

Multivariate Analysis of Gestational Diabetes Risk Factors in a North African Population: A Call for Targeted Maternal Health Interventions

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Abstract: Gestational Diabetes (GD) is a multifactorial condition influenced by demographic, anthropometric and obstetric determinants. Identifying predictive factors is essential to anticipate the disorder, guide prevention strategies and reduce maternal and neonatal complications. To assess the risk factors associated with GDM in pregnant women in the Marrakech-Safi region, in order to fill a gap in national data. A retrospective cross-sectional study was conducted on 331 women (202 with GDM and 129 without GDM). Data collected included sociodemographic and clinical characteristics: maternal age, pregestational Body Mass Index (BMI), parity, obstetric history, family history of diabetes and blood type. Multivariate logistic regression was applied, with significance set at $p < 0.05$. Mean maternal age was 27 years, with 17% of participants aged ≥ 35 years. Multivariate analysis identified as independent factors for GDM: Maternal age 26-35 years (aOR = 2.58; CI95% [1.37-4.88]) and ≥ 35 years (aOR = 4.37; CI95% [1.88-10.14]), history of miscarriage (aOR = 2.47; CI95% [1.18-5.15]), multiparity (2 pregnancies: aOR = 31.62; ≥ 3 pregnancies: aOR = 36.40) and family history of diabetes (aOR = 2.81; CI95% [1.56-5.07]). Blood groups A (aOR = 0.29; CI95% [0.12-0.67]) and O (aOR = 0.39; CI95% [0.18-0.87]) were associated with a lower risk of GDM compared to group B. BMI was not significantly associated. Advanced maternal age, multiparity, history of miscarriage and family history of diabetes are major determinants of GDM in the Marrakech-Safi region. The protective association observed for blood groups A and O needs to be confirmed by further studies. These results underline the need for early screening and targeted preventive strategies, adapted to local resources, to improve maternal and neonatal outcomes.

Keywords: Gestational Diabetes Mellitus, Maternal Risk Factor, Multivariate Analysis, North Africa

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Introduction

Gestational Diabetes Mellitus (GDM) is defined, according to the World Health Organization, as any degree of glucose intolerance appearing or manifesting for the first-time during pregnancy. It has become a growing public health problem

worldwide, with a steadily increasing prevalence, including in Morocco [1]. Although GDM generally disappears after delivery, persistent glucose intolerance can occur in some women [2], increasing their risk of developing type 2 diabetes in later life [3]. Beyond the long-term risks, this condition has a significant impact on maternal and neonatal outcomes, with complications such as macrosomia (birth weight $\geq 4\text{kg}$), preterm delivery and pre-eclampsia frequently reported [4].

Screening for GDM is usually performed between 24- and 28-weeks' gestation [5], most often on the basis of a fasting plasma glucose level $\geq 0.92\text{ g/l}$ and confirmed by an oral glucose tolerance test (OGTT) [6]. Standard management involves dietary modification to reduce sugar intake, with insulin therapy prescribed when nutritional measures alone fail to control blood glucose [7].

Several maternal risk factors are well recognized for their role in the development of GDM; Family history of diabetes markedly increases susceptibility [8], while pregestational overweight and obesity, both strongly associated with impaired insulin sensitivity, are major predictive factors [9]. Advanced maternal age (≥ 35 years), sedentary lifestyle, and poor dietary habits further exacerbate risk. A personal history of GDM also considerably raises the likelihood of recurrence in subsequent pregnancies [10-12].

While these predictive factors are well documented in the global literature, regional variations underscore the need for locally anchored studies. In particular, data from North Africa remain fragmentary and often limited to small clinical series, failing to capture the region's demographic and cultural diversity. Yet these specific contexts influence disease perception, prevention behavior and access to care. In Morocco, data remain limited, particularly in the Marrakech-Safi region, where demographic, anthropometric and cultural characteristics may shape distinct risk profiles. Consequently, the present study was conducted to identify the determinants of gestational diabetes in this population, with the aim of providing evidence to guide a targeted maternal health intervention in North Africa.

