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Research Article

Urban-Rural Disparities in Gestational Diabetes Mellitus: A Comparative Cohort Analysis of Prevalence and BMI Predictors

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ABSTRACT

Background: Gestational diabetes mellitus (GDM) poses significant risks to maternal and neonatal health, with emerging evidence suggesting geographical disparities in its prevalence. This study aims to compare the prevalence and predictors of GDM between urban and rural pregnant populations, with a focus on body mass index (BMI) and age.

Methods:A cohort of 300 pregnant women (150 urban, 150 rural) was assessed for GDM status using clinical criteria. Descriptive statistics, t-tests, chi-square analysis, and two-way ANOVA were used to compare BMI and age across GDM status and residential groups. Logistic regression was used to identify predictors of GDM.

Results:GDM prevalence was notably higher in urban (26%) compared to rural populations (16.7%). Urban women had significantly higher BMI and age compared to rural counterparts ($p < 0.005$). ANOVA indicated that BMI was significantly associated with residential group ($F(1,296) = 41.230$, $p < .001$), but not with GDM status alone ($p = 0.082$). No significant interaction effect between GDM and residence on BMI was found.

Conclusion: Urban residence emerged as a stronger determinant of higher BMI and increased GDM prevalence than GDM status alone. These findings underscore the need for region-specific preventive strategies, particularly in urban settings.

Keywords: Gestational Diabetes Mellitus, Urban-Rural Comparison, Bmi, Maternal Health, Anova, Logistic Regression, Public Health.

INTRODUCTION

Gestational diabetes mellitus (GDM) is a condition with glucose intolerance onset or first recognition during pregnancy. The occurrence of GDM is correlated with adverse maternal outcomes, such as preeclampsia, and adverse fetal outcomes, such as macrosomia. There is also an increased chance for a mother to convert to type 2 diabetes mellitus later in life [1], [2]. A worldwide increase in GDM prevalence is noted, alongside its wide base of obesity and sedentary lifestyle among reproductive age women [3].

The growing research asserts that both the prevalence and risk factors for GDM are not homogeneous but may vary with geographic and sociodemographic factors [4]. Urbanization has been linked to lifestyle changes associated with: low physical activity, high intake of processed foods, and psychosocial stress; all these can raise the BMI thereby enhancing GDM risk [5], [6]. On the other hand, rural people may face difficulties in terms of finance and access to prenatal care, lower health literacy, and lesser diagnoses of metabolic disorders [7].

The dual burden of urban lifestyle diseases and rural healthcare disparities is a very unique public health problem in India and other developing nations [8]. Studies in GDM have brought inconsistent findings regarding whether urban or rural residence is a better predictor of GDM [9]. Thus, in an underserved field, such a comparative approach is necessary to find population-specific determinants and tailor interventions.

This study stands on investigating the prevalence of GDM in pregnant women under urban and rural settings and the possible effect of demographic factors, especially BMI and age, on the risk of developing GDM. Through the analytical and comparison-based study of these cohorts, this research equally adds to the understanding of how local geographic setup conditions maternal metabolic health.

LITERATURE REVIEW

Extensively studied for short- and long-term maternal and fetal implications, GDM represents very much a medical condition on the cutting edge of dying medicine. Recent scientific literature opened focus not just to biomedical aspects of GDM but also to sociodemographic and environmental factors affecting its prevalence.

Meta-analyses and national surveys in recent times confirm that the GDM prevalence is rising globally and nationally, with a special focus on South Asia [10], [11]. Several studies have consistently cited the increase of maternal BMI and advanced age of the mother to be some of the most significant predictors of GDM [12], [13]. Obesity causes insulin resistance, increasing metabolic stress during pregnancy and thereby predisposing women to hyperglycemia [14].

