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# Health-Related Quality of Life Among Pregnant Women Diagnosed with Gestational Diabetes

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## Abstract

**Background:** Gestational diabetes mellitus (GDM) is a common metabolic complication of pregnancy with implications that extend beyond glycemic control and obstetric outcomes. Health-related quality of life (HRQoL) is an important patient-reported outcome that may reflect the broader physical, psychological, social, and environmental burden of GDM. This study aimed to evaluate HRQoL among pregnant women with GDM compared with women with uncomplicated pregnancies and to explore demographic, obstetric, and glycemic factors associated with HRQoL outcomes. **Methods:** A cross-sectional comparative observational study was conducted at the Athens Naval Hospital. The study included 111 pregnant women aged 20–45 years with GDM and 112 pregnant women without known pathological conditions. HRQoL was assessed using the WHOQOL-BREF questionnaire. Non-parametric statistical tests included the Mann-Whitney U test, Friedman test, Kruskal-Wallis test, and Spearman's correlation coefficient. Adjusted general linear models were used to examine the association between GDM status and HRQoL after accounting for selected measured covariates. **Results:** Women with GDM had significantly lower HRQoL scores than controls across all WHOQOL-BREF domains, including physical health, psychological health, social relationships, environment, and overall quality of life. Effect sizes ranged from small to moderate (r = 0.23–0.35). Among women with GDM, the Environment domain showed the lowest relative score, followed by Psychological Health, Social Relationships, and Physical Health. Fasting glucose showed initial negative associations with Psychological Health and Social Relationships, but these did not remain significant after Bonferroni correction. In adjusted models, GDM status remained significantly associated with lower HRQoL across all outcomes. **Conclusions:** GDM was associated with lower HRQoL during pregnancy after adjustment for selected measured covariates. These findings support consideration of maternal HRQoL alongside glycemic monitoring and obstetric surveillance in antenatal GDM care.

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## 1. Introduction

Pregnancy is accompanied by substantial metabolic, hormonal, and physiological adaptations that support fetal growth and prepare the maternal body for delivery and lactation [1,2]. A progressive increase in insulin resistance is a physiological feature of pregnancy, particularly during the second and third trimester, and is driven by placental and maternal hormonal changes [1]. Gestational diabetes mellitus (GDM) develops when pancreatic β-cell compensation is insufficient to meet the increased insulin demand of pregnancy, resulting in hyperglycemia first recognized during gestation [1,3].

GDM is one of the most common metabolic complications of pregnancy and remains an important global public health concern [4]. In 2024, approximately 19.7% of live births were affected, with 79% of cases due to GDM and 20% due to overt diabetes in pregnancy and pre-existing diabetes in pregnancy combined [5]. The reported prevalence of GDM varies substantially across populations because of differences in maternal age, body mass index, ethnicity, healthcare access, screening strategies, and diagnostic criteria [6]. GDM is clinically important because it is associated with adverse maternal, obstetric, fetal, and neonatal outcomes, as well as increased long-term risk of type 2 diabetes and cardiometabolic disease in women after pregnancy [7].

The management of GDM traditionally focuses on glycemic control, nutritional management, lifestyle modification, glucose monitoring, and pharmacological treatment when indicated [2,8]. However, the diagnosis of GDM may also alter women's everyday experience of pregnancy because it often requires dietary modification, self-monitoring of blood glucose, repeated clinical appointments, and possible treatment escalation [9]. These disease-management demands may contribute to psychological, social, lifestyle-related, informational, and healthcare-related challenges during pregnancy [10]. Therefore, evaluating health-related quality of life (HRQoL) in women with GDM is important for understanding the broader impact of the condition beyond biomedical and obstetric outcomes [11,12].

Health-related quality of life (HRQoL) is a multidimensional construct that reflects an individual's subjective perception of health and well-being within the context of personal expectations, cultural values, goals, and concerns [13,14]. The World Health Organization Quality of Life-BREF (WHOQOL-BREF) assesses quality of life across four domains: physical health, psychological health, social relationships, and environment, providing a broad multidimensional assessment of perceived well-being [13,14]. In the present study, the WHOQOL-BREF was selected because the primary research question required direct comparison between women diagnosed with GDM and women with uncomplicated pregnancies using the same measurement framework. Although disease-specific instruments may provide greater sensitivity to diabetes-related concerns and treatment burden, such measures contain condition-specific items that are not directly applicable to women without GDM. The use of a generic instrument therefore allowed comparable assessment of the same quality-of-life domains across both study groups. Nevertheless, the generic nature of the WHOQOL-BREF may limit its sensitivity to GDM-specific experiences, and this issue is considered in the interpretation of the findings. In pregnancy, HRQoL may be shaped by biological changes, maternal expectations, family and social support, socioeconomic circumstances, access to care, and concerns about fetal development and delivery [12,15]. In women with GDM, HRQoL may be further influenced

by treatment modality, dietary limitations, perceived restrictions in daily life, illness acceptance, self-efficacy, and uncertainty regarding future metabolic health [15,16].

