Innovations

Diabetes in Pregnancy: Prevalence and Determinants- A Systematic Review

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Abstract: *Diabetes Mellitus that is diagnosed during pregnancy is termed Gestational Diabetes Mellitus and that diagnosed before pregnancy is termedPregestational Diabetes Mellitus. Hyperglycaemia during pregnancy causes several harmful effects and hence the diagnosis criteria adopted for the diagnosis plays a vital role. The International Association of Diabetes and Pregnancy Study Group formed in 1998 has implemented comprehensive diagnostic criteria for hyperglycaemia during pregnancy. The prevalence of GDM and PGDM are associated with several determinants like ethnicity, age, BMI and maternal history. Each of these factors are studied in detail in the present review.*

Keywords*: Pregnancy, Hyperglycaemia, Gestational Diabetes Mellitus, Pregestational Diabetes Mellitus, Diagnosis, Prevalence, Determinants.*

Introduction

Diabetes Mellitus is a chronic multisystem disorder of abnormal insulin production, impaired insulin utilization or both. Since 1980, about four to five folds of increase has been witnessed in the number of women affected with Diabetes (Iminger-Finger, Kargul, & Laurent, 2017). Life style changes, rapid socioeconomic development and demographic changeshave led to the explosive increase in the prevalence of diabetes mellitus(Unnikrishnan, Anjana, & Mohan, 2016).Diabetes is one of the most prevalent metabolic disorders that happens during pregnancy. The incidence of diabetes in pregnancy is increasing day by day as the epidemics of obesity and overweight are growing worldwide. Diabetic mothers present with a higher incidence of gestational hypertension, preeclampsia, polyhydramnios, miscarriage, cesarean section, subsequent obesity, and type 2 diabetes in later life(Aviram et al., 2016; Luengmettakul, Sunsaneevithayakul, & Talungchit, 2015). Neonates born to these mothers are at high risk of macrosomia, congenital anomalies, preterm birth, hypoglycemia, hyperbilirubinemia, hypocalcemia, polycythemia and respiratory distress syndrome(Blank, Grave, & Metzger, 1995; Van Zyl & Levitt, 2018).Diabetes Mellitus in pregnancy are of mainly two types Gestational Diabetes Mellitus and Pregestational Diabetes Mellitus (Gupta, Goyal, Kalra, & Tandon, 2020).

The International Association of Diabetes and Pregnancy Study Group (IADPSG)classifies diabetes in pregnancy into two categories- Gestational Diabetes and Pregestational Diabetes (Metzger et al., 2010).Gestational Diabetes is defined as any degree of glucose intolerance with onset or first recognition during pregnancy(Association, 2009; "Diagnosis and classification of diabetes mellitus," 2010).Usually, it develops around the 24th week of pregnancy and the condition arises as the action of insulin is blocked due to the effect of placental hormones(Group, 2015). Pregnant women who have type 1 or type 2 diabetes before conception are known to have pregestational or overt diabetes.

The prevalence of diabetes in pregnancy shows an increasing trend worldwide and it is determined by manyfactors that need to be controlled before conception. The incidence of the disease can be reversed if it is managed well during the preconception period itself. Hencea detailedreview of the occurrence of the disease, diagnostic measures,and its determinants may help the health workers for effective pre-conceptional management of pregestational and gestational diabetes.

Methodology

A systematic literature search in Scopus and PubMed of published longitudinal cohort studies on prevalence, diagnostic criteria, and determinants of diabetes in pregnancy was conducted. Study selection, data extraction, and quality assessment were performed by two authors independently. The methodological quality was judged using a critical appraisal tool. Finally, data were narratively synthesized.