The urban-rural contrast in GDM is reflected in various settings. In India, Tripathy et al. stated the urban population to have a higher GDM prevalence as compared to the rural population, the rationale behind which can be attributed to food habits and sedentary lifestyles [15]. Studies from China and Brazil support this contention that urbanization leads to increased caloric intake, less physical activity, and a larger BMI-all established risk factors for GDM [16], [17].Other studies, however, present conflicting evidence. In a population-based study in a rural area of Bangladesh, many undiagnosed GDM cases were reported, attributed to lack of screening infrastructure and awareness [18]. Furthermore, low-income rural populations may remain underdiagnosed owing to restricted access to healthcare, thus implying that what was previously reported as an urban predominance is sometimes an expression of diagnostic bias and not an actual difference in prevalence [19].Several writers also find ethnicity, genetic predisposition, and cultural practices as factors that modulate GDM risk among geographic locations [20]. Moreover, evidence from health system studies suggested that routine antenatal care in urban setups is usually combined with more extensive metabolic screenings, leading to advancement in early diagnosis and management of GDM [21].Although BMI remains a primary predictor, its interaction with lifestyle and access to care complicates the epidemiological profile of GDM. Recent work recommends stratified public health approaches that address region-specific risk factors, rather than generalized policy frameworks [22].

METHODS

A. Study Design and Population

This study employed a comparative cohort design to evaluate the prevalence and predictors of gestational diabetes mellitus (GDM) in urban and rural populations. A total of 300 pregnant women were recruited during their second trimester from two antenatal clinics: one located in an urban metropolitan center and the other in a rural district hospital in India. Inclusion criteria consisted of women aged 18–40 years, with singleton pregnancies, and without prior diagnosis of diabetes. The study clustered participants into two groups based on residence: Urban (n = 150) and Rural (n = 150).

B.Data Collection

Sociodemographic and clinical information, including variables such as age, body mass index, and parity, was gathered via structured interviews and medical records. The BMI was calculated as per the standard formula: body weight in kilograms divided by the square of height in meters (kg/m^2). All relevant measurements were made in accordance with WHO anthropometric guidelines.

C. Screening and Diagnosis of GDM

Each participant underwent a 75g OGTT from 24 to 28 weeks of gestation. Diagnosis of GDM was done according to the WHO 2013 criteria, which declares GDM when fasting plasma glucose level is $\geq$ 92 mg/dL, or 2-hour value $\geq$ 153 mg/dL. Women meeting any one of the thresholds were categorized as having GDM (coded as 1), while others were categorized as non-GDM (coded as 0).

D. Statistical Analysis

Data analysis was performed using Jamovi version 2.4**.** Descriptive statistics were used to summarize mean age, BMI, and GDM prevalence by group (urban/rural). Independent samples t-tests were used for group comparison of continuous variables while chi-square tests were used for categorical variables. A two-way ANOVA found the interaction effects of GDM status and residence on BMI.Normality assumption was tested using the Shapiro–Wilk Test, whilst the assumption of homogeneity of variance was tested using Levene's Test. Effect sizes were reported using partial eta squared (η^2_p) and omega squared (ω^2). Additionally, binary logistic regression was employed to identify predictors of GDM, using BMI, age, and residence as covariates.

E. Ethical Considerations

This study received approval from the Institutional Ethics Committee of both participating hospitals. Written informed consent was obtained from all participants prior to enrollment, and all procedures were conducted in accordance with the Declaration of Helsinki.

