, women from Hispanic or African-American backgrounds with GDM are more likely to develop hypertension post-partum. This review highlights the fact that management needs to be individualised and the clinician should be mindful of the impact that differences in ethnicity may have on the clinical characteristics and pregnancy outcomes in women affected by GDM, particularly those living in Western countries. Understanding these differences is critical in the delivery of optimal antenatal care for women from diverse ethnic backgrounds.

**Key words:** Gestational diabetes mellitus; Ethnicity; Peri-natal outcomes; Medical nutrition therapy; Prevalence

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**Core tip:** The prevalence of gestational diabetes mellitus (GDM) is increasing world-wide, and studies have shown that optimal management of GDM improves pregnancy outcomes. This review summarises the differences in prevalence, clinical profile, management and pregnancy outcomes among women from various ethnic backgrounds who have GDM. Ethnicity is an important consideration in women affected by GDM, particularly in an antenatal service based in a Western society. There are particular challenges in individualising and tailoring medical nutritional therapy and insulin therapy. Also women from certain ethnic groups are at a higher risk of increased foetal and maternal morbidity and mortality. Understanding these challenges is important in providing optimal antenatal care for women of diverse ethnic backgrounds.

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**INTRODUCTION**

Gestational diabetes mellitus (GDM) is defined as glucose intolerance first recognized during pregnancy[1]. GDM has been reported to affect between 1.4% to 12.3% of pregnancies[2], and its prevalence is increasing and parallels the rising incidence of type 2 diabetes mellitus worldwide[3,4]. Risk factors for developing GDM in pregnancy include obesity, previously GDM, glycosuria, family history, ethnicity and hypertension[5,6]. Arguably, one of the strongest non-modifiable risk factor for GDM relates to the woman’s ethnicity.

The Oxford Dictionary defines ethnicity as “belonging to a social group that has a common national or cultural tradition”[7]. In particular, ethnic groups that are considered high-risk include Hispanic, African-Americans, Native American, South or South East Asian, Pacific Islander or Indigenous Australian[8]. It is also recognised that women with GDM from these and other ethnic groups may differ with regards to peri-natal and maternal outcomes[9-12].

In this review we discuss the differences amongst women from various ethnic groups in terms of prevalence, diagnosis, treatment of GDM and pregnancy outcomes. Because of the variance in the diagnosis and management of GDM around the world, it is difficult to compare women with GDM between countries. In order to delineate ethnic differences in terms of GDM prevalence, metabolic profiles of the women and pregnancy and long-term outcomes, studies were often conducted in the same country (or under the same health care system) where the diagnostic criteria, screening process, treatment regimen and delivery of health care are uniform for all women[13-16] (refer A Table 1).

## DIAGNOSTIC CRITERIA

There are numerous diagnostic criteria for GDM currently being utilized in various parts of the world, as shown in Table 2. Many countries have based their GDM diagnostic criteria on the 1999 World Health Organisation (WHO) Criteria[17], while in Australasia and the United States, they have a adopted different glucose cut-offs to diagnose GDM based on the oral glucose tolerance test (OGTT)[18,19]. Findings from the Hyperglycaemia and Adverse Pregnancy Outcomes (HAPO) study has put impetus on revising the diagnostic criteria for GDM, and the International Association of Diabetes in Pregnancy Study Group (IADPSG) had subsequently recommended new threshold glucose levels on the 75 g OGTT for diagnosing GDM[20,21]. In 2013, the WHO adopted the IADPSG guidelines and revised the cut-offs for fasting plasma levels to 5.1 mmol/L, (92 mg/dL), 1-h glucose level to ≥ 10.0 mmol/L (180 mg/dL) and 2-h glucose level to ≥ 8.5 mmol/L (153 mg/dL) following 75g OGTT[22]. It is expected that the 2013 WHO diagnostic criteria may standardise the diagnosis of GDM worldwide, but to date the implementation of this new criteria has been slow internationally.

There is preliminary data reflecting on the impact the new diagnostic criteria may have on the prevalence of GDM amongst different ethnic groups. A Singaporean study demonstrated that the proportion of women diagnosed with GDM in the Asian population using the 2013 WHO Criteria would be lower[23]. The prevalence could drop from 30.9% to 18.9% in women from Chinese background, and from 33.5% to 28.1% among the South Asian population[23]. On the other hand, in a predominantly Anglo-European population in Australia, the prevalence of GDM will increase from 9.6% to 13.0%[24]. The reason for this divergence is that there are differences between ethnic groups in the glycaemic profiles on the OGTT from which GDM is diagnosed. In a cohort of over 850 women diagnosed with GDM from a multi-cultural community in south western Sydney, Australia, from the 75 g OGTT, those from South-East Asia had the lowest fasting glucose levels (4.95 ± 0.65 mmol/L) but the highest 2-h glucose level (8.75 ± 1.17 mmol/L). In contrast, Pacific Islanders had the highest fasting levels (5.71 ± 1.19 mmol/L) but the lowest 2-h levels (7.73 ± 1.27 mmol/L)[25].

## ETHNICITY AND THE PREVALENCE OF GDM

Specific ethnicities of women have long been considered as a risk factor for developing GDM. At-risk ethnic groups identified in the literature, are Aboriginal women in Australia, Middle Eastern (Lebanese, Syrian, Iranian, Iraqi or Afghanistan) women and Pacific Islanders[2,8,26,27]. Table 1 outlines some large population studies describing the prevalence of GDM among different ethnic groups who resided in western societies.