Study Design and Methods

Study Area



Fig. 1: Geographical Map of the Study Area

The research was conducted in Morocco's central administrative region of Marrakech - Safi (Figure 1), which covers approximately 39,167 km² and had an estimated population of 4.5 million in 2020. This region comprises seven provinces and prefectures, three of which were included in this study:

- Marrakech Prefecture, encompassing the urban and peri urban areas surrounding the city of Marrakech
- Al Haouz Province, characterized by mountainous and rural communes such as Tahnaout, Amizmiz and Tameslouht
- El Kelaa des Sraghna Province, a predominantly semi-rural and agricultural zone

The climate ranges from semi-arid conditions in the Houz plain, with average annual rainfall between 200 and 400 mm, to sub-humid conditions at higher elevations of the High Atlas foothills, where rainfall may reach 800 mm. Altitudes vary from 450 m in the plains to over 4000 m in the high Atlas Mountains, Shaping local agriculture, lifestyle and access to healthcare services [13].

Healthcare infrastructure includes a tertiary university hospital in Marrakech, provincial hospitals in Al Haouz and Kelaa des Sraghna, and a network of community health centers. Collectively, these facilities manage approximately 4000 pregnancies annually and provide antenatal care, including gestational diabetes screening in accordance with national guideline [14].

Ethical Considerations

Ethical approval was obtained from the Regional Directorate of Health, Marrakech-Safi (authorization number 3235, dated 10 May 2021). Permission was granted to conduct a regional survey on gestational diabetes. Prior to data collection, coordination meetings were held with representatives of the Provincial Health Divisions. All participants were fully informed about the objectives, procedures, and confidentiality of the study. Written informed consent was obtained before inclusion. All collected data were anonymized to ensure confidentiality and privacy.

Study Population

The target population was pregnant women attending antenatal care in selected provinces of the Marrakech-Safi region between October 2021 and January 2023. Inclusion criteria concerned all women with an ongoing pregnancy and a complete clinical record, whether or not gestational diabetes (GDM) had been diagnosed during antenatal consultations by midwives, general practitioners or specialists. Women with pre-existing diabetes (type 1 or type 2 diagnosed before pregnancy) were excluded in order to include only incident cases of GDM. Diagnosis was established according to World Health Organization criteria, based on fasting blood glucose ≥ 0.92 g/L (5.1 mmol/L), blood glucose ≥ 1.80 g/L (10.0 mmol/L) at 1 hour or ≥ 1.53 g/L (8.5 mmol/L) at 2 hours after an oral glucose tolerance test (OGTT) at 75 g ; the presence of at least one of these criteria was sufficient to classify a woman as a GDM carrier. Risk factors studied included maternal age (< 26 vs. ≥ 26 years), family history of diabetes (present/absent), pregestational weight status defined by body mass index (overweight: 25-29.9 kg/m²; obese: ≥ 30 kg/m²), history of miscarriage (yes/no), parity (primigravida, two pregnancies, ≥ 3 pregnancies) as well as pre-pregnancy physical activity, collected by self-report and classified into three categories: active (≥ 150 minutes of moderate activity per week), moderately active, or inactive (< 150 minutes per week).

Data Collection

Data were collected using a structured questionnaire developed by the research team using tools validated in the literature and adapted to the Moroccan context. The questionnaire comprised several sections covering socio-demographic and economic characteristics, medical and obstetrical history, lifestyle habits (physical activity), anthropometric measurements and information about the current pregnancy. Prior to its administration, it was pre-tested with 30 women in a province not included in the main study, to assess the clarity and relevance of the items and make any necessary adjustments. Data collection was carried out by the first author, by means of face-to-face interviews, supplemented by consultation of prenatal medical records.

Sampling Methods

A non-probability convenience sampling approach was applied. Based on the number of women attending maternal health services in Al Haouz (2,240), El Kelaa des Sraghna (2,676), and Marrakech (3,638), the reference population was estimated at 8,554 women.