Recent evidence suggests that women with GDM may experience lower quality of life than women without GDM, although the magnitude and affected domains vary across studies [11,12]. A recent systematic review and meta-analysis reported that GDM may reduce quality of life, particularly in mental and social health domains [11]. Another systematic review and meta-analysis identified sociodemographic, medical, treatment-related, and psychosocial factors as relevant determinants of quality of life among women with GDM [12]. Disease-specific quality-of-life research has also shown that GDM can affect multiple aspects of daily life, particularly freedom around eating and drinking, treatment burden, and perceived impact of the diagnosis [16]. However, previous studies have shown considerable heterogeneity in study populations, measurement instruments, gestational timing, and analytical approaches [11,12]. As a result, the domain-specific pattern and magnitude of HRQoL differences between women with GDM and women with uncomplicated pregnancies remain incompletely characterized, particularly after adjustment for relevant measured covariates. In addition, it remains important to determine whether poorer HRQoL is closely related to glycemic indices or reflects a broader burden associated with the diagnosis and management of GDM. The present study was designed to address these issues by combining a contemporaneous control group, domain-specific HRQoL assessment, estimation of effect sizes, adjusted analyses, and evaluation of associations between glycemic indicators and HRQoL outcomes. Therefore, the present study aimed to evaluate HRQoL among pregnant women with GDM compared with women with uncomplicated pregnancies. Secondary objectives were to identify the WHOQOL-BREF domains most affected among women with GDM and to examine whether demographic, obstetric, anthropometric, and glycemic characteristics were associated with HRQoL outcomes. The study also examined whether the association between GDM status and HRQoL persisted after adjustment for selected demographic, socioeconomic, and clinical covariates.

## 2. Materials and Methods

This was a cross-sectional comparative observational study assessing HRQoL among pregnant women with and without GDM. The study was conducted at the Athens Naval Hospital. Participant recruitment for both the GDM and control groups took place from April 2017 to April 2020. The GDM group consisted of 111 pregnant women aged 20–45 years who had been diagnosed with GDM for the first time during the current pregnancy and were in the third trimester at the time of study participation. These women were recruited during follow-up at the outpatient Endocrinology Clinic. The control group consisted of 112 pregnant women aged 20–45 years who were also in the third trimester of pregnancy and had no known pathological conditions. Control participants were recruited during follow-up at the outpatient Gynecology Clinic of the same hospital. The same general eligibility criteria regarding the ability to speak and understand Greek were applied to all participants. Pregnant women with pre-existing type 1 or type 2 diabetes mellitus, autoimmune disease, current corticosteroid treatment, mental illness, cardiac or renal disease, or substance or alcohol abuse were excluded from the study. No formal a priori sample-size calculation was performed.

Data collection included the administration of questionnaires designed to record demographic and clinical characteristics. Glycemic indices included fasting plasma glucose and 2-h plasma glucose measured following a 75-g oral glucose tolerance test (OGTT), both expressed in mg/dL. Throughout the manuscript, “post-load glucose” refers to the 2-h glucose value obtained during the 75-g OGTT. Quality of life was assessed using the Greek version of the World Health Organization Quality of Life-BREF (WHOQOL-BREF)

questionnaire. The instrument assesses four domains: Physical Health, Psychological Health, Social Relationships, and Environment, as well as two global items addressing overall quality of life and overall health. The Greek version has demonstrated satisfactory psychometric properties in both clinical and healthy Greek populations [17]. Domain scores were calculated according to the Greek WHOQOL-BREF scoring instructions. Relevant negatively worded items were reverse-scored, and the mean item score for each domain was multiplied by 4, yielding scores ranging from 4 to 20, with higher scores indicating better perceived quality of life. Overall QoL/health was calculated as the mean of the two global items, G1 (overall quality of life) and G2 (overall health), multiplied by 4. No total score combining the four WHOQOL-BREF domains was calculated.

*Statistical Analysis*

Normality of continuous variables was assessed using the Shapiro-Wilk test, which indicated a deviation from normal distribution; non-parametric methods were therefore used for the unadjusted analyses. Missing outcome data were handled using complete-case analysis separately for each HRQoL outcome; no imputation was performed. Between-group comparisons were performed using the Mann-Whitney U test, with calculation of effect size r as a measure of effect magnitude. Within-group comparisons across quality-of-life domains were performed using the Friedman test, with calculation of Kendall's W as a measure of effect size, and correlations between continuous variables were assessed using Spearman's correlation coefficient. Baseline categorical characteristics were compared between the GDM and control groups using Pearson's chi-square test, with continuity correction applied to 2 × 2 tables. Associations between categorical demographic variables and HRQoL outcomes were assessed using the Kruskal-Wallis test, followed by post-hoc comparisons where appropriate. Bonferroni correction was applied separately within analysis-specific families of related hypotheses rather than across all analyses jointly: five between-group comparisons (four WHOQOL-BREF domains plus Overall QoL), eight glycemic correlations (two glycemic indices across four WHOQOL-BREF domains), five GROUP effects across the adjusted GLM models, and six pairwise post-hoc comparisons following the significant Kruskal-Wallis test for educational level. Statistical significance was set at $p < 0.05$. Statistical analysis was performed using IBM SPSS Statistics (version 28.0) and supplementarily in Python 3.15.1. To examine whether the association between GDM diagnosis and quality of life remained statistically significant after accounting for potential covariates, an analysis was conducted using a general linear model for each of the HRQoL outcomes. Candidate covariates were identified based on prior literature reporting associations between sociodemographic factors and quality of life in pregnant women with GDM or hyperglycemia during pregnancy [12,15]. Covariates for inclusion in the adjusted models were selected through a two-stage statistical procedure. In the first stage, each candidate variable (age, educational level, income, marital status, living situation, parity, and mode of conception) was examined individually in relation to each dependent variable (overall QoL and domains) through a univariate general linear model. In the second stage, factors satisfying $p < 0.1$ were entered together into a multivariable model along with the GROUP variable, which remained fixed in the model as the primary variable of interest. Backward elimination was then applied, sequentially removing the least significant factor until all remaining factors showed $p < 0.05$. Given that the effect of the GROUP variable was examined across five separate adjusted models, Bonferroni correction was applied to the corresponding $p$-value. Model assumptions were examined for all adjusted models, including residual normality (Shapiro-Wilk test and Q-Q plots), homoscedasticity (Breusch-Pagan test), multicollinearity using generalized variance inflation factors (GVIFs), and influential observations (Cook's distance). Where