Among Asian women, the prevalence for GDM varies greatly. For instance, a study conducted in New York showed the prevalence of South-Asian (Indian, Sri Lankan, Pakistani, Fijian Indian) women having GDM are generally higher than the risk of South-East Asian (Cambodian, Vietnamese, Laotian, Thai, Filipino, Malaysian) women and the East-Asian (Chinese, South Korean, Taiwanese and Japanese) women. The prevalence of GDM in women who were born in Asian countries varied from 3.0% to 21.2%[28]. Many studies have shown Asian women had a much higher risk of GDM than women of United States Caucasian or Australian descent (Table 1). The highest risk appears to belong to women from South Asia and their adjusted relative risk is quoted by Savitz *et al*[28] to be as high as 7.1 (95%CI: 6.8 to 7.3).

Interestingly, studies have demonstrated that women who migrated from their native countries to a western society had a higher rate of GDM compared to women of a foreign ethnicity but who were born in western countries[28]. However this trend did not apply to Japanese and South Korean women[29]. Table 3 summarises two large studies showing the prevalence of GDM amongst women of various ethnic groups who were born in western countries compared with those born in their native countries. Again the data seems to suggest women born in South Asian and Pacific Islander countries who have migrated to the United States had the highest rate of GDM than United States born women from the same ethnicity[29].

The demographic profiles of migrant mothers also varied among different ethnic groups. Studies had shown that Vietnam-born pregnant women with GDM who moved to Australia were more likely to be older, underweight and pregnant for the first time[30]. Similarly, Shah *et al*[31] found that United States Caucasian and Asian women with GDM were more likely to be over the age of 35 and have a higher education level. Compared with other Asian groups, Japanese and South Korean women have the lowest risk of GDM[12,29,32].

## BODY MASS INDEX

Body Mass Index (BMI) has long been considered as a risk factor associated with the development of GDM[33]. Ethnic origin also appears to be a factor with a twofold higher rate in obese Hispanic women compared to African-American and Caucasian women[34]. Women with GDM from Pacific Islands had the highest pre-pregnant BMI (34.5 ± 8.0 kg/m2), while those from South East Asia had the lowest (23.7 ± 4.8 kg/m2)[25]. As BMI increases, the sensitivity of BMI to identify GDM in each racial/ethnic group decreases while the specificity increases. In a retrospective study of 24325 patients presenting at the University of San Francisco using a BMI of ≥ 25 as a screening tool classified 76.8% of African-Americans with GDM in this category but only 24.9% of Asian women. Using a BMI cut-off of > 21.0 identified 91.5% of African-American women with GDM, 90.1% of Hispanic, and 79.8% of United States Caucasian, but only 68.4% of Asian women. African-Americans were shown to have the highest increased risk (OR 5.1) of GDM when BMI > 25.0 was used as a screening tool, compared with US Caucasians (OR 3.6), Hispanics (OR 2.7) and Asians (OR 2.3)[31].

Women from Asia were shown to have GDM during pregnancy despite having a BMI that is within or below normal range[30,32,35]. Therefore the role of BMI as a screening tool or risk factor for GDM in women from Asia is certainly questionable[31]. Hunsberger *et al*[15] found that Asian women had the greatest risk of having GDM compared to other ethnicities regardless of whether their BMI was greater or less than 26 kg/m2. This population tend to have more visceral or central fat, which is a known risk factor for insulin resistance and cardiovascular disease[36]. Hence we would recommend screening pregnant Asian women for GDM regardless of their BMI.

A recent study on the interaction between maternal age and BMI showed the odds ratios for GDM development were significantly higher in women older than 30 years if they were Caucasian, older than 25 years if they were African and older than 20 years if they were South-Asians. This study also found that Africans and South-Indians were at higher risk of developing GDM irrespective of BMI[37].

## MANAGEMENT OF GDM

Medical nutritional therapy (MNT) is the cornerstone in the management of GDM. The goal of MNT is to provide adequate calories and nutrients to meet the needs of pregnancy and consistent with maintaining normoglycaemia[5]. Yet there is very little consensus on a specific recommended dietary approach in the treatment of GDM[6,38,39]. A recent review of 6 randomised controlled trials in 250 women with GDM suggested that a diet higher in complex carbohydrate and fibre, low in simple sugar and saturated fat may be effective in preventing postprandial hyperglycaemia and avoid worsening insulin resistance and excess foetal growth[40]. Yet studies comparing low-glycaemic index (GI) with a high-GI or conventional high-fibre diet showed no difference in birth weight or adverse pregnancy outcomes[41,42]. Similarly a 2013 Cochrane Review assessing 11 different types of dietary advice for women with GDM was unable to conclude on which was the most suitable dietary advice. The specific diets analysed were low-and high-carbohydrate, high-monounsaturated fat, fibre-enriched diet, low-, moderate-, and high-GI, and energy-restricted and unrestricted. Overall there were no significant differences seen in the rates of macrosomia, large-for-gestational age deliveries or caesarean section[39].

To achieve treatment goals, dietary plans should be prescribed by an accredited dietitian and should be culturally appropriate and tailored to the individual[5]. The ability to adjust the amount and type of carbohydrate by training patients in “carbohydrate counting” is important to achieve target blood postprandial glucose levels[38]. However, the amount of carbohydrate intake varies greatly between different ethnic and cultural groups. For instance, in South East Asia, rice is the staple food and this may pose major challenges for women from this background to curtail their rice intake. The diet for South-Asians is similarly heavily reliant on carbohydrate, and multiple sources of carbohydrate are often included at any one meal (*e.g.*, lentil, dhal, rice in combination)[43].