1.Prevalence of Diabetes in Pregnancy

Prevalence is the proportion of persons having the disease at a specific point of time in a community.There is a drastic increase in the prevalence of Diabetes in pregnancy globally.Due to the presence of unwanted pregnancy outcomes, the wild increase in GDM and PGDM prevalence is became a public health concern(Ferrara, 2007). It is essential to control the glycemic status during pregnancy in order to reduce the adverse perinatal outcomes. As per the report of the International Diabetes Federation (IDF) published in 2019, the global prevalence of diabetes in pregnancy is 15.8%, which constitutes both GDM and PGDM. Out of this 15.8%, GDM covers 83.6% and PGDM covers 16.4%(IDF, 2019). The recent report of the International Diabetes Federation (IDF) published in 2021 suggests that about 16.7% of the live births to women had some form of hyperglycemia in pregnancy. Out of this, 80.3% had GDM while 10.6% had hyperglycemia detected before pregnancy and the rest 9.1% covers those who have other types of diabetes first detected in pregnancy. The report in 2021 demonstrates an elevated rate of prevalence with respect to the previous report which was explained to be due to the improved methods of diagnosis before and during pregnancy. Additionally, a prominent heterogeneity in the prevalence of PGDM and GDM was observed among the population of major mainland of the world. In the IDF Diabetes Atlas-2021, 58 studies from 47 countries were used for estimating country-level, age-specific prevalence of GDM and PGDM following a generalised linear regression model. As per the study, South-East Asian (SEA) Region recorded the

highest age-adjusted comparative prevalence at 28.0%, compared to 8.6% in the Middle-East and North-African (MENA) Region. The report points out that the vast majority (87.5%) of cases of hyperglycaemia in pregnancy are seen in low and middle-income countries, which in turn can be attributed to the limited access to antenatal care. The discrepancy is mainly due to the established relationship of hyperglycaemia with ethnicity and genetic predisposition. Moreover, specific genes are associated with some ethnic groups and it would influence body composition and gestational weight gain (Jaffe et al., 2020; Savitz, Janevic, Engel, Kaufman, & Herring, 2008; Yuen, Wong, & Simmons, 2018). Diabetes in pregnancy is more prevalent in developing countries where the range of the PGDM prevalence is 1% – 4.3% and GDM prevalence is 3.8% – 27.9%. However, the developed countries show a comparatively lower PGDM prevalence range of 0.3% – 4.3% and GDM prevalence range of 1% – 15%. The variance in the prevalence may be due to racial, ethnic, lifestyle, or socioeconomic disparities (Lili Yuen & Vincent W Wong, 2015).

2. Determinants

Various determinants of Gestational and Pre-Gestational Diabetes were reported and explained previously in different studies (El Mallah, Narchi, Kulaylat, & Shaban, 1997; Fatima et al., 2017; Fong, Serra, Herrero, Pan, & Ogunyemi, 2014). The major determinants wereracial or ethnical diversity, age of pregnant women, history of GestationalDiabetes Mellitus, family history of Diabetes Mellitus, history of abortion, history of big baby and Body Mass Index (BMI). This session intends to describe the already identified determinants in both Gestational and Pre-Gestational Diabetes Mellitus.

2.1 Racial or Ethnical Diversity

Ethnicity is defined to be the social cluster of people belonging to a shared culture, history, geographical unity in origin, language, lifestyle or may have physical, genetic or other shared factors. Epidemiological studies on ethnical factors between groups were conducted for various diseases including diabetes (Butler, 2017; Walker, Strom Williams, & Egede, 2016). Members of some ethnicity are reported to be associated with a higher risk of GDM. Several studies demonstrated the prevalence of GDM and their contributing potential of ethnical origin in GDM(Blumberg, Ballares, & Durbin, 2018; L. Yuen & V. W. Wong, 2015; Yuen et al., 2018). Studies on the prevalence of gestational diabetes among the Malaysian, Chinese and Indian populations were found to be 27.2%, 40.5% and 19.7% respectively; however, a more detailed study in Chinese population were not yet conducted. In addition, comparison studies on the Chinese population to other ethnic groups are also vital to be determined to identify whether some geographical or genetic factors influence the higher prevalence in Chinese population. The course of pre-gestational diabetes in this epidemiological study was not determined; however, in Asia, a well characterized study was conducted in Qatar, exploring both pre-gestational and gestational diabetes in Asian population (Bashir et al., 2018). The prevalence rate of gestational diabetes was characterized on a Qatari, Arab and a group explained as other Asia group, which were found to be 23.5%, 19.4%,