heteroscedasticity was detected, models were re-estimated using HC3 heteroscedasticity-consistent robust standard errors.

As a sensitivity analysis, additional models were fitted using a fixed covariate set selected on clinical and epidemiological grounds rather than on statistical significance in the present dataset. Maternal age, educational level, marital status, and pre-pregnancy BMI were included in all five HRQoL models. These variables were selected as relevant pre-existing demographic, socioeconomic, and metabolic characteristics that may be associated with GDM status and/or maternal HRQoL. The same covariate set was retained in all models irrespective of individual covariate *p*-values, and no univariable screening or backward elimination was applied. The sensitivity analysis was performed to assess whether the estimated association between GDM diagnosis and HRQoL was robust to an alternative covariate-selection strategy.

## 3. Results

### *3.1. Descriptive Statistics and Group Comparisons*

The two groups were comparable with respect to gestational age, educational level, income, marital status, living situation, parity, mode of conception and history of GDM in a previous pregnancy (all $p > 0.05$). Women with GDM were significantly older (34.23 vs. 32.31 years, $p = 0.009$), had higher pre-pregnancy BMI (24.12 vs. 23.38 kg/m$^2$, $p = 0.013$), greater pre-pregnancy weight (66.32 vs. 64.39 kg, $p = 0.032$), higher rates of excessive gestational weight gain (30.9% vs. 17.1%, $p = 0.025$), and a higher prevalence of family history of diabetes (57.7% vs. 38.4%, $p = 0.006$). As expected, fasting and post-load glucose values were significantly higher in the GDM group (both $p < 0.001$) (Table 1).

**Table 1.** Baseline Characteristics of Women with GDM and Controls.

| Variable | GDM (*n* = 111) | Control (*n* = 112) | *p* |
|---|---|---|---|
| **Continuous Variables** | **Mean (SD)/Median (IQR)** | **Mean (SD)/Median (IQR)** | |
| **Age (years)** | 34.23 (5.79)/35.00 (31–38) | 32.31 (5.60)/32.00 (28–37) | 0.009 |
| **Gestational age (weeks)** | 30.85 (4.03)/30.00 (28–34) | 29.19 (7.63)/31.00 (25–35) | 0.721 |
| **Pre-pregnancy weight (kg)** | 66.32 (10.27)/65.00 (59–72) | 64.39 (13.10)/61.25 (55–71) | 0.032 |
| **Pre-pregnancy BMI (kg/m$^2$)** | 24.12 (3.29)/23.99 (21.92–25.61) | 23.38 (4.61)/22.29 (20.20–25.77) | 0.013 |
| **Fasting glucose (mg/dL)** | 91.99 (7.76)/92.00 (88–97) | 87.10 (9.23)/88.00 (80–93) | <0.001 |
| **2-h post-load glucose (mg/dL)** | 155.97 (28.23)/158.00 (140–180) | 135.94 (28.07)/136.50 (115–158) | <0.001 |
| **Categorical variables** | ***n* (%)** | ***n* (%)** | |
| **Marital status** | | | 0.216 |
| Married/cohabiting | 94 (84.7%) | 99 (88.4%) | |
| Single | 6 (5.4%) | 2 (1.8%) | |
| Divorced/separated | 4 (3.6%) | 1 (0.9%) | |
| Other | 7 (6.3%) | 10 (8.9%) | |
| **Educational level** | | | 0.935 |
| Primary | 2 (1.8%) | 1 (0.9%) | |
| Secondary | 40 (36.4%) | 43 (38.4%) | |
| University/TEI | 48 (43.6%) | 48 (42.9%) | |
| Postgraduate | 20 (18.2%) | 20 (17.9%) | |
| **Income level** | | | 0.421 |
| Level 1 (lowest) | 17 (15.5%) | 26 (23.2%) | |
| Level 2 | 27 (24.5%) | 33 (29.5%) | |
| Level 3 | 42 (38.2%) | 34 (30.4%) | |
| Level 4 | 15 (13.6%) | 12 (10.7%) | |
| Level 5 (highest) | 9 (8.2%) | 7 (6.2%) | |