The required sample size was calculated using the finite population correction formula: $N = (Z^2 \times p(1-p)) / (e^2 + ((Z^2 \times p(1-p)) / N))$

Where n represents the sample size, Z the normal deviation at 95% confidence level (1.96), p the expected prevalence, e the margin of error, and N the population size. Based on a prevalence of 16% from local health reports, the adjusted population size was 1,369 women, resulting in a final sample size of 202 participant. To increase statistical power and provide an adequate comparison group, 129 women without gestational diabetes were recruited in the same way, bringing the total number of participants to 331.

Data Analysis

Data analysis was performed using SPSS software, version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics summarized the socio-demographic and clinical characteristics of participants. Bivariate and multivariate logistic regression models were used to identify independent risk factors associated with GDM. Results are presented as odds ratios (ORs) with 95% confidence intervals (CIs). A p -value < 0.05 was considered statistically significant.

Results

Sociodemographic Characteristics

The mean age of participants was 27.09 ± 6.4 years, with values ranging from 17 to 41 years. The majority of women had social security coverage (71.9%, $n = 238$), while 28.1% ($n = 93$) did not. Over half the participants lived in urban areas (51.7%, $n = 171$), 26.9% ($n = 89$) in semi-rural areas and 21.5% ($n = 71$) in rural areas.

With regard to level of education, 15.1% ($n = 50$) of the women had received no education at all, 36.6% ($n = 121$) had attained primary education, 33.5% ($n = 111$) secondary education and 14.8% ($n = 49$) higher education. The vast majority of participants were housewives (90.3%, $n = 299$). Other occupational categories represented 3.9% ($n = 13$) for self-employed women, 2.7% ($n = 9$) for the public sector, 0.6% ($n = 2$) for the semi-public sector and 2.4% ($n = 8$) for the private sector.

In terms of monthly income, 20.2% ($n = 67$) of participants had an income of less than 2,000 dirhams, 40.8% ($n = 135$) between 2,000 and 4,000 dirhams, and 27.5% ($n = 91$) between 4,000 and 10,000 dirhams (Table 1).

Table 1: Socioeconomic characteristics of the study population

Variable	Modality	Frequency	Percentage
Social Coverage	Yes	238	71.9%
	No	93	28.1%
Place of Residence	Urban	171	51.7%
	Semi-rural	89	26.9%
	Rural	71	21.5%
	None	50	15.1%
Education Level	Primary	121	36.6%
	Secondary	111	33.5%
	Higher Education	49	14.8%
Woman's Occupation	Housewife	299	90.3%
	Self-employed	13	3.9%
	Public sector	9	2.7%
	Semi-public sector	2	0.6%
Monthly Income	Private sector	8	2.4%
	<2000 MAD*	67	20.2%
	2000-4000 MAD	135	40.8%
	4000-10000 MAD	91	27.5%

MAD: Moroccan Dirham; 1 MAD = 0,1 USD

Clinical and Obstetric Characteristics

According to the participants' clinical and personal characteristics, as illustrated in Figure 2, approximately half (49.5%; n = 164) of the women were under the age of 26, 34.4% (n = 114) were between the ages of 26 and 35, and 16.0% (n = 53) were over the age of 35. In terms of BMI, 43.2% (n = 143) of the women were classified as overweight or obese. With 11.5% (n = 38) of patients reporting at least one miscarriage. In terms of parity, 19.0% (n = 63) had three or more pregnancies, 29.9% (n = 99) had two pregnancies, and more than half (51.1%; n = 169) were primiparous. In the study sample, 35 women (10.5%) were classified as active, 172 women (52.0%) as moderately active, and 124 women (37.5%) as inactive prior to becoming pregnant. Furthermore, half (50.5%; n = 167) and about one-quarter (27.8%; n = 92) of respondents reported a Gestational Diabetes Mellitus (GDM) and family history of diabetes, respectively. The distribution of blood groups revealed that group O (45.0%; n = 149) was the most prevalent, followed by group A (39.3%; n = 130), group B (10.6%; n = 35), and group AB (5.1%; n = 17) (Figure 2).