and 21.7% respectively. The pre-gestational incidence in the same study among Qatari, Arab and the other Asia group was found to be 2.3%, 2.6% and 2.7% respectively. The incidence of both gestational diabetes and pre-gestational diabetes was found to be similar between the study group, suggesting a similar rate in the prevalence of both gestational and pre-gestational diabetes irrespective of ethnicity. In a Brazilian cohort study in South America neither identified anysignificant changes in the prevalence of hyperglycaemia among white (14.6%) and non-white (15%) ethnic populations(Nicolosi et al., 2020). A retrospective study conducted among North American group elicits a disparity in the prevalence of GDM and PGDM among different races and ethnic groups. The GDM prevalence was found to be much higher among Asians (8.61%) than Caucasian(4.29%),Black(3.98%), Native Americans (5.32%) and Hispanic (5.32%) in California whereas the PGDM prevalence was higher in native North Americans (1.65%) than Black (1.23%), Hispanic (0.92%), Native Americans(1.65%)and Caucasians (0.64%). The Table. 3 represent the studies that shows prevalence for either GDM or PGDM or both on the basis of ethnicity and respective continents. The studies were more established for the GDM; however, more detailed studies determining the prevalence on the focus to ethnicity among continents or countries are vital to explore more evidence on the prevalence of PGDM in detailed.

Table 1.Racial and Ethnical disparity in prevalence of Diabetes in Pregnancy

Continent	**Region of study**	**sample size**	**Ethnic group**	**Prevalence of GDM (%)**	**Prevalence of PGDM (%)**	**Reference**
Asia	Qatar	2000	Qatari	23.5	2.3	(Bashir et al., 2018)
			Arab	19.4	2.6	
			Other Asian	21.7	2.7	
	Malaysia	659	Malaya	27.2		(Logakodie, Azahadi, Fuziah, Norizzati, Tan, Zienna, Norliza, Noraini, Hazlin, Noraliza, Sazidah, & Mimi, 2017)
			Chinese	40.5		
			Indians	19.7		
South America	Brazil	1008	White	14.6		(Nicolosi et al., 2020)
			Non-white	15		
North America	California	3,556,567	Caucasian	4.29	0.64	(Fong, Serra, Herrero, Pan, & Ogunyemi,
			Black	3.98	1.23	

			Native American	5.32	1.65	2013)
			Asian	8.61	0.66	
			Hispanic	5.62	0.92	

2.2 Age as a determinant of Diabetes in Pregnancy

Diabetes mellitus is a common endocrine disorder with a higher incidence among middle to old age people(Ebrahimi, Emamian, Hashemi, & Fotouhi, 2016). This is mainly due to the combined effect of increase in insulin resistance and impaired pancreatic islet function with aging(Kirkman et al., 2012).With regard to Diabetes Mellitus in Pregnancy (DIP), maternal age act as a key factor which directly influence its incidence and prevalence. Globally an increased prevalence of PGDM and GDM is observed among mothers in the age group of 30-40 years. A prospective Cohort study among 9000 samples in Saudi Arabia shows that the prevalence of GDM and PGDM are more in the age group of 30-34 years. The results were similar with another Asian study conducted in India with 956 samples. However, a retrospective Korean study shows that an increased prevalence of GDM and PGDM by 41-49 years of age. Studies from other parts of the world like Northern California and Canada also elicits that there is an increased prevalence of Diabetes in Pregnancy in the age group of 30-34 years. The impact of older age with increase in prevalence of Diabetes Mellitus in Pregnancy may be due to age-related declines in muscle mass and increase in adipose tissues(Karakelides, Irving, Short, O'Brien, & Nair, 2009).