On the other hand, some women from the Middle East typically have a large meal in the afternoon with relatively smaller meals consumed at breakfast and dinner. They also have a tendency to delay breakfast till mid-morning and have dinner very late in the evening. Ramadan, an annual month of fasting observed by people of the Muslim faith, has significant impact on the timing of carbohydrate intake and meal portions. Ironically, it is the month where food consumption increases dramatically for Muslim communities as the daytime fasting is broken each evening with large banquets among family and friends which can last until dawn[44]. Although pregnant women are exempted from observing Ramadan, many pregnant women with GDM still choose to observe the important religious ritual with their family

For Pacific Islanders, they also tend to have large servings of carbohydrate at main meals and multiple sources of carbohydrate at the one meal (taro, yam, cassava, green bananas, bread and rice)[45]. All these factors should be taken into consideration when prescribing MNT. An overly regimental dietary recommendation will therefore result in poor compliance to therapy and suboptimal glycaemic control.

Health literacy among women from different ethnic groups may be highly variable, and this could have a significant impact on management of GDM. A study of women with GDM in the United Arab Emirates showed they had little understanding of carbohydrate knowledge, but not significantly different to women who did not have GDM. Moreover 22% of women with GDM were not reviewed by a dietitian for nutrition counselling and 65% attended a dietitian only once or twice[46]. Furthermore, migrants in a western society may also face huge challenges in managing their GDM. This could be related to language difficulty or their inability to adapt to an unfamiliar health system. A cross-sectional study performed in Melbourne Australia showed that women coming from Vietnam had the poorest English skills and lowest education levels, with the greatest risk of misunderstanding GDM[47]. Women with a history of GDM were shown to have poor diet quality as determined by the Australian Recommended Food Score, and in particular women who spoke a language other than English had significantly poorer knowledge than those who spoke English only[48].

There were few studies that examined compliance to therapy for women with GDM. In an Australian study looking at failure-to-attend (FTA) rates of women with GDM, women who FTA more than once during their pregnancy had higher BMI, greater incidence of previous GDM and were more likely to be from non-Caucasian backgrounds[49]. Apart from language barriers, women from non-Caucasian backgrounds may need greater resources and time from clinicians to help them understand their condition better in order to improve their adherence to treatment recommendations.

**INSULIN THERAPY**

The glycaemic targets set for the management of GDM may also differ between countries, and hence it would be difficult to compare the proportion of women requiring insulin therapy across different regions. From a database in south western Sydney, women from South-East Asia had the lowest prevalence for insulin therapy (37.2%), compared with Anglo-Europeans (56.7%)[25]. Despite having the highest 2-h glucose level on OGTT, women from South-East Asia also had the lowest need for rapid-acting insulin for the management of post-prandial hyperglycaemia. In that cohort, Pacific Islanders had the greatest need for insulin therapy, with 65% failing MNT. These women also had higher glycosylated haemoglobin (5.9% ± 0.9%, 41 ± 10 mmol/mol) at the time of diagnosis of GDM compared to women from South East Asia (5.4% ± 0.4%, 36 ± 4 mmol/mol)[25]. In a similar study conducted in Hawaii, women from Pacific Islands had the highest rate of commencement of insulin therapy (27.5%), while women from Chinese heritage had the lowest (11.1%)[11]. The higher percentage Pacific-Islanders requiring insulin before 20 wk of gestation in that study suggested that there could be a larger subset of Pacific-Islander women with previously undiagnosed type 2 diabetes.

## FOETAL AND PERINATAL OUTCOMES

There is good evidence that treatment of women with GDM leads to better obstetrics and peri-natal outcomes[50]. GDM increases risks of adverse perinatal outcomes including large for gestational age, shoulder dystocia, surgically assisted delivery and hypertensive disorders in pregnancy[20]. In a 2013 systematic review commissioned by the United States Preventative Services Task Force and the National Institute of Health Office of Medical Applications of Research showed that treating GDM will result in a reduction in rates of preeclampsia, shoulder dystocia and macrosomia, but the benefits on preventing neonatal hypoglycaemia and averting long-term adverse metabolic outcomes of offspring are yet to be established[51].

Among Asian groups, Cambodian and Laotian women with GDM had increased odds of macrosomia when compared with Japanese women with GDM. However, South East Asian women had lower rates of foetal macrosomia when compared with United States Caucasian women but preterm delivery with preeclampsia occurred more often when compared with Japanese and United States Caucasian women[52]. Pacific Islanders have a higher rate of macrosomia than Asian or Caucasian women, but Asian neonates born with macrosomia had comparatively higher levels of NICU admission, need for intravenous dextrose treatment for hypoglycaemia and respiratory distress, although the overall numbers were small[10].

However another study from Ontaria Canada showed that mothers of Chinese heritage had a significantly lower risk of adverse outcome at delivery compared to South Asian mothers. Chinese women also had a lower risk of adverse maternal outcomes compared with the general population[53]. Several recent studies suggest infants born to mothers of non-Caucasian nationalities have lower adverse outcomes. A retrospective cohort study of 1865 adolescent women of different ethnicities born in a Californian University found that African-American, Hispanics and Asians had significantly lower rates of Caesarian delivery and low Apgar scores, while Asians and African-Americans had decreased rates of preterm delivery[54]. There is no evidence to suggest any increase in peri-natal mortality for a particular ethnic group within a health care system. In a study of neonates admitted to intensive care unit, the mortality of 9813 infants of Australian-born mothers was not different to the 2166 infants born from migrant mothers[55].

