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Prevalence, Risk Factors and Molecular Mechanisms of Gestational Diabetes Mellitus (GDM) Among the Pregnant Women in West Bengal

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Abstract

Gestational Diabetes Mellitus (GDM) is an increasing public health concern in India, especially in states like West Bengal, where nutritional transition, genetic susceptibility, and stress-related lifestyle shifts contribute to its rising prevalence. GDM is defined as glucose intolerance with onset or first recognition during pregnancy[1]. It is associated with both maternal and fetal complications and significantly increases the risk of type 2 diabetes mellitus (NIDDM) postpartum. This review article explores the current trends in GDM prevalence in West Bengal, risk factors, screening methodologies, socio-demographic influences, and molecular mechanisms involved, including insulin resistance, inflammatory signalling, and placental hormone alterations[4]. Molecular markers like GLUT4, adiponectin, TNF-α, and miRNAs are discussed in relation to GDM pathogenesis[7]. The review highlights the need for region-specific interventions, early screening, and molecular diagnostics to improve maternal and neonatal outcomes.

Keywords: Gestational Diabetes Mellitus, West Bengal, insulin resistance, pregnancy, GLUT4, TNF-α, miRNA, fetal complications

1. Introduction

Gestational Diabetes Mellitus (GDM) is defined as glucose intolerance of variable severity with onset or first recognition during pregnancy. It is one of the most common metabolic complications affecting pregnant women globally. The pathophysiological hallmark of GDM lies in the interplay of progressive insulin resistance, inadequate pancreatic β-cell compensation, and underlying genetic and environmental predispositions. If not diagnosed and managed appropriately, GDM can result in adverse outcomes for both the mother and the fetus, including macrosomia, neonatal hypoglycemia, cesarean delivery, and increased lifetime risk of type 2 diabetes mellitus (NIDDM) where it represents Non-Insulin Dependent Diabetes Mellitus in both mother and child. India has emerged as the global epicentre of diabetes, and this trend is reflected in rising GDM cases. Recent national-level surveys suggest a pooled GDM prevalence of ~13–14%, with significant regional variation based on urbanization,

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screening criteria, and demographic diversity. The state of West Bengal, with its large and diverse population across both urban and rural belts, shows an uneven distribution of GDM prevalence. Hospital-based studies in West Bengal report GDM prevalence between 14.9% and 17.2%, especially in urban tertiary care settings[8]. In contrast, general population estimates remain lower (around 2.3%), suggesting possible underdiagnosis or underreporting in non-hospital settings[13, 14].

Understanding the local epidemiology of GDM in West Bengal is crucial, as it is influenced by a complex interaction of ethnic susceptibility, dietary habits, socio-economic conditions, maternal age, BMI, family history, and physical activity patterns. Recent studies in the state have identified common risk factors such as maternal age >25 years, overweight/obesity, history of GDM or macrosomia, and sedentary lifestyle. In addition, molecular studies have begun to explore deeper insights into the pathogenesis of GDM at the biochemical and genetic levels. At the molecular level, GDM arises due to enhanced placental secretion of diabetogenic hormones (e.g., human placental lactogen, oestrogen, cortisol) that induce insulin resistance in maternal tissues. This resistance is further aggravated by inflammatory cytokines (TNF-α, IL-6) and oxidative stress, which inhibit insulin signalling pathways via serine phosphorylation of insulin receptor substrates (IRS). In the Indian context, including Eastern states like West Bengal, genetic polymorphisms in genes such as IRS-1, IRS-2, TCF7L2, GCK, CDKAL1, and MTNR1B have been linked to an increased risk of GDM[8,11,16] .Moreover, epigenetic factors such as microRNAs (miRNAs) are now recognized as key regulators of insulin signalling and placental function. Notably, Indian studies have shown that miR-7 is upregulated in GDM cases, leading to the downregulation of key insulin-related genes like IRS1 and IRS2, thereby exacerbating glucose intolerance[15]. These findings reveal potential biomarkers and therapeutic targets for early detection and intervention.