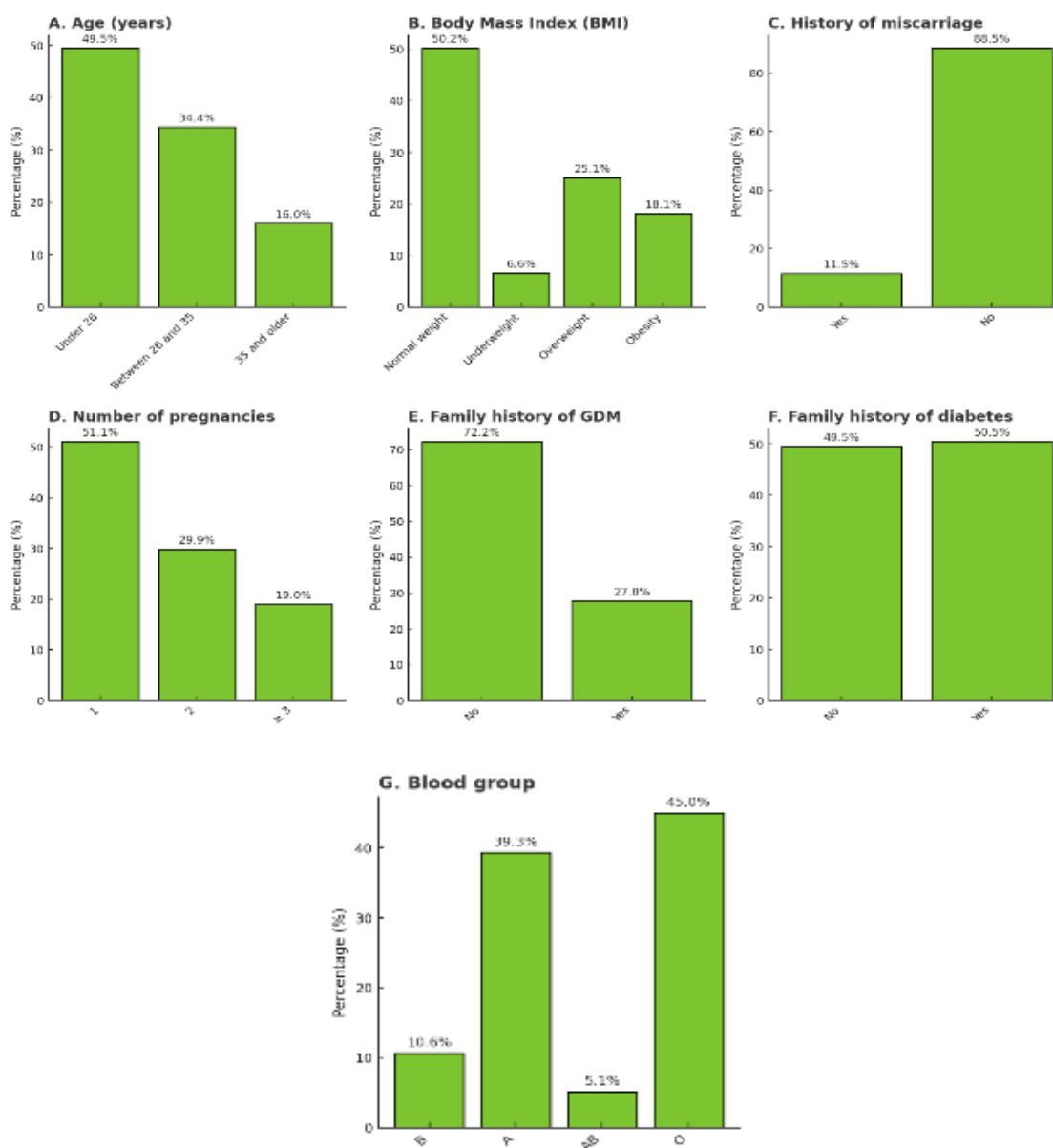


Fig. 2: Distribution of Clinical and Personal Characteristics of Participants: (A) Maternal Age; (B) Body Mass Index; (C) History of miscarriage; (D) Number of pregnancies; (E) Family history of gestational diabetes mellitus; (F) Family history of diabetes; (G) Blood group