Table 2. Age as a determinant of Diabetes in Pregnancy

Continent	Region of study	Highest sample size	Age group with high prevalence	% Of GDM cases in the age group (%)	% Of PGDM cases in the age group (%)	Reference
Asia	India (Kashmir)	2000	30-34	8.1		(Zargar et al., 2004)
	Saudi Arabia (Rahma)	9723	30 -34	29.2	27.8	(Wahabi, Fayed, Esm

						aeil, Mamdouh, & Kotb, 2017)
	Oman	307	>35	14.7		(Abu-Heija, Al-Bash, & Mathew, 2015)
	Korea	1,282,498	41 -49	12.6	6.6	(Son, Lim, Lee, Cho, & Park, 2015)
	China (Tianjin)	18589	30 -35	28.9		(Leng et al., 2015)
	China (Tianjin)	105473	30-34	10.3		(Zhang et al., 2011)

Australia	Australia	40800	45 -49	25		(Health & Welfare, 2019)
Africa	Cameroon	200	31 -45	31.6		(Egbe, Tsaku, Tchounzou, & Ngowe, 2018)
Europe	Italy	3950	>35	12.3		(Di Cianni et al., 2003)
South America	Brazil	1008	>25	62.7 (Both GDM & PGDM)		(Nicolosi et al., 2020)
North America	Canada	111563	20 -34	75		(Xiong, Saunders, Wang, & Demianczuk, 2001

						)
	California	3,556,567	>45	2.82	15.61	(Fong et al., 2013)

2.3Body Mass Indexas a determinant of Diabetes in Pregnancy

Body Mass Index (BMI) is the estimation of the body fat of individuals and is calculated based on height and weight at any age. The calculated value of BMI is used to determine a person as underweight (BMI under 18.5 kg/m^2), Normal weight (BMI greater than or equal to 18.5 to 24.9 kg/m^2), overweight (BMI greater than or equal to 25 to 29.9 kg/m^2), or obese (BMI greater than or equal to 30 kg/m^2)(Organization, 2015; Weir & Jan, 2021).BMI above normal levels (BMI $\geq$25 kg/m^2) is highly associated with higher incidence of type 2 Diabetes Mellitus and higher risk of associated cardiovascular, cerebrovascular, renal and lower extremity complications (Astrup & Finer, 2000).Pregnancy with obesity (BMI >30) is closely associated with complications such as stillbirth, foetal macrosomia and significant increase in emergency caesarean birth rates(Bracken & Langhe, 2021).

Well characterised studies conducted in Asian countries show a higher prevalence of both GDM and PGDM among mothers with BMI above or equal to 30. A cohort study conducted among 9723 Saudi Arabian mothers demonstrated an increased prevalence of GDM and PGDM along with increased BMI, that is majority of pregnant diabetic mothers (50.1% GDM and 54.4% of PGDM) were having BMI greater than 30(Wahabi et al., 2017). Retrospective study in Qatar among 2000 pregnant women shows the similar range of BMI (30-34.9) with 31.3% GDM and 6.6% PGDM cases(Bashir et al., 2018). Screening studies for GDM conducted in China and Turkey also demonstrated the higher prevalence of GDM associated with BMI above 30(Erem, Kuzu, Deger, & Can, 2015; Zhang et al., 2011). Even if studies conducted in European countries like Sweden and Italy also show the similar pattern, but a cross sectional study conducted in Cameroon-Africa elicits that the GDM prevalence is increasing with overweight mothers that is BMI 25 -29.9 ranges(Di Cianni et al., 2003; Egbe et al., 2018; Fadl & Simmons, 2016). This may be due to the strong association of higher degree Body Mass Index with development of type-2 Diabetes Mellitus in women(Wang et al., 2016).However more established studies from different parts of the world is needed to prove the BMI association with Diabetes in pregnancy.

Table 3.Body Mass Index as a determinant of Diabetes in Pregnancy

Continent	Region of study	Highest sample size	BMI with high prevalence (Kg/m^2)	GDM prevalence in the BMI group (%)	PGDM prevalence in the BMI group (%)	Reference
Asia	Saudi Arabia-(Rahma)	9723	>30	50.1	54.4	(Wahabi et al., 2017)
	Qatar	2000	30 – 34.9	31.3	6.6	(Bashir et al., 2018)
	China - Tianjin	105473	30-34	10.3		(Zhang et al., 2011)
	Turkey	815	>30	25.8		(Erem et al., 2015)
Africa	Cameroon	200	25 – 29.9	90.48		(Egbe et al., 2018)
Europe	Sweden	1507699	30 -34.9	9		(Fadl & Simmons, 2016)
	Italy	3950	>30	21.2		(Di Cianni et al., 2003)