## MATERNAL OUTCOMES

GDM represents relative beta-cell dysfunction which is caused by insulin resistance, revealed in response to the metabolic stress experienced during pregnancy[56,57]. Women from particular ethnic groups who have GDM may be more susceptible to developing diabetes in the future[2]. In particular, it appears that women with GDM from an Asian background who live in western societies are more likely than Anglo-European women to subsequently develop diabetes[30,58]. Moreover a recent meta-analysis showed that women from ethnic groups other than “non-Hispanic white” had a higher rate of GDM recurrence of 56% compared with 39% in “non-Hispanic white” women who experienced GDM[59].

A study of three ethnic groups of European, South Asian and Afro-Caribbean found that women who had a history of GDM had a range of metabolic abnormalities including beta-cell dysfunction with variable insulin resistance despite normal fasting blood glucose levels postpartum[60]. Similarly a study in the United Kingdom of 221 women with GDM or impaired glucose tolerance (IGT) showed Asian women were shown to have significantly higher rates of persisting glucose intolerance compared with Afro-Caribbean or Anglo-European women post-partum. Use of insulin in Asian women during pregnancy was also associated with postpartum IGT[14]. Development of Type 2 diabetes mellitus in all ethnic groups was 3.5 times greater in women using insulin[58].

An Australian study found that all ethnic groups living in a multicultural region with a high percentage of foreign-born residents all had a high rate of post-GDM diabetes or impaired glucose tolerance[2]. After a mean follow-up of 5.5 years, the study found that South Asians had the highest rate of either diabetes or IGT at 69%, more than the other ethnic groups combined. South Asians and South-East Asians with either diabetes or IGT were also shown to have significantly lower BMI than Middle-Eastern or South European counterparts[2].

A recent large retrospective analysis of women who delivered at Massachusetts General Hospital between 1998 and 2007 showed that women with GDM were 2.45 times more likely to develop hypertension compared to women without GDM. Furthermore, African-American and Hispanic women with GDM had a higher risk of developing hypertension and Asian women had a lower risk compared to United States Caucasian women subsequent to pregnancy[61].

**CONCLUSION**

The increased risk of pregnant women developing GDM who belong to specific ethnic groups is widely acknowledged in the literature. This review highlights the major challenges in the provision of diabetes education and delivering MNT for GDM in an antenatal service where women may come from diverse ethnic and cultural backgrounds. Treatment involving MNT needs to be individually tailored and culturally sensitive, and insulin use may be more prevalent among some ethnic groups. Clinicians should appreciate that a “one size fits all” approach may not be appropriate in managing these women with GDM.

**REFERENCES**

1 **Metzger BE**, Coustan DR. Summary and recommendations of the Fourth International Workshop-Conference on Gestational Diabetes Mellitus. The Organizing Committee. *Diabetes Care* 1998; **21** Suppl 2: B161-B167 [PMID: 9704245]

2 **Girgis CM**, Gunton JE, Cheung NW. The influence of ethnicity on the development of type 2 diabetes mellitus in women with gestational diabetes: a prospective study and review of the literature. *ISRN Endocrinol* 2012; **2012**: 341638 [PMID: 22577574 DOI: 10.5402/2012/341638]

3 **Wild S**, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004; **27**: 1047-1053 [PMID: 15111519]

4 **Feig DS**, Zinman B, Wang X, Hux JE. Risk of development of diabetes mellitus after diagnosis of gestational diabetes. *CMAJ* 2008; **179**: 229-234 [PMID: 18663202 DOI: 10.1503/cmaj.080012]

5 **American Diabetes A**. Gestational diabetes mellitus. *Diabetes Care* 2003; **26** Suppl 1: S103-S105 [PMID: 12502631]

6 **Cheung NW**. The management of gestational diabetes. *Vasc Health Risk Manag* 2009; **5**: 153-164 [PMID: 19436673]

7 Oxford University Press. The Oxford English dictionary online. Oxford: Oxford University Press, 2000. Available from: URL: http: //www.oxforddictionaries.com/definition/english/ethnicity

8 **Kjos SL**, Buchanan TA. Gestational diabetes mellitus. *N Engl J Med* 1999; **341**: 1749-1756 [PMID: 10580075 DOI: 10.1056/NEJM199912023412307]

9 **Scholl TO**, Chen X, Gaughan C, Smith WK. Influence of maternal glucose level on ethnic differences in birth weight and pregnancy outcome. *Am J Epidemiol* 2002; **156**: 498-506 [PMID: 12225997]

10 **Sinclair BA**, Rowan JA, Hainsworth OT. Macrosomic infants are not all equal. *Aust N Z J Obstet Gynaecol* 2007; **47**: 101-105 [PMID: 17355297 DOI: 10.1111/j.1479-828X.2007.00694.x]

11 **Silva JK**, Kaholokula JK, Ratner R, Mau M. Ethnic differences in perinatal outcome of gestational diabetes mellitus. *Diabetes Care* 2006; **29**: 2058-2063 [PMID: 16936153 DOI: 10.2337/dc06-0458]

12 **Rao AK**, Cheng YW, Caughey AB. Perinatal complications among different Asian-American subgroups. *Am J Obstet Gynecol* 2006; **194**: e39-e41 [PMID: 16579923 DOI: 10.1016/j.ajog.2006.01.027]

13 **Oldfield MD**, Donley P, Walwyn L, Scudamore I, Gregory R. Long term prognosis of women with gestational diabetes in a multiethnic population. *Postgrad Med J* 2007; **83**: 426-430 [PMID: 17551077 DOI: 10.1136/pgmj.2006.056267]

14 **Sinha B**, Brydon P, Taylor RS, Hollins A, Munro A, Jenkins D, Dunne F. Maternal ante-natal parameters as predictors of persistent postnatal glucose intolerance: a comparative study between Afro-Caribbeans, Asians and Caucasians. *Diabet Med* 2003; **20**: 382-386 [PMID: 12752487]