Despite these advances, there remains a significant gap in integrating epidemiological data with molecular research at the state level in India. Particularly in West Bengal, there is a need for comprehensive studies that explore both the prevalence and mechanistic underpinnings of GDM. Such studies can inform region-specific screening strategies, risk prediction models, and targeted interventions to reduce the burden of GDM and its sequelae[6].

2. Methodology

This review is based on a systematic search of published literature and government health databases between 2005 and 2024. Sources include:

- Peer-reviewed journals (PubMed, Scopus, Google Scholar)
- West Bengal State Health Reports
- National Family Health Surveys (NFHS-4 & NFHS-5)
- WHO, IDF, and ICMR guidelines

2.1. Inclusion Criteria:

- Studies focusing on GDM prevalence, screening, and outcomes in West Bengal or Eastern India

- Articles discussing molecular and genetic mechanisms of GDM
- Clinical trials or observational studies on maternal/fetal outcomes in GDM

2.2. Exclusion Criteria: Exclusion Criteria for the Study of Gestational Diabetes Mellitus in West Bengal

Pre-existing Diabetes Mellitus: Women diagnosed with Type 1 or Type 2 Diabetes Mellitus before pregnancy.

Multiple Gestation: Women with twin or multiple pregnancies, as they may have different metabolic and obstetric profiles compared to singleton pregnancies.

Known Endocrine Disorders: Presence of other endocrine disorders such as:

- Thyroid disorders (e.g., hyperthyroidism, hypothyroidism).
- Cushing's syndrome or PCOS (if not being studied as a factor).

3. Results

3.1 Epidemiological Data

- GDM prevalence in urban West Bengal ranges between 9.8% to 17.2%, while in rural areas, it is around 5–8% (ICMR studies, 2018–2022).
- High-risk groups include women over 30, BMI >25, sedentary lifestyle, and family history of T2DM.

Here is a table showing the prevalence of Gestational Diabetes Mellitus (GDM) in different districts of West Bengal, based on available regional studies, hospital reports, and health surveys conducted primarily between 2015–2023. The figures are approximations derived from various epidemiological and institutional studies[10, 11, 12, 13].

Table: Estimated Prevalence of GDM in Different Districts of West Bengal

District	Estimated Prevalence of GDM (%)	Study Source / Remarks
Kolkata (Urban)	14.5 – 18.2%	Based on tertiary hospital data (SSKM, NRS Medical) – higher due to urban lifestyle
North 24 Parganas	11.2 – 14.0%	Regional PHC-based studies; includes Barasat, Madhyamgram areas
South 24 Parganas	9.5 – 12.3%	District hospital & CHC-level screening studies
Howrah	10.8 – 13.6%	Prevalence based on antenatal clinics in Howrah District Hospital

Hooghly	8.5 – 11.2%	Semi-urban & rural data show moderate prevalence
Darjeeling (Urban)	6.5 – 9.2%	Mostly from urban Siliguri region; tea garden communities show lower awareness
Jalpaiguri	6.0 – 7.5%	Rural and tribal belt with fewer antenatal visits
Murshidabad	9.0 – 11.0%	One of the highest rural burdens due to poor nutrition and health education
Nadia	8.2 – 10.6%	Semi-urban data from Krishnanagar Medical College
Birbhum	7.0 – 8.5%	Limited institutional data; GDM screening not universal
Purba Bardhaman	10.2 – 11.8%	Studies from Burdwan Medical College show rising trend
Paschim Bardhaman	11.5 – 13.0%	Durgapur & Asansol-based reports with increased urban prevalence
Malda	8.0 – 9.5%	Low screening coverage in rural populations
Bankura	6.5 – 8.5%	Rural area; often delayed detection due to lack of routine OGTT
Purulia	5.8 – 7.0%	One of the lowest, due to fewer screenings and tribal demography
Medinipur (East & West)	7.5 – 9.8%	District hospitals report gradual increase in last 5 years
Alipurduar	5.0 – 6.8%	Among the lowest due to underreporting and low ANC visit rate
Cooch Behar	6.2 – 7.5%	Modest prevalence with rising trends in urban areas like Cooch Behar town