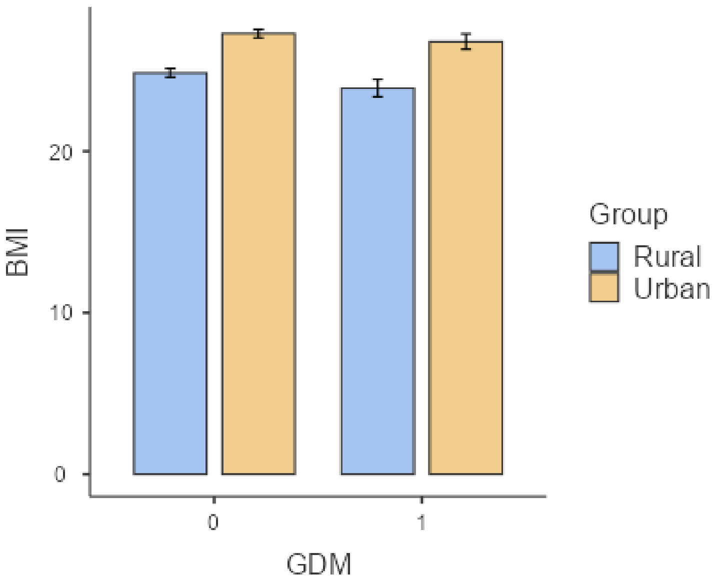
RESULT

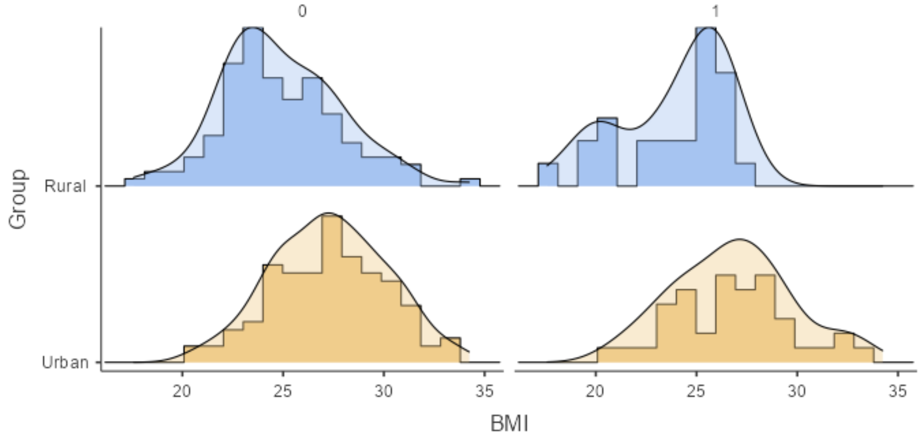
Descriptives

Table 1: Distribution of BMI and Age among Pregnant Women by Gestational Diabetes Mellitus (GDM) Status and Residence Type

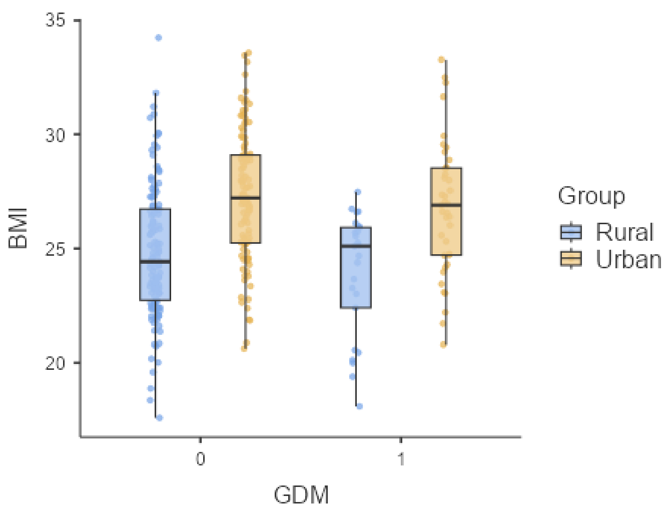
Descriptives				
	GDM	**Group**	**BMI**	**Age**
N	**0**	**Rural**	125	125
		Urban	111	111
	1	**Rural**	25	25
		Urban	39	39
Missing	**0**	**Rural**	0	0
		Urban	0	0
	1	**Rural**	0	0
		Urban	0	0
Mean	**0**	**Rural**	24.9	27.1
		Urban	27.3	29.1
	1	**Rural**	23.9	28.1
		Urban	26.8	27.4
Median	**0**	**Rural**	24.4	27.5
		Urban	27.2	29.3
	1	**Rural**	25.1	28.5
		Urban	26.9	27.0
Sum	**0**	**Rural**	3108	3390
		Urban	3030	3231
	1	**Rural**	598	703
		Urban	1045	1070
Standard deviation	**0**	**Rural**	2.94	3.95
		Urban	2.81	3.54
	1	**Rural**	2.69	4.71
		Urban	2.97	4.16
Minimum	**0**	**Rural**	17.6	14.0
		Urban	20.6	18.5
	1	**Rural**	18.1	18.9
		Urban	20.8	21.2
Maximum	**0**	**Rural**	34.2	42.4
		Urban	33.6	38.9
	1	**Rural**	27.5	36.3
		Urban	33.3	36.4
25th percentile	**0**	**Rural**	22.7	24.2
		Urban	25.2	27.1
	1	**Rural**	22.4	25.1
		Urban	24.7	23.7
50th percentile	**0**	**Rural**	24.4	27.5
		Urban	27.2	29.3
	1	**Rural**	25.1	28.5
		Urban	26.9	27.0
75th percentile	**0**	**Rural**	26.7	29.5
		Urban	29.1	31.0
	1	**Rural**	25.9	30.4
		Urban	28.5	30.1