| | | | |
|---|---|---|---|
| **Living situation** | | | 0.125 |
| Alone | 16 (14.4%) | 8 (7.1%) | |
| With others | 95 (85.6%) | 104 (92.9%) | |
| **Parity** | | | 0.309 |
| 1st pregnancy | 64 (57.7%) | 67 (60.4%) | |
| 2nd pregnancy | 34 (30.6%) | 36 (32.4%) | |
| 3rd pregnancy | 10 (9.0%) | 5 (4.5%) | |
| 4th pregnancy | 2 (1.8%) | 0 (0%) | |
| 5th pregnancy | 1 (0.9%) | 3 (2.7%) | |
| **Mode of conception** | | | 0.228 |
| Spontaneous | 97 (87.4%) | 103 (92.0%) | |
| Artificial insemination | 7 (6.3%) | 2 (1.8%) | |
| IVF | 7 (6.3%) | 7 (6.2%) | |
| **GDM in previous pregnancy** | | | 0.084 |
| Yes | 27 (24.3%) | 16 (14.3%) | |
| No | 84 (75.7%) | 96 (85.7%) | |
| **Excessive weight gain** | | | 0.025 |
| Yes | 34 (30.9%) | 19 (17.1%) | |
| No | 76 (69.1%) | 92 (82.9%) | |
| **Family history of diabetes** | | | 0.006 |
| Yes | 64 (57.7%) | 43 (38.4%) | |
| No | 47 (42.3%) | 69 (61.6%) | |

The study included 111 women diagnosed with GDM and 112 women with uncomplicated pregnancies who served as the control group. Regarding HRQoL, women with GDM demonstrated lower scores across all domains compared with controls: Physical Health (mean = 14.15, SD = 2.43 vs. mean = 15.50, SD = 2.08), Psychological Health (mean = 13.78, SD = 2.45 vs. mean = 15.58, SD = 2.04), Social Relationships (mean = 13.82, SD = 3.17 vs. mean = 15.77, SD = 2.42), Environment (mean = 13.02, SD = 2.65 vs. mean = 14.17, SD = 1.91), and Overall Quality of Life (mean = 14.63, SD = 2.92 vs. mean = 16.34, SD = 2.02). Median and interquartile range (IQR), as well as minimum and maximum values, are also presented, given that the distributions of the study variables deviated from normality. Missing data were handled using complete-case analysis for each outcome separately. All 111 women with GDM had complete outcome data; among controls, 111 observations were available for Physical Health and Psychological Health and 112 for Social Relationships, Environment, and Overall QoL (Table 2).

The Mann-Whitney U test revealed statistically significant differences between the two groups for all variables examined: Physical Health ($p < 0.001$, r = 0.27), Psychological Health ($p < 0.001$, r = 0.35), Social Relationships ($p < 0.001$, r = 0.31), Environment ($p < 0.001$, r = 0.23), and Overall Quality of Life ($p < 0.001$, r = 0.33). Women with GDM exhibited significantly lower quality of life across all domains compared with the control group. Values in parentheses indicate effect size r. The effect sizes ranged from small to moderate in magnitude. Reported $p$-values reflect Bonferroni-corrected significance levels, applied to account for multiple comparisons.

**Table 2.** Descriptive Statistics of Health-Related Quality of Life Among Women with GDM and Controls.

| Variable | Group | N | Mean (SD) | Median | IQR | Min–Max |
|---|---|---|---|---|---|---|
| **Physical Health** | GDM | 111 | 14.15 (2.43) | 14.67 | 3.56 | 8.00–19.56 |
| | Control | 111 | 15.50 (2.08) | 15.56 | 2.67 | 8.00–20.00 |
| **Psychological Health** | GDM | 111 | 13.78 (2.45) | 14.00 | 3.33 | 7.33–18.67 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Control | 111 | 15.58 (2.04) | 16.00 | 3.33 | 10.67–20.00 |
| **Social Relationships** | GDM | 111 | 13.82 (3.17) | 14.40 | 4.00 | 4.00–20.00 |
| | Control | 112 | 15.77 (2.42) | 16.00 | 3.20 | 8.00–20.00 |
| **Environment** | GDM | 111 | 13.02 (2.65) | 13.50 | 4.00 | 5.50–19.00 |
| | Control | 112 | 14.17 (1.91) | 14.50 | 2.50 | 8.00–18.50 |
| **Overall QoL** | GDM | 111 | 14.63 (2.92) | 16.00 | 2.00 | 4.00–20.00 |
| | Control | 112 | 16.34 (2.02) | 16.00 | 2.00 | 10.00–20.00 |

Note: Abbreviations: SD, standard deviation; IQR, interquartile range; GDM, gestational diabetes mellitus. WHOQOL-BREF scores are presented on a 4–20 scale, with higher scores indicating better perceived quality of life. N varies slightly across outcomes because one participant in the control group had missing data for the Physical Health and Psychological Health domains. Complete-case analysis was performed separately for each outcome, and no imputation was used.

### *3.2. HRQoL Domains Most Affected*

The Friedman test revealed statistically significant differences among the four HRQoL domains ($p < 0.001$, Kendall's W = 0.108), although the effect size was small. The most adversely affected domain was Environment (Mean Rank = 1.90), followed by Psychological Health (Mean Rank = 2.54), Social Relationships (Mean Rank = 2.69), and Physical Health (Mean Rank = 2.86) (Figure 1).