Multivariate Analysis of Risk Factors

The results showed that maternal age over 26 years was associated with an increased risk of developing gestational diabetes. Women aged 26-35 had a 2.6-fold increased risk (aOR = 2.58; 95% CI [1.37-4.88]; p = 0.003), and those aged 35 and over a 4.4-fold increased risk (aOR = 4.37; 95% CI [1.88-10.14]; p < 0.001), compared with women aged ≤ 26 years.

A history of miscarriage was also significantly associated with gestational diabetes (aOR = 2.47; 95% CI [1.18-5.15]; p = 0.016). High parity was a major risk factor: women with two pregnancies had a 31.6-fold increased risk (aOR = 31.62; CI95% [9.40-106.35]; p < 0.001) and those with three or more pregnancies a 36.4-fold increased risk (aOR = 36.40; CI95% [10.45-126.85]; p < 0.001), compared with primiparous women.

Similarly, a family history of diabetes was significantly associated with the onset of gestational diabetes (aOR = 2.81; CI95% [1.56-5.07]; p < 0.001).

With regard to body mass index, although obesity showed an aOR of 1.90, the association was not statistically significant (CI95% [0.71-5.04]; p = 0.199).

On the other hand, the analysis revealed that women from blood group A (aOR = 0.29; CI95% [0.12-0.67]; p = 0.004) and group O (aOR = 0.39; CI95% [0.18-0.87]; p = 0.021) had a significantly lower risk of gestational diabetes than those from group B.

On the other hand, no significant association was found for family history of gestational diabetes, presence of chronic diseases, pre-pregnancy physical activity and whether the pregnancy was wanted or not (Table 2).

Table 2: Multivariable logistic regression of factors associated with GDM

	Adjusted OR	95% CI Lower	95% CI Upper	P-Value
Age (years)				
≤ 26	1.00 *	Ref	Ref	Ref
26-35	2.58	1.37	4.88	0.0034
≥ 35	4.37	1.88	10.14	0.0006
BMI class				
Normal	1.00 *	Ref	Ref	Ref
Underweight	0.50	0.23	1.11	0.0875
Overweight	1.33	0.67	2.63	0.4182
Obese	1.90	0.71	5.04	0.1994
History of miscarriage				
No	1.00 *	Ref	Ref	Ref
Yes	2.47	1.18	5.15	0.016
Number of pregnancies				
1	1.00 *	Ref.	Ref.	Ref.
2	31.62	9.40	106.35	< 0.001
≥3	36.40	10.45	126.85	< 0.001
Family history of GDM				
No	1.00 *	Ref	Ref	Ref
Yes	1.76	0.99	3.12	0.0555
Family history of diabetes				
No	1.00 *	Ref	Ref	Ref
Yes	2.81	1.56	5.07	0.0006
Chronic conditions				
No chronic disease	1.00 *	Ref	Ref	Ref

Any chronic disease	1.42	0.50	4.07	0.51
Pre-pregnancy physical activity				
Active	1.00 *	Ref	Ref	Ref
Moderately active	0.72	0.26	1.99	0.5226
inactive	1.56	0.61	4.02	0.3555
Desired Pregnancy				
Yes	1.00 *	Ref	Ref	Ref
No	1.19	0.60	2.37	0.6136
Blood group				
B	1.00 *	Ref	Ref	Ref
A	0.29	0.12	0.67	0.0039
AB	0.52	0.14	1.94	0.3303
O	0.39	0.18	0.87	0.0215

* Ref = reference category. For reference levels, ORs are fixed to 1.00 by definition; CIs and p-values are not applicable. All other levels report adjusted OR, 95% CI and p-value

Discussion

Such integrated approaches would help reduce the burden of GDM and improve maternal and neonatal outcomes in North Africa, particularly in resource-limited settings. This study sheds important light on the determinants of gestational diabetes in Moroccan women in the Marrakech-Safi region. Multivariate analysis confirmed that advanced maternal age, overweight and obesity, multiparity, previous miscarriage and family history of diabetes were significant predictors of GDM, in line with international literature [9, 15-19].