15 **Hunsberger M**, Rosenberg KD, Donatelle RJ. Racial/ethnic disparities in gestational diabetes mellitus: findings from a population-based survey. *Womens Health Issues* 2010; **20**: 323-328 [PMID: 20800768 DOI: 10.1016/j.whi.2010.06.003]

16 **Wong LF**, Caughey AB, Nakagawa S, Kaimal AJ, Tran SH, Cheng YW. Perinatal outcomes among different Asian-American subgroups. *Am J Obstet Gynecol* 2008; **199**: 382.e1-382.e6 [PMID: 18722570 DOI: 10.1016/j.ajog.2008.06.073]

17 **World Health Organization**. Definition, Diagnosis and Classification of Diabetes Mellitus and its Complications. Part 1: Diagnosis and Classification of Diabetes Mellitus. 2nd ed. WHO/NCD/NCS/99, 1999. Available from: URL: http://apps.who.int/iris/bitstream/10665/66040/1/WHO\_NCD\_NCS\_99.2.pdf?ua=1

18 **American Diabetes A**. Standards of medical care in diabetes--2011. *Diabetes Care* 2011; **34** Suppl 1: S11-S61 [PMID: 21193625 DOI: 10.2337/dc11-S011]

19 **Hoffman L**, Nolan C, Wilson JD, Oats JJ, Simmons D. Gestational diabetes mellitus--management guidelines. The Australasian Diabetes in Pregnancy Society. *Med J Aust* 1998; **169**: 93-97 [PMID: 9700346]

20 **Metzger BE**, Lowe LP, Dyer AR, Trimble ER, Chaovarindr U, Coustan DR, Hadden DR, McCance DR, Hod M, McIntyre HD, Oats JJ, Persson B, Rogers MS, Sacks DA. Hyperglycemia and adverse pregnancy outcomes. *N Engl J Med* 2008; **358**: 1991-2002 [PMID: 18463375 DOI: 10.1056/NEJMoa0707943]

21 **Metzger BE**, Gabbe SG, Persson B, Buchanan TA, Catalano PA, Damm P, Dyer AR, Leiva Ad, Hod M, Kitzmiler JL, Lowe LP, McIntyre HD, Oats JJ, Omori Y, Schmidt MI. International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. *Diabetes Care* 2010; **33**: 676-682 [PMID: 20190296 DOI: 10.2337/dc09-1848]

22 **World Health Organization**. Diagnostic criteria and classification of hyperglycaemia first detected in pregnancy. 2013. Available from: URL: http://apps.who.int/iris/bitstream/10665/85975/1/WHO\_NMH\_MND\_13.2\_eng.pdf

23 **Yew TW**, Khoo CM, Thai AC, Kale AS, Yong EL, Tai ES. The Prevalence of Gestational Diabetes Mellitus Among Asian Females is Lower Using the New 2013 World Health Organization Diagnostic Criteria. *Endocr Pract* 2014; **20**: 1064-1069 [PMID: 24936548 DOI: 10.4158/EP14028.OR]

24 **Moses RG**, Morris GJ, Petocz P, San Gil F, Garg D. The impact of potential new diagnostic criteria on the prevalence of gestational diabetes mellitus in Australia. *Med J Aust* 2011; **194**: 338-340 [PMID: 21470082]

25 **Wong VW**. Gestational diabetes mellitus in five ethnic groups: a comparison of their clinical characteristics. *Diabet Med* 2012; **29**: 366-371 [PMID: 21913963 DOI: 10.1111/j.1464-5491.2011.03439.x]

26 **Ferrara A**. Increasing prevalence of gestational diabetes mellitus: a public health perspective. *Diabetes Care* 2007; **30** Suppl 2: S141-S146 [PMID: 17596462 DOI: 10.2337/dc07-s206]

27 **Beischer NA**, Oats JN, Henry OA, Sheedy MT, Walstab JE. Incidence and severity of gestational diabetes mellitus according to country of birth in women living in Australia. *Diabetes* 1991; **40** Suppl 2: 35-38 [PMID: 1748263]

28 **Savitz DA**, Janevic TM, Engel SM, Kaufman JS, Herring AH. Ethnicity and gestational diabetes in New York City, 1995-2003. *BJOG* 2008; **115**: 969-978 [PMID: 18651880 DOI: 10.1111/j.1471-0528.2008.01763.x]

29 **Chu SY**, Abe K, Hall LR, Kim SY, Njoroge T, Qin C. Gestational diabetes mellitus: all Asians are not alike. *Prev Med* 2009; **49**: 265-268 [PMID: 19596364 DOI: 10.1016/j.ypmed.2009.07.001]

30 **Henry OA**, Beischer NA, Sheedy MT, Walstab JE. Gestational diabetes and follow-up among immigrant Vietnam-born women. *Aust N Z J Obstet Gynaecol* 1993; **33**: 109-114 [PMID: 8216103]

31 **Shah A**, Stotland NE, Cheng YW, Ramos GA, Caughey AB. The association between body mass index and gestational diabetes mellitus varies by race/ethnicity. *Am J Perinatol* 2011; **28**: 515-520 [PMID: 21404165 DOI: 10.1055/s-0031-1272968]

32 **Kim SY**, Saraiva C, Curtis M, Wilson HG, Troyan J, Sharma AJ. Fraction of gestational diabetes mellitus attributable to overweight and obesity by race/ethnicity, California, 2007-2009. *Am J Public Health* 2013; **103**: e65-e72 [PMID: 23947320 DOI: 10.2105/AJPH.2013.301469]