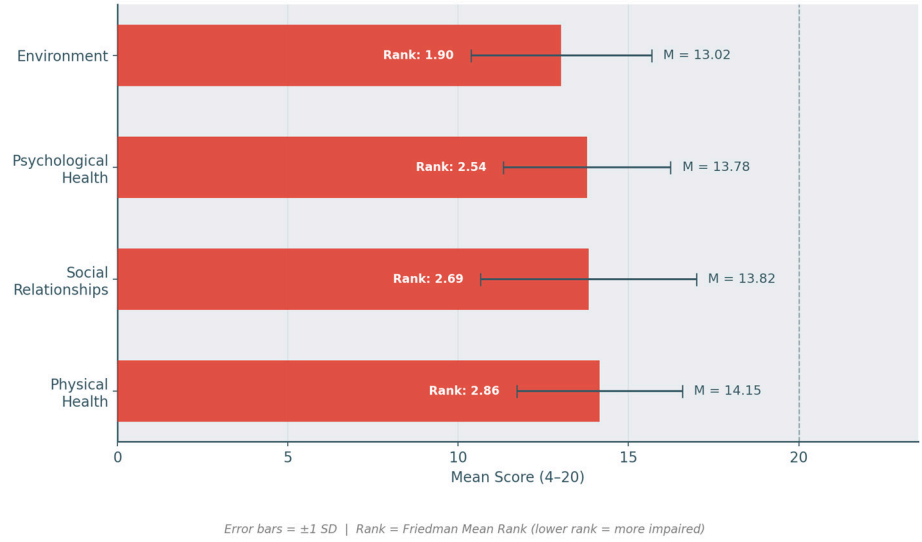



**Figure 1.** Relative impairment of HRQoL domains among women with GDM. Bars represent mean WHOQOL-BREF domain scores, and error bars represent ±1 SD. The ordering of domains is based on mean ranks derived from the Friedman analysis, with lower mean rank indicating greater relative impairment.

### *3.3. The Role of Demographic Variables*

Non-parametric statistical tests were employed to investigate the role of demographic variables. Regarding age, Spearman's correlation analysis did not reveal any significant associations between age and any of the examined domains.

With respect to educational level, Kruskal-Wallis analysis demonstrated a statistically significant effect only for the Physical Health domain ($p = 0.029$), whereas the effect for the Environment domain approached statistical significance ($p = 0.053$). No significant differences were observed for Psychological Health, or Social Relationships. Post-hoc analysis for Physical Health indicated that the only statistically significant difference was between women with secondary education and those with university-level education

(adjusted $p = 0.036$). Finally, regarding economic status, the Kruskal-Wallis analysis did not reveal statistically significant differences for any of the examined variables.

### 3.4. Clinical Glucose Indicators and HRQoL

Spearman's correlation analysis demonstrated that fasting blood glucose levels were negatively associated with Psychological Health (rho = −0.246, $p = 0.009$) and Social Relationships (rho = −0.196, $p = 0.040$), suggesting that higher fasting glucose levels are associated with poorer quality of life in these domains. However, neither association remained statistically significant after Bonferroni correction for multiple comparisons (adjusted $p = 0.074$ and $p = 0.318$, respectively). No significant associations were found with Physical Health (rho = −0.064, $p = 0.504$) or Environment (rho = −0.093, $p = 0.333$). Furthermore, 2-h post-load glucose levels were not significantly associated with any quality-of-life domain (Table 3).

**Table 3.** Spearman Correlations Between Glycemic Indices and HRQoL Domains in Women with GDM.

| Glycemic Index | HRQoL Outcome | Rho (Spearman) | *p* | Adjusted *p* (Bonferroni) |
|---|---|---|---|---|
| **Fasting plasma glucose (mg/dL)** | Physical Health | −0.064 | 0.504 | 1.000 |
| | Psychological Health | −0.246 | 0.009 | 0.074 |
| | Social Relationships | −0.196 | 0.040 | 0.318 |
| | Environment | −0.093 | 0.333 | 1.000 |
| **2-h post-load plasma glucose (mg/dL)** | Physical Health | −0.031 | 0.746 | 1.000 |
| | Psychological Health | −0.059 | 0.540 | 1.000 |
| | Social Relationships | 0.046 | 0.634 | 1.000 |
| | Environment | −0.067 | 0.483 | 1.000 |

Note: Abbreviations: GDM, gestational diabetes mellitus; HRQoL, health-related quality of life. Post-load glucose refers to the 2-h plasma glucose value measured following a 75-g oral glucose tolerance test (OGTT). Spearman's rho is reported. Bonferroni-adjusted *p*-values were calculated across the eight glycemic correlation tests.