2.4 Maternal History as a determinant of Diabetes in Pregnancy

Mothers with Diabetes in pregnancy are presented with previous incidence of abortion, family history of Diabetes Mellitus and history of Gestational Diabetes MellitusUncontrolled Diabetes Mellitus in pregnancy is a major etiological factor for abortion and interestingly the previous studies around the world elicit that around half percentage of diabetic pregnancies are significantly associated with a history of abortion. A cross sectional study conducted in Kerala, and a retrospective cohort study from Saudi Arabia observed that around 46% of PGDM mothers had a history of abortion.Another cross-sectional study from Saudi Arabia and Kuwait exhibit that mothers with Gestational Diabetes Mellitus also had previous history of abortion at 58% and 37% respectively. The previous incidence of abortion may be the after effects of undetected and uncontrolled diabetes mellitus duringthe earlier pregnancies.

The family history of Diabetes Mellitus and incidence of Gestational Diabetesarefound associated with Diabetes mellitus in Pregnancy among Asian mothers than others. This may be due to the genetic predisposition of Diabetes Mellitus.Another factor elicited among diabetic mothers is previous history of having big baby (Birth weight more than 4 Kg). A study conducted in Africa; Cameroon shows that 44.44% of total GDM cases have a history of a big baby. Studies conducted in Asian counties also shows there is a

history of big baby.This is directly indicating that the previous pregnancy might be endeavoured with ill effects of Diabetic Mellitus as big baby is a common outcome of the same.

Table 4.Maternal History as a determinant of Diabetes in Pregnancy

Maternal History as a determinant of Diabetes in Pregnancy						
	Continent	Region of study	Highest sample size	% Of GDM cases with a Previous h/o Abortion	% Of PGDM cases with a Previous h/o Abortion	Reference
	Asia	India (Kerala)	400		46.7	(Renji, Lekshmi, & Chellamma, 2017)
		Pan Saudi Arabia	3157		46.6	(H. A. Wahabi, Esmaeil, Fayed, Al-Shaikh, &Alzeidan, 2012)
		Saudi	954	58		(Alfadhli et al., 2015)
		Kuwait	868	37.6		(Groof et al., 2019)
	South America	Brazil	1008	11.3		(Nicolosi et al., 2020)
	Africa	Cameroon	200	39		(Egbe et al., 2018)
Maternal History of GDM as a determinant of Diabetes in Pregnancy						
	Continent	Region of study	Highest sample size	% Of GDM cases with a history of GDM	% Of PGDM cases with a history of GDM	Reference
	Asia	India (Kerala)	400		60	(Renji et al., 2017)
		India (Kerala)	201	12.5		(Mohan & Chandrakumar,

						2016)
		India (Rajasthan)	500	12.12		(Kalra, Kachhwaha, & Singh, 2013)
		India (Karnataka)	200	43.47		(S., Prabhudev, & Bhovi, 2017)
		Malaysia	745	16.3		(Logakodie, Azahadi, Fuziah, Norizzati, Tan, Zienna, Norliza, Noraini, Hazlin, Noraliza, Sazidah, & Omar, 2017)
		Turkey	815	50		(Erem et al., 2015)
	South America	Brazil	1008	6		(Nicolosi et al., 2020)

Maternal History of Big baby as a determinant of Diabetes in Pregnancy

Continent	Region of study	Highest sample size	% Of GDM cases with a h/o big baby	% Of PGDM cases with a h/o big baby	Reference
Asia	India (Karnataka)	200	34.78		(S. et al., 2017)
	India (Kerala)	201	12.5		(Mohan & Chandrakumar, 2016)
	India (Rajasthan)	500	6.06		(Kalra et al., 2013)
	Malaysia	745	4.8		(Logakodie, Azahadi, Fuziah, Norizzati, Tan, Zienna, Norliza, Noraini, Hazlin, Noraliza, Sazidah, &

					Omar, 2017)
Africa	Cameroon	200	44.44		(Egbe et al., 2018)