33 **Radesky JS**, Oken E, Rifas-Shiman SL, Kleinman KP, Rich-Edwards JW, Gillman MW. Diet during early pregnancy and development of gestational diabetes. *Paediatr Perinat Epidemiol* 2008; **22**: 47-59 [PMID: 18173784 DOI: 10.1111/j.1365-3016.2007.00899.x]

34 **Hollander MH**, Paarlberg KM, Huisjes AJ. Gestational diabetes: a review of the current literature and guidelines. *Obstet Gynecol Surv* 2007; **62**: 125-136 [PMID: 17229329 DOI: 10.1097/01.ogx.0000253303.92229.59]

35 **Hedderson M**, Ehrlich S, Sridhar S, Darbinian J, Moore S, Ferrara A. Racial/ethnic disparities in the prevalence of gestational diabetes mellitus by BMI. *Diabetes Care* 2012; **35**: 1492-1498 [PMID: 22619080 DOI: 10.2337/dc11-2267]

36 **Pi-Sunyer FX**. The epidemiology of central fat distribution in relation to disease. *Nutr Rev* 2004; **62**: S120-S126 [PMID: 15387477]

37 **Makgoba M**, Savvidou MD, Steer PJ. An analysis of the interrelationship between maternal age, body mass index and racial origin in the development of gestational diabetes mellitus. *BJOG* 2012; **119**: 276-282 [PMID: 22044452 DOI: 10.1111/j.1471-0528.2011.03156.x]

38 **Metzger BE**, Buchanan TA, Coustan DR, de Leiva A, Dunger DB, Hadden DR, Hod M, Kitzmiller JL, Kjos SL, Oats JN, Pettitt DJ, Sacks DA, Zoupas C. Summary and recommendations of the Fifth International Workshop-Conference on Gestational Diabetes Mellitus. *Diabetes Care* 2007; **30** Suppl 2: S251-S260 [PMID: 17596481 DOI: 10.2337/dc07-s225]

39 **Han S**, Crowther CA, Middleton P, Heatley E. Different types of dietary advice for women with gestational diabetes mellitus. *Cochrane Database Syst Rev* 2013; **3**: CD009275 [PMID: 23543574 DOI: 10.1002/14651858.CD009275.pub2]

40 **Hernandez TL**, Anderson MA, Chartier-Logan C, Friedman JE, Barbour LA. Strategies in the nutritional management of gestational diabetes. *Clin Obstet Gynecol* 2013; **56**: 803-815 [PMID: 24047934 DOI: 10.1097/GRF.0b013e3182a8e0e5]

41 **Moses RG**, Barker M, Winter M, Petocz P, Brand-Miller JC. Can a low-glycemic index diet reduce the need for insulin in gestational diabetes mellitus? A randomized trial. *Diabetes Care* 2009; **32**: 996-1000 [PMID: 19279301 DOI: 10.2337/dc09-0007]

42 **Louie JC**, Markovic TP, Perera N, Foote D, Petocz P, Ross GP, Brand-Miller JC. A randomized controlled trial investigating the effects of a low-glycemic index diet on pregnancy outcomes in gestational diabetes mellitus. *Diabetes Care* 2011; **34**: 2341-2346 [PMID: 21900148 DOI: 10.2337/dc11-0985]

43 **Bienvenido J**. Rice in Human Nutrition. Rome: Food and Agriculture Organization of the United Nations, 1993

44 **Zubaida S**. Middle East. Encyclopedia of Food and Culture: Encyclopedia.com, 2003. Available from: URL: http://www.encyclopedia.com/topic/Middle\_East.aspx

45 **Misra R**, James D. Diet of Pacific Islander Americans. Nutrition and Well-Being A to Z: Encyclopedia.com, 2004. Available from: URL: http://www.encyclopedia.com/doc/1G2-3436200213.html

46 **Ali HI**, Jarrar AH, El Sadig M, B Yeatts K. Diet and carbohydrate food knowledge of multi-ethnic women: a comparative analysis of pregnant women with and without Gestational Diabetes Mellitus. *PLoS One* 2013; **8**: e73486 [PMID: 24069200 DOI: 10.1371/journal.pone.0073486]

47 **Carolan M**, Steele C, Margetts H. Knowledge of gestational diabetes among a multi-ethnic cohort in Australia. *Midwifery* 2010; **26**: 579-588 [PMID: 19261362 DOI: 10.1016/j.midw.2009.01.006]

48 **Morrison MK**, Koh D, Lowe JM, Miller YD, Marshall AL, Colyvas K, Collins CE. Postpartum diet quality in Australian women following a gestational diabetes pregnancy. *Eur J Clin Nutr* 2012; **66**: 1160-1165 [PMID: 22781022 DOI: 10.1038/ejcn.2012.84]

49 **Wong VWC**, Astorga S, Jalaludin C. Gestational Diabetes Mellitus: A Study of Women Who Fail to Attend Appointments. *Diabetes Spectrum* 2013; **26**: 267-271. Available from: URL: http://spectrum.diabetesjournals.org/content/26/4/267.extract

50 **Crowther CA**, Hiller JE, Moss JR, McPhee AJ, Jeffries WS, Robinson JS. Effect of treatment of gestational diabetes mellitus on pregnancy outcomes. *N Engl J Med* 2005; **352**: 2477-2486 [PMID: 15951574 DOI: 10.1056/NEJMoa042973]

51 **Hartling L**, Dryden DM, Guthrie A, Muise M, Vandermeer B, Donovan L. Benefits and harms of treating gestational diabetes mellitus: a systematic review and meta-analysis for the U.S. Preventive Services Task Force and the National Institutes of Health Office of Medical Applications of Research. *Ann Intern Med* 2013; **159**: 123-129 [PMID: 23712381 DOI: 10.7326/0003-4819-159-2-201307160-00661]