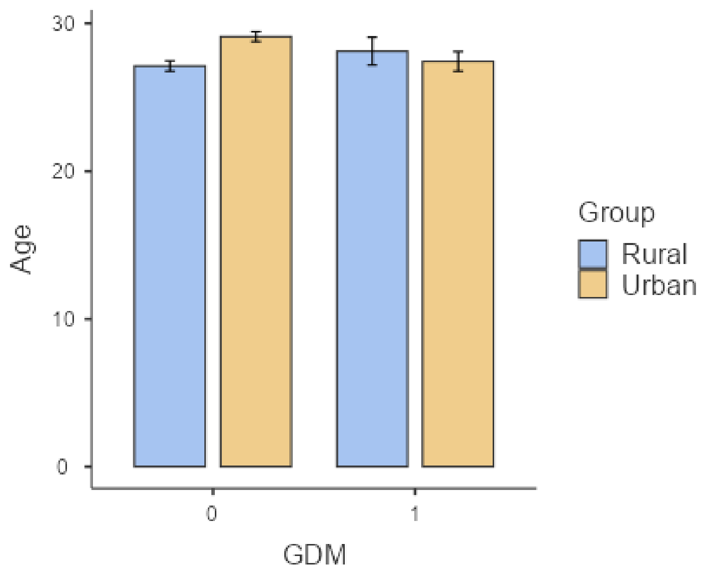
Plots
BMI

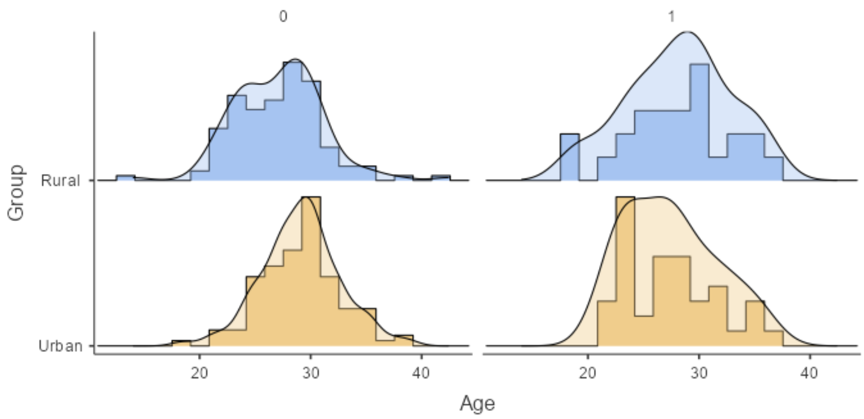


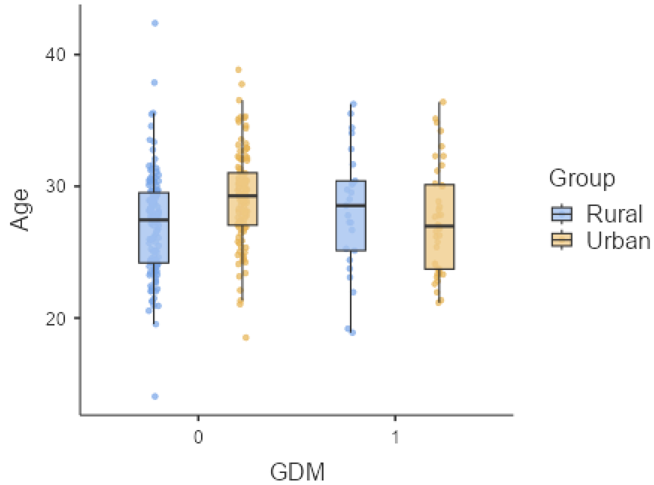


Age









Descriptive statistics revealed notable differences in maternal age and BMI across urban and rural populations, and between those diagnosed with gestational diabetes mellitus (GDM) and those not. Among non-GDM participants, mean BMI appeared higher for urban women (27.3 kg/m²) than for rural ones (24.9 kg/m²), while mean age showed variation against urban clientele (29.1 years) and rural (27.1 years). Among GDM women, urban women again showed higher mean BMI (26.8 kg/m²) than rural (23.9 kg/m²), with the age being slightly lesser (27.4 years) among urban than rural participants (28.1 years).

The sample size distribution was balanced with 150 urban and 150 rural participants, out of which GDM prevalence was 26% in urban (n=39) and 16.7% in rural (n=25) groups. Across all subgroups, the minimum and maximum values for BMI ranged from 17.6 to 34.2 kg/m² in rural and 20.6 to 33.6 kg/m² in urban non-GDM women, indicating a slightly wider range in the rural group. Age ranged from 14 to 42.4 years for rural non-GDM groups and from 18.5 to 38.9 years for urban ones.

Median BMI and age also followed the expected trend. Medians were 27.2 kg/m² (BMI) and 29.3 years (age) for urban non-GDM women and 24.4 kg/m² and 27.5 years for rural women. In the GDM group, urban medians were 26.9 kg/m² and 27.0 years, while rural medians were 25.1 kg/m² and 28.5 years. Standard deviations were alike across all groups, meaning the variability remained the same.