### 3.5. Adjusted General Linear Model Analysis

In the model with overall quality of life (Overall QoL) as the dependent variable, the covariates selected through the procedure described in the methodology were age ($p = 0.047$) and educational level ($p = 0.001$), with the model explaining 16.0% of the variance (Adjusted $R^2 = 0.160$). In the model with Physical Health as the dependent variable, the covariate selected through the procedure was educational level ($p = 0.001$), with the model explaining 13.4% of the variance (Adjusted $R^2 = 0.134$). In the model with Psychological Health as the dependent variable, the covariates selected through the procedure were marital status ($p = 0.015$) and living situation ($p = 0.011$), with the model explaining 18.6% of the variance (Adjusted $R^2 = 0.186$). In the model with Social Relationships as the dependent variable, the covariates selected through the procedure were marital status ($p < 0.001$) and living situation ($p = 0.006$), with the model explaining 21.1% of the variance (Adjusted $R^2 = 0.211$). In the model with Environment as the dependent variable, the covariates selected through the procedure were educational level ($p = 0.006$) and living situation ($p = 0.009$), with the model explaining 12.9% of the variance (Adjusted $R^2 = 0.129$) (Table 4).

**Table 4.** Adjusted General Linear Models for HRQoL Outcomes: GDM Group Effect and Domain-Specific Covariates.

| Predictor | Overall QoL | Physical Health | Psychological Health | Social Relationships | Environment |
|---|---|---|---|---|---|
| **GROUP (GDM vs. Control)** | | | | | |
| **B (95% CI)** | −1.53 [−2.18, −0.89] | −1.30 [−1.88, −0.72] | −1.69 [−2.27, −1.10] | −1.67 [−2.38, −0.96] | −1.03 [−1.63, −0.44] |
| **F (*p*)** | 21.70 (<0.001) | 19.65 (<0.001) | 31.92 (<0.001) | 21.62 (<0.001) | 11.87 (0.0007) |
| **Covariates** | Age, Education | Education | Marital, Living | Marital, Living | Education, Living |
| **Age F (*p*)** | 4.00 (0.047) | — | — | — | — |
| **Education F (*p*)** | 5.55 (0.001) | 5.96 (0.001) | — | — | 4.33 (0.006) |
| **Marital Status F (*p*)** | — | — | 3.59 (0.015) | 8.11 (<0.001) | — |
| **Living Situation F (*p*)** | — | — | 6.55 (0.011) | 7.82 (0.006) | 6.95 (0.009) |
| **$R^2$** | 0.179 | 0.150 | 0.204 | 0.229 | 0.148 |
| **Adjusted $R^2$** | 0.160 | 0.134 | 0.186 | 0.211 | 0.129 |
| **Residual df** | 215 | 216 | 216 | 217 | 216 |

Note: B represents the unstandardized regression coefficient for the GROUP predictor (GDM vs. control); negative values indicate lower HRQoL scores in the GDM group. CI, confidence interval; $R^2$, coefficient of determination; Adjusted $R^2$, adjusted coefficient of determination. Detailed regression coefficients, standard errors, confidence intervals, and *p*-values for model covariates are presented in Table A1.

Across all models, GDM status remained significantly associated with lower HRQoL after adjustment for the corresponding measured covariates and Bonferroni correction across the five GROUP-effect tests. The strongest association was observed for Psychological Health (F = 31.92, adjusted $p < 0.001$), whereas the weakest, although still statistically significant, was observed for Environment (F = 11.87, adjusted $p = 0.0034$) (Table 5).

**Table 5.** Effect of GDM Status Across the Adjusted HRQoL Models.

| HRQoL Outcome | Covariates | F (GROUP) | df | *p* | Adj. *p* (Bonferroni *n* = 5) | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| **Overall QoL** | Age, Education | 21.70 | 1, 215 | <0.001 | <0.001 | 0.160 |
| **Physical Health** | Education | 19.65 | 1, 216 | <0.001 | <0.001 | 0.134 |
| **Psychological Health** | Marital, Living | 31.92 | 1, 216 | <0.001 | <0.001 | 0.186 |
| **Social Relationships** | Marital, Living | 21.62 | 1, 217 | <0.001 | <0.001 | 0.211 |
| **Environment** | Education, Living | 11.87 | 1, 216 | 0.0007 | 0.0034 | 0.129 |

Note: Bonferroni correction was applied across the five GROUP-effect tests corresponding to Overall QoL, Physical Health, Psychological Health, Social Relationships, and Environment. For the Environment model, the unrounded raw *p*-value was 0.000684, reported as 0.0007; the corresponding Bonferroni-adjusted *p*-value was 0.0034. Adjusted $R^2$ represents the proportion of variance explained by each model after adjustment for the number of predictors.

Calculation of the variable coefficients of the adjusted models (Appendix, Table A1) showed that GDM diagnosis is associated with lower HRQoL scores across all examined domains. As illustrated in Figure 2, the 95% confidence intervals of all five estimates lie entirely on the negative side, indicating statistically significantly lower scores in women with GDM compared to the control group, even after adjustment for the corresponding covariates. The largest difference was observed for Psychological Health, while the smallest was observed for Environment.