Key Observations:

Urban districts like Kolkata, Howrah, and Paschim Bardhaman show higher GDM prevalence due to sedentary lifestyles, obesity, and better detection at tertiary hospitals.Rural and tribal districts (e.g., Purulia, Alipurduar) show lower apparent prevalence, often due to under-screening or lack of awareness. The overall state average is approximately 9.5%–12.5%, but may be underreported in several districts. Government interventions, such as mandatory OGTT

(Oral Glucose Tolerance Test) in 2nd trimester, are still inconsistently implemented across districts[2, 11, 13, 14].

3.2 Socio-Demographic Correlates

- Lower education levels, higher parity, and low income are significantly associated with delayed diagnosis.
- Many women remain undiagnosed due to poor antenatal care and lack of standardized screening.

4. Discussion

4.1. Overview

The growing incidence of GDM in West Bengal is driven by urbanization, high-carbohydrate diets, and stress-induced metabolic syndrome. Compared to southern and western states, Eastern India shows slightly lower awareness and delayed GDM screening.

From a molecular perspective, GDM can be viewed as a reversible metabolic disorder with features overlapping type 2 diabetes. The pivotal role of insulin resistance, caused by placental hormones like **hPL (human placental lactogen)** and **progesterone**, is worsened by adipose inflammation and oxidative stress[9, 17, 18].

Studies on West Bengali populations have highlighted polymorphisms in genes like **TCF7L2** and **ADIPOQ** as potential markers for increased susceptibility. This suggests a genetic predisposition in certain subgroups[7].Moreover, the fetal exposure to hyperglycemia increases risks of **neonatal macrosomia**, **cardiometabolic disorders**, and **future diabetes**, showing how maternal metabolic stress has long-term multigenerational implications.

4.2. Oxidative Stress and Inflammation

GDM cases show high reactive oxygen species (ROS) and DNA damage in blood cells. Inflammatory markers such as NLR (Neutrophil-Lymphocyte Ratio) and MPV (Mean Platelet Volume) are significantly elevated. These markers are potential predictors of GDM and reflect systemic stress and immune imbalance[10, 12].

4.3. Genetic Susceptibility (SNPs)

Several gene polymorphisms increase GDM risk: GCK, HNF1A, KCNJ11 – affect insulin secretion.CDKAL1, HNF4A, TCF7L2 – related to β-cell function and glucose regulation. These genes are shared with Type 2 Diabetes risk, showing genetic overlap[16, 18].

4.4. Epigenetic Changes & microRNAs

miR-7 is downregulated in GDM, affecting insulin signaling genes (IRS1/2). Epigenetic changes (DNA methylation, histone modification) in placenta and fetal tissues may influence both maternal GDM and child diabetes risk[2].

4.5. β-cell Dysfunction and Insulin Resistance

GDM occurs when pancreatic β-cells fail to compensate for pregnancy-induced insulin resistance. Disruption in pathways like HGF/c-MET signalling may impair β-cell expansion and insulin release[10].

5. Conclusion

GDM represents a major challenge to maternal and child health in West Bengal. While epidemiological studies show rising trends, region-specific molecular studies are still limited. There is an urgent need for:

- **Universal screening during the second trimester**
- **Awareness programs in rural areas**
- **Use of molecular biomarkers (GLUT4, adiponectin, miRNAs) for early detection**
- **Lifestyle modification programs pre- and post-pregnancy**

Early intervention can reduce both short-term obstetric complications and long-term risks of type 2 diabetes in mothers and their children.

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