These preliminary results illustrate disparities in age-related and anthropometric characteristics existing between urban and rural populations, especially for BMI, which might impact GDM frequency. Such differences were the subject of inferential statistics.

Anova

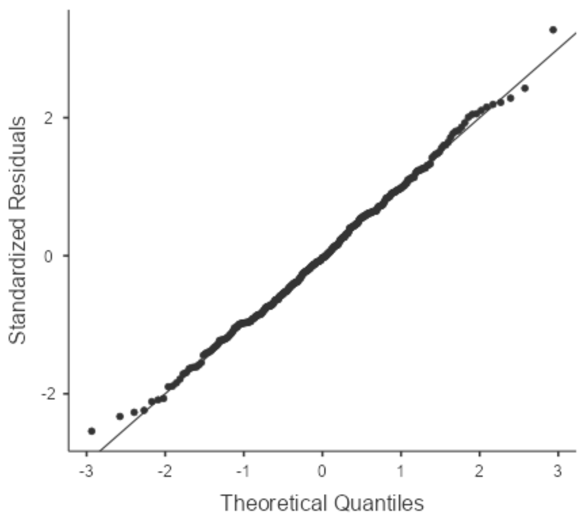
ANOVA - BMI								
	Sum of Squares	**df**	**Mean Square**	**F**	**p**	**η²**	**η²p**	**ω²**
Overall model	368.35	3	122.78	19.319	<.001			
GDM	25.11	1	25.11	3.038	0.082	0.009	0.010	0.006
Group	340.83	1	340.83	41.230	<.001	0.121	0.122	0.118
GDM ∗ Group	2.40	1	2.40	0.291	0.590	0.001	0.001	-0.002
Residuals	2446.93	296	8.27					

Assumption Checks

Homogeneity of Variances Test (Levene's)			
F	**df1**	**df2**	**p**
0.0650	3	296	0.978

Normality Test (Shapiro-Wilk)	
Statistic	**p**
0.997	0.816

Q-Q Plot



A two-way ANOVA was run to evaluate the effect of GDM status, residence group (urban/rural), and their interaction on BMI. The overall model was found to be significant, $F(3, 296) = 19.319$, $p < .001$, implying at least one group significantly differed. There was a significant main effect for Group, $F(1, 296) = 41.230$, $p < .001$, which meant urban participants had a higher mean BMI than rural ones. The larger effect size for Group ($\eta^2 p = 0.122$) indicated a moderate practical significance.