The risk appeared markedly increased in women aged 35 and over, consistent with studies linking advanced maternal age to progressive impairment of insulin sensitivity and pancreatic beta-cell dysfunction [20, 21]. In contrast, no significant association was found with body mass index. Although obesity showed a trend towards increased risk (adjusted OR 1.90), this relationship did not reach statistical significance. This result contrasts with the majority of published studies, which systematically identify overweight and obesity as major determinants of GDM [22-26]. Several hypotheses can be put forward, including sample size, distribution of BMI categories and contextual differences linked to the participants' nutritional profile.

History of miscarriage also showed a significant association with GDM. This link could reflect the existence of common pathophysiological mechanisms or underlying metabolic dysfunctions. Previous studies have reported similar relationships between adverse pregnancy outcomes and subsequent abnormalities in carbohydrate metabolism [27,28]. As for physical activity, it did not reach statistical significance in our cohort. This result could be explained by the low levels of activity reported, limiting discriminatory power, but also by methodological differences between assessment tools and heterogeneity in exercise intensity [29,30].

Family history of diabetes confirmed its role as an independent risk factor, reflecting genetic predisposition to GDM and reinforcing the value of enhanced screening in women from affected families [31,33]. Another original finding of our study concerns the distribution of blood groups. Multivariate analysis showed that women from blood groups A and O had a significantly lower risk of GDM than those from blood group B. This finding is at odds with several publications that have not observed any association, or on the contrary have reported an increased frequency of GDM in certain groups, notably A or AB [34-36]. These differences could be explained by a particular distribution of blood groups in the region studied, by specific genetic or immunological mechanisms, or by methodological limitations. This result must be interpreted with caution, and calls for further investigations on larger samples and in other regions of Morocco.

Finally, physical activity, family history of GDM, chronic disease and desired pregnancy did not show a significant association with GDM in our cohort. Overall, our results fill an important gap in the available data on the determinants of GDM in Morocco. They underline the importance of early and systematic screening, as well as contextualized prevention strategies targeting in particular older, multiparous women, with a history of miscarriage or a family history of diabetes. The

exploration of emerging factors, such as blood group distribution, is also opening up new avenues of research into the genetic and immunological dimensions of GDM.

However, certain methodological limitations should be emphasized. The use of convenience sampling may introduce a selection bias and limit the representativeness of the region's entire pregnant population. The results should therefore be interpreted with caution and considered exploratory. Nevertheless, the size of the sample, the geographical diversity of the sites included and the multivariate analysis provide a relative robustness that reinforces the internal validity of our observations.

Conclusion

Our study showed that advanced maternal age, multiparity, history of miscarriage and family history of diabetes are major determinants of gestational diabetes in the Marrakech-Safi region. The association observed with blood groups A and O, suggesting a protective effect over group B, needs to be confirmed by further studies. These results highlight the need for early screening, nutritional monitoring and promotion of an active lifestyle as part of prenatal care, with adaptations taking into account local resources, in order to improve maternal and neonatal health.

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Author's Contributions

Hafssa Abdellaoui: Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Data curation, Visualization, Writing - original draft.

Nadia Ouzennou: Methodology, Validation, Writing - review & editing, Project administration.

Adnane Hakem: Software, Technical support.

Samia Rkha: Conceptualization, Validation, Supervision, Project administration, Writing - review & editing.

All authors have read and approved the final version of the manuscript.

Ethics

The present study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the Ethics Committee of the Regional Directorate of Health, Marrakech-Safi, Morocco (protocol code 3235; approval date: 10 May 2021).

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