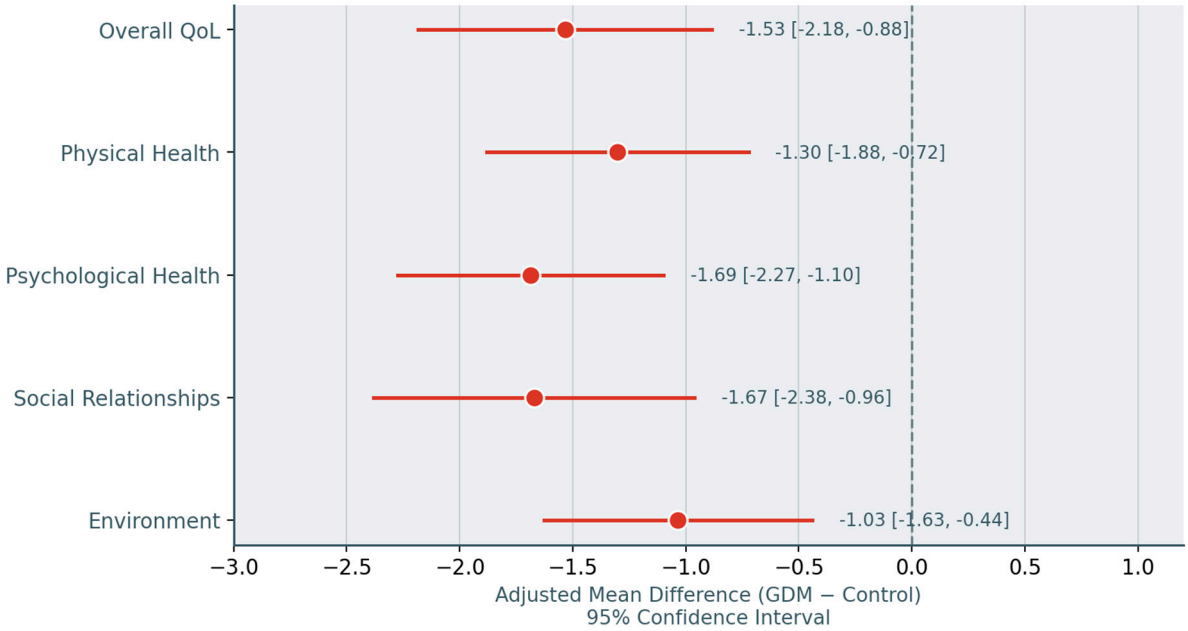



**Figure 2.** Adjusted differences in HRQoL scores between women with GDM and controls across all examined outcomes. Points represent the unstandardized regression coefficient (B) for the GROUP predictor in each adjusted model, and horizontal lines represent 95% confidence intervals. Negative coefficient values indicate lower HRQoL scores in the GDM group compared with the control group.

Multicollinearity was assessed using generalized variance inflation factors (GVIFs) to account for multi-level categorical predictors. GVIF values ranged from 1.002 to 1.073 across all predictors, with adjusted GVIF1/(2·df) values ranging from 1.000 to 1.036, indicating no evidence of problematic multicollinearity. Although the raw WHOQOL-BREF scores deviated from normality, model adequacy was assessed through residual diagnostics, as the relevant normality assumption pertains to the model residuals. The Shapiro-Wilk test did not indicate significant departures from residual normality in two of the five models; deviations in the remaining three were mild on Q-Q plot inspection. Heteroscedasticity was detected in four models (Breusch-Pagan $p < 0.05$). Therefore, all models were re-estimated using HC3 robust standard errors, which produced negligible changes in standard errors (<0.012 units) and no change in the statistical significance of the GDM effect. Influential observations exceeding Cook's $D > 4/n$ were identified in all models (10–17 observations), but the maximum Cook's D remained below 1 and no systematic pattern with respect to group membership or covariate values was identified.

To evaluate the robustness of the findings to the covariate-selection strategy, additional models were fitted using a fixed epidemiologically justified covariate set comprising maternal age, educational level, marital status, and pre-pregnancy BMI. The estimated GDM coefficients were highly consistent with those obtained from the primary data-driven models, with absolute changes in the regression coefficients ranging from 0.022 to 0.096 (<7% for all outcomes) and GDM remaining significantly associated with lower HRQoL across all five outcomes (all $p < 0.001$) (Table A2).

## 4. Discussion

The present study evaluated health-related quality of life among pregnant women with GDM compared with women with uncomplicated pregnancies. The main finding was that women with GDM reported lower quality-of-life scores across all examined WHOQOL-BREF domains, including physical health, psychological health, social relationships, environment, and overall quality of life. The observed differences indicate that lower HRQoL among women with GDM was not confined to a single domain. GDM status remained significantly associated with lower HRQoL across all adjusted models after adjustment for selected measured covariates.

Previous studies and systematic reviews have generally reported poorer quality of life among women with GDM, although the magnitude and specific dimensions of impairment have varied according to study population, measurement instrument, gestational stage, and treatment context [11,18–21]. Trutnovsky et al. [18] described deterioration in several aspects of quality of life during pregnancy among women with GDM, while Marchetti et al. [19] and Mobasseri et al. [11] highlighted the multidimensional nature of this burden and the considerable heterogeneity across available studies. Pantzartzis et al. [20] and Liu et al. [21] similarly reported poorer perceived health or quality of life among women with GDM compared with women without GDM. Collectively, these findings support the broader association between GDM and reduced maternal well-being but also demonstrate that the magnitude and pattern of impairment are not uniform across populations and assessment methods.