Maternal History of Diabetes Mellitus as a determinant of Diabetes in Pregnancy

Continent	Region of study	Highest sample size	% Of GDM cases with a family history of DM	% Of PGDM cases with a family history of DM	Reference
Asia	India (Kerala)	400		73	(Renji et al., 2017)
	India (Kashmir)	2000	33.3		(Zargar et al., 2004)
	Pan India	31746			(Swaminathan, Swaminathan, & Corsi, 2020)
	India (Kerala)	201	68.8		(Mohan & Chandrakumar, 2016)
	India (Rajasthan)	500	33.33		(Kalra et al., 2013)
	India (Karnataka)	200	60.86		(S. et al., 2017)
	Kuwait	947	15.1		(Groof et al., 2019)
	Bangladesh	3447	10.5		(Jesmin et al., 2014)
	Malaysia	745	33.2		(Logakodie, Azahadi, Fuziah, Norizzati, Tan, Zienna, Norliza, Noraini, Hazlin, Noraliza, Sazidah, & Omar, 2017)
	Turkey	815	20.1		(Erem et al., 2015)

South America	Brazil	1008	31.3	(Nicolosi et al., 2020)	

3. Discussion

These studies suggested an increased prevalence of GDM in Asian countries. But none of these studies have focused on the prevalence of maternal hyperglycaemic subtypes in different ethnicities. Recently, Liu et al., have carried out a retrospective multi-ethnic cohort study in the United States about the prevalence of maternal hyperglycaemic subtypes with respect to various ethnicities (Liu et al., 2024). Even this study pointed out that the prevalence of hyperglycaemic subtypes was higher in Asians. Characteristic genetic modulations in a particular ethnic group is considered as an unmodifiable risk factor involved in the increasing prevalence of GDM. Along with genetic predispositions, variations in lifestyle and dietary habits can contribute to GDM. Sedentary life-style and consumption of high calorie processed food in turn direct to the occurrence of DM in pregnant women (Chermon & Birk, 2024). A study conducted in South-East Asian pregnant women evidenced that obesity causes maternal co-morbidities like the risk of GDM signifying the role of changing life style (Kunasegaran, Balasubramaniam, Arasoo, Palanisamy, & Ramadas, 2021).

The tabulated data show that advancing maternal age is an auxiliary factor for GDM and PGDM. A recent study in the Indian population in 2019–21 by Chakraborty et al., shows that the prevalence of GDM is dependent on socioeconomic and demographic factors, such as age groups, religions, castes, and types of places of residence.The prevalence of GDM increased in gradient from the lowest value of 0.48% in the 15–19 years' age group to the highest value of 3.91% in 40–44 years' age group. Nevertheless, the age group 45–49 years showed a prevalence of GDM of 2.44%, demonstrating a drop in gradient compared to that in younger age groups (Chakraborty & Yadav, 2024). Glucose tolerance is the ability of our body to metabolise glucose and the glucose metabolism is associated with insulin sensitivity and secretory function of pancreatic β-cells. Henceforth, the increased risk of GDM in advanced maternal age can be attributed to the impaired β-cell function, decreased insulin sensitivity, dysregulation of lipid metabolism, and high oxidative stress with aging (Fulop, Larbi, & Douziech, 2003; Kolovou & Bilianou, 2008).

Previous incidence of abortion, family history of Diabetes Mellitus and history of Gestational Diabetes Mellitus are considered to be factors associated with GDM and PGDM. Mostly, maternal history of DM are accompanied with pre-term birth and macrosomia that eventually ends up in caesarian section(Oros Ruiz et al., 2024). Along with GDM and PGDM, obesity, age of the pregnant mother, body mass index, hypertension, and smoking are the ssupplementary factors associated with macrosomia.

6. Conclusion

GDM and PGDM are accompanied by abortion, pre-term birth, and macrosomia. The review suggests that with the increasing prevalence of GDM and PGDM, it is very

crucial to monitor DM before and during pregnancy. Apart from genetic factors, proper management of blood sugar level can be achieved by maintaining the right BMI and planning pregnancy at pregnancy at appropriate age. Women should be provided counseling regarding the risk factors associated with GDM and the importance of following healthy habits to maintain a normal blood sugar level.

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