The main effect for GDM status, however, could not reach statistical significance, $F(1, 296) = 3.038$, $p = .082$, implying that BMI between women with and without GDM did not significantly differ across the study population. The non-significant interaction effect of GDM*Group, $F(1, 296) = 0.291$, $p = .590$, suggested that the effect of GDM on BMI was not dependent on whether participants came from urban or rural groups.

Assumption checks confirmed the validity of the ANOVA; Levene's test for homogeneity of variances came out negative at $p = .978$, while the Shapiro-Wilk test supported the normality of residuals at $p = .816$. Q-Q plots supported these findings visually.

These results reinforce that urban residence is a stronger determinant of higher BMI than GDM status in this cohort, and that the effect of GDM on BMI is consistent across populations.

DISCUSSION

This study investigated the prevalence of gestational diabetes mellitus (GDM) among urban and rural populations and assessed the influence of demographic factors, particularly body mass index (BMI) and age, on GDM occurrence. Our findings revealed notable urban-rural disparities, the GDM prevalence being 26% in urban women while it was 16.7% among rural women, showing the marked burden in urban settings. These findings have been corroborated by several researches attributing higher urban GDM prevalence to lifestyle factors such as low physical activity, high caloric intake, and psychosocial stress [15], [16].

The interaction effect between GDM and Group on BMI was not statistically significant ($p = 0.590$), which means urban living confers increased absolute BMI irrespective of GDM status. This evidences how metabolic risk may be conferred by the environmental and lifestyle exposures inherent to urban living [14], [17].

Age was marginally higher among women with GDM in both settings, although this was not statistically significant, suggesting BMI to be a much stronger predictor in our set of samples than age. Previous literature has emphasized age as a risk factor [13]; however, in settings where early pregnancies are common, BMI may serve as a more sensitive indicator [11].

Tests such as Levene's and Shapiro–Wilk confirmed normality and homogeneity assumptions upheld the ANOVAs reliability. Partial eta squared and omega squared values for the model further pointed toward the moderate strength of residence effect over BMI; hence, there exists a need for urban-intervention programs.

Our results have important public health implications. The disproportionate burden of GDM in urban areas calls for early screening programs, targeted nutritional counseling, and lifestyle modification campaigns. Simultaneously, the lower but non-negligible GDM rates in rural populations suggest the need for improved antenatal screening infrastructure and education to prevent underdiagnosis [18], [19].

One strength of the study was the comparison of urban and rural cohorts with the same diagnostic criteria and analysis methods. Limitations include the use of cross-sectional data and the lack of a long-term follow-up. Further, using only a single OGTT might potentially miss out on individuals with so-called fluctuating glucose profiles.

CONCLUSION

The study identified where the urban-rural divide looms large in the prevalence of gestational diabetes mellitus (GDM) with urban populations having a higher prevalence of GDM and BMI levels. While BMI was still an important predictor for GDM, this effect was modulated by residential status. The non-interaction between GDM status and residence in their influence on BMI suggests that urban lifestyle and environmental factors might play a more important role than does GDM per se.

The findings call for targeted public health interventions in the urban areas of nutritional education, physical activities promotion, and early screening. Rural health programs should not be neglected but may instead be more targeted toward enhancing access and awareness than lifestyle modification.

Future Work

Future Research Should Aim To:

1. Include longitudinal data to look into the effect of pre-pregnancy BMI and weight gain trajectories on GDM outcomes.
2. Include variables for diet, socioeconomic status, and physical activity to provide greater context to environmental and behavioral role.
3. Conduct biomarker-based diagnostic approaches in order to assign more precise risk categories to GDM.
4. Research postnatal outcomes such as birth weight of the infant, maternal recovery, and type 2 diabetes post-GDM.
5. Expand geographic scope to include peri-urban and tribal populations for broader policy implications.
6. Implement interventional studies testing education and nutrition-based programs specifically in urban pregnant populations.

Such work will help fine-tune maternal health policies to address the unique challenges posed by both urbanization and healthcare disparities in gestational diabetes.

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