The present study extends this evidence by providing a domain-specific comparison with a contemporaneous control group and by quantifying the magnitude of between-group differences. Lower HRQoL scores were observed across all WHOQOL-BREF domains and overall quality of life, with small-to-moderate effect sizes. Importantly, the association between GDM status and lower HRQoL remained statistically significant after adjustment for selected measured covariates and was highly consistent in the sensitivity analysis using a fixed clinically and epidemiologically informed covariate set. In addition, glycemic indices were not robustly associated with HRQoL after correction for multiple comparisons. Taken together, these findings suggest that the quality-of-life burden associated with GDM is multidimensional and may not be adequately reflected by isolated glycemic measures alone. Although all between-group differences were statistically significant, the corresponding effect sizes were small to moderate ($r = 0.23–0.35$). Statistical significance should therefore not be interpreted as evidence that every observed difference was clinically important at the individual level. Because the present study did not prespecify a minimal clinically important difference for WHOQOL-BREF scores in pregnant women with GDM, the clinical magnitude of the observed score differences cannot be determined definitively. The findings are therefore best interpreted as evidence of consistent group-level differences in HRQoL, while the clinical importance of these differences requires further investigation.

In the present study, the Environment domain showed the lowest relative score among women with GDM, followed by Psychological Health, Social Relationships, and Physical Health. The Environment domain of the WHOQOL-BREF encompasses aspects such as access to health care, financial resources, opportunities for information, daily living conditions, transport, safety, and leisure. However, the present study did not directly assess factors such as frequency of clinical visits, dietary restrictions, glucose-monitoring burden, financial strain, transportation difficulties, or access to specialist care. These factors therefore cannot be identified as explanations for the observed Environment-domain findings, although they may represent plausible contextual factors that warrant direct investigation in future studies. In the adjusted models, the strongest between-group association was observed for Psychological Health, whereas the weakest, although still

statistically significant, was observed for Environment. This distinction indicates that within-group domain ranking and adjusted between-group differences capture different aspects of HRQoL.

The limited associations observed between demographic variables and HRQoL outcomes should also be interpreted carefully. Age was not significantly associated with the examined HRQoL domains, while educational level was significantly associated only with physical health. Economic status was not significantly associated with the examined variables. These findings suggest that, in this cohort, GDM status showed a more consistent association with HRQoL than the individual demographic characteristics examined. Nevertheless, previous studies have reported that quality of life among women with diabetes or hyperglycemia during pregnancy may be influenced by illness acceptance, self-efficacy, income status, social support, educational level, marital status, living conditions, and professional activity [15,22–24]. Therefore, the absence of broad demographic associations in the present study may reflect sample characteristics, limited variability within the cohort, or the conservative effect of correction for multiple comparisons.

The relationship between glycemic indicators and quality of life was less robust. Fasting glucose was negatively associated with psychological health and social relationships in the initial analysis; however, these associations did not remain statistically significant after Bonferroni correction. Post-load glucose values were not significantly associated with any HRQoL domain. These findings suggest that isolated laboratory glucose values may not fully explain the HRQoL burden experienced by women with GDM. Rather, HRQoL in this population may be shaped by a broader combination of clinical, psychological, behavioral, informational, and contextual factors. This interpretation is consistent with the heterogeneity reported in previous studies and systematic reviews, where QoL impairment varied according to measurement tool, population, gestational timing, treatment modality, and psychosocial context [11,19].

Overall, the present study contributes to the existing literature by demonstrating that pregnant women with GDM experience lower quality of life across multiple WHOQOL-BREF domains and that this association remains significant after adjustment for domain-specific covariates. These findings support the integration of patient-reported outcome measures into antenatal care for women with GDM. In clinical practice, assessment should not be limited to glucose values and obstetric parameters but should also include maternal perceptions of physical functioning, psychological well-being, social relationships, and environmental constraints. Such an approach may help identify women requiring additional education, counselling, dietetic support, social support, or more individualized follow-up.

From a personalized-care perspective, the assessment of HRQoL may complement glycemic and obstetric information by identifying women whose needs extend beyond metabolic control. Domain-specific HRQoL profiles could help clinicians recognize women reporting greater psychological, social, physical, or practical difficulties and may therefore support more individualized antenatal counselling and follow-up. Such information could be used to guide targeted referral, when appropriate, to diabetes nurses or midwives, dietitians, psychological services, or social support services. Rather than implying that HRQoL scores alone should determine clinical management, the present findings support their potential use as an additional patient-reported measure within a broader individualized assessment. In particular, poorer scores in specific WHOQOL-BREF domains may help identify areas in which additional education, psychosocial support, dietary counselling, or practical assistance could be considered. This approach is consistent with personalized antenatal care by tailoring supportive interventions to the individual needs and experiences reported by each woman.

Future research should evaluate HRQoL longitudinally from the time of GDM diagnosis through late pregnancy and the postpartum period in larger and more diverse multicenter populations. The combined use of generic and GDM-specific quality-of-life instruments may be particularly useful, allowing direct comparison with women without GDM while also capturing disease-specific concerns and treatment burden. Future studies should also systematically assess potentially modifiable factors such as treatment modality, social support, health literacy, illness acceptance, self-efficacy, dietary adherence, and access to specialist care. Intervention studies are needed to determine whether multidisciplinary care, structured education, psychosocial support, and strategies aimed at reducing the practical burden of GDM management can improve maternal HRQoL while maintaining appropriate glycemic and obstetric outcomes.

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design does not permit conclusions regarding temporality or causality. Therefore, the lower HRQoL observed among