52 **Cripe SM**, O'Brien W, Gelaye B, Williams MA. Perinatal outcomes of Southeast Asians with pregnancies complicated by gestational diabetes mellitus or preeclampsia. *J Immigr Minor Health* 2012; **14**: 747-753 [PMID: 22002706 DOI: 10.1007/s10903-011-9537-7]

53 **Mukerji G**, Chiu M, Shah BR. Gestational diabetes mellitus and pregnancy outcomes among Chinese and South Asian women in Canada. *J Matern Fetal Neonatal Med* 2013; **26**: 279-284 [PMID: 23039093 DOI: 10.3109/14767058.2012.735996]

54 **Penfield CA**, Cheng YW, Caughey AB. Obstetric outcomes in adolescent pregnancies: a racial/ethnic comparison. *J Matern Fetal Neonatal Med* 2013; **26**: 1430-1434 [PMID: 23488933 DOI: 10.3109/14767058.2013.784738]

55 **Uppal P**, Holland AJ, Bajuk B, Abdel-Latif M, Jaffe A, Hilder L, Lui K, Oei JL. The association between maternal country of birth and neonatal intensive care unit outcomes. *Early Hum Dev* 2013; **89**: 607-614 [PMID: 23567194 DOI: 10.1016/j.earlhumdev.2013.03.003]

56 **Buchanan TA**. Pancreatic B-cell defects in gestational diabetes: implications for the pathogenesis and prevention of type 2 diabetes. *J Clin Endocrinol Metab* 2001; **86**: 989-993 [PMID: 11238474 DOI: 10.1210/jcem.86.3.7339]

57 **Xiang AH**, Kjos SL, Takayanagi M, Trigo E, Buchanan TA. Detailed physiological characterization of the development of type 2 diabetes in Hispanic women with prior gestational diabetes mellitus. *Diabetes* 2010; **59**: 2625-2630 [PMID: 20682697 DOI: 10.2337/db10-0521]

58 **Lee AJ**, Hiscock RJ, Wein P, Walker SP, Permezel M. Gestational diabetes mellitus: clinical predictors and long-term risk of developing type 2 diabetes: a retrospective cohort study using survival analysis. *Diabetes Care* 2007; **30**: 878-883 [PMID: 17392549 DOI: 10.2337/dc06-1816]

59 **Schwartz N**, Nachum Z, Green MS. The prevalence of gestational diabetes mellitus recurrence-effect of ethnicity and parity: a metaanalysis. *Am J Obstet Gynecol* 2015 [PMID: 25757637 DOI: 10.1016/j.ajog.2015.03.011]

60 **Kousta E**, Lawrence NJ, Godsland IF, Penny A, Anyaoku V, Millauer BA, Robinson S, Johnston DG, McCarthy MI. Early metabolic defects following gestational diabetes in three ethnic groups of anti-GAD antibodies negative women with normal fasting glucose. *Hormones* (Athens) 2007; **6**: 138-147 [PMID: 17704045]

61 **Bentley-Lewis R**, Powe C, Ankers E, Wenger J, Ecker J, Thadhani R. Effect of race/ethnicity on hypertension risk subsequent to gestational diabetes mellitus. *Am J Cardiol* 2014; **113**: 1364-1370 [PMID: 24576544 DOI: 10.1016/j.amjcard.2014.01.411]

62 **Brown CJ**, Dawson A, Dodds R, Gamsu H, Gillmer M, Hall M, Hounsome B, Knopfler A, Ostler J, Peacock I, Rothman D, Steel J. Report of the Pregnancy and Neonatal Care Group. *Diabet Med* 1996; **13**: S43-S53 [PMID: 8894455]

63 **Solomon CG**, Willett WC, Carey VJ, Rich-Edwards J, Hunter DJ, Colditz GA, Stampfer MJ, Speizer FE, Spiegelman D, Manson JE. A prospective study of pregravid determinants of gestational diabetes mellitus. *JAMA* 1997; **278**: 1078-1083 [PMID: 9315766]

64 **Sullivan JR**, Shepherd SJ. Obstetric outcomes and infant birthweights for Vietnamese-born and Australian-born women in southwestern Sydney. *Aust N Z J Public Health* 1997; **21**: 159-162 [PMID: 9161071]

65 Classification and diagnosis of diabetes mellitus and other categories of glucose intolerance. National Diabetes Data Group. *Diabetes* 1979; **28**: 1039-1057 [PMID: 510803]

66 **Simmons D**, Rowan J, Reid R, Campbell N. Screening, diagnosis and services for women with gestational diabetes mellitus (GDM) in New Zealand: a technical report from the National GDM Technical Working Party. *N Z Med J* 2008; **121**: 74-86 [PMID: 18364758]

67 **Booth G**, Cheng AY. Canadian Diabetes Association 2013 clinical practice guidelines for the prevention and management of diabetes in Canada. Methods. *Can J Diabetes* 2013; **37** Suppl 1: S4-S7 [PMID: 24070961 DOI: 10.1016/j.jcjd.2013.01.010]

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**Table 1 Large studies highlighting the prevalence of GDM in women of different ethnicities living within a geographic region**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ref.** | **Year** | **City/region** | **Number of Women with GDM by ethnicity** | **Rate of GDM by ethnicity** |
| Beischer, Oats, Henry, Sheedy and Walstab[27] | 1979- 1998 | Melbourne, Australia | 66 Indian subcontinent91 Chinese60 Egypt and Arab countries132 Other Asian95 Vietnamese143 United Kingdom and Northern Europe270 Mediterranean1008 Australian and New Zealand | 15% Indian subcontinent13.9% Chinese7.2% Egypt and Arab countries10.9% Other Asian7.3% Vietnamese5.2% United Kingdom and Northern Europe7.3% Mediterranean4.3% Australian and New Zealand |
| Solomon, Willett, Carey *et al*[63] | 1990- 1994 | The Nurses Health Study II: 14 states in the United States of Amercia | 655 White12 African-American17 Hispanic26 Asian | 4.7% White10.6% African-American7.6% Hispanic10.5% Asian |
| Sullivan and Shepherd[64] | 1997 | Sydney, Australia | 730 Vietnamese7226 Australian | 5.3% Vietnamese1.6% Australian |
| Savitz, Janevic, Engel, Kaufman and Herring[28] | 1995-2003 | New York City, United States of America | 398 North African1018 Sub-Saharan Africa3512 East Asia1027 South-East Asia & Pacific Islands4758 South Central Asia5038 Non-Hispanic Caribbean8767 Hispanic Caribbean2780 Mexico1133 Central American4189 South American6387 African-American9846 Non-Hispanic White | 7.2% North African5.9% Sub-Saharan Africa6.2% East Asia8.6% South-East Asia & Pacific Islands14.3% South Central Asia6.8% Non-Hispanic Caribbean4.9% Hispanic Caribbean6.3% Mexico4.9% Central American6.6% South American34.3% African-American3.6% Non-Hispanic White |
| Chu, Abe, Hall, Kim, Njoroge and Qin[29] | 2005- 2006 | Up to 19 states in the United States of America | 5326 Japanese32460 Asian Indian25530 Chinese25785 Filipino11561 South Korean21721 Vietnamese20718 Other Asian5761 Pacific Islander1873925 White non-Hispanic394091 Black non- Hispanic677392 Hispanic14617 American Indian | 3.45% Japanese8.03% Asian Indian6.44% Chinese6.9% Filipino3.9% South Korean6.14% Vietnamese5.07% Other Asian5.17% Pacific Islander3.82% White non-Hispanic3.54% Black non- Hispanic3.63% Hispanic5.13% American Indian |
| Kim, Saraiva, Curtis *et al*[32] | 2007-2009 | California, United States of America | 20129 Asian and Pacific Island316 American Indian3371 Black American52256 Hispanic1483 Other18806 Non-Hispanic White | 11.9% Asian and Pacific Island7.6% American Indian5.6% Black American8.4% Hispanic6.6% Other5.4% Non-Hispanic White |

GDM: Gestational diabetes mellitus.

**Table 2 Diagnostic criteria for gestational diabetes mellitus prior to recommendations by the International Association of Diabetes in Pregnancy Study Group in 2010**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **ADA-NDDG[65]**  | **ADIPS[19]** | **NZSSD[66]** | **WHO (1999)[17]** | **CDA[67]** | **EASD[62]** |
| **Glucose load (g)** | 100  | 75 | 75 | 75 | 75 | 75  |
| **FPG (mmol/L)** | 5.3 | 5.5 | 5.5 | 7.0 | 5.3 | 6.0 |
| **1-h Glc (mmol/L)** | 10.0 | - | - | - | 10.6 | - |
| **2-h Glc (mmol/L)** | 8.6 | 8.0 | 9.0 | 7.8 | 9.0 | 9.0 |
| **3-h Glc (mmol/L)** | 7.8 | - | - | - | - | - |
| **Abnormal results to diagnose GDM**  | 2 or more | 1 or more | 1 or more | 1 or more | 1 or more | 1 or more |

ADA-NDDG : American Diabetes Association National Diabetes Diagnostic Group; ADIPS: Australian Diabetes in Pregnancy Society; NZSSD: New Zealand Society for the Study of Diabetes; WHO: World Health Organization; CDA: Canadian Diabetes Association; EASD: European Association for the Study of Diabetes; FPG: Fasting plasma glucose; Glc: Glucose; GDM: Gestational diabetes mellitus.

**Table 3 Studies comparing the prevalence of gestational diabetes mellitus among different ethnicities in women born in Western countries with women born in foreign countries**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ref.** | **Year** | **City/Region** | **Rate of GDM in ethnic groups born in Western country**  | **Rate of GDM in ethnic groups who migrated from their native country to a western country** |
| Savitz, Janevic, Engel, Kaufman and Herring[28] | 1995-2003 | New York City, United States of America | 1.7% North African3.1% Sub-Saharan Africa5.6% East Asia4.3% South-East Asia and Pacific Islands6.8% South Central Asia3.4% Non-Hispanic Caribbean4.4% Hispanic Caribbean4.0% Mexico3.4% Central American3.1% South American | 7.5% North African5.9% Sub-Saharan Africa6.3% East Asia8.9% South-East Asia and Pacific Islands14.5% South Central Asia7.1% Non-Hispanic Caribbean5.3% Hispanic Caribbean6.4% Mexico5.1% Central American7.0% South American |
| Chu, Abe, Hall, Kim, Njoroge and Qin[29] | 2005-2006 | Up to 19 states in the United States of America | 4.91% Japanese5.54% Asian Indian4.64% Chinese5.95% Filipino5.31% Korean5.16% Vietnamese4.39% Other Asian5.82% Pacific Islander  | 3.27% Japanese8.81% Asian Indian6.25% Chinese7.31% Filipino4.92% Korean6.2% Vietnamese6.21% Other Asian8.38% Pacific Islander  |

GDM: Gestational diabetes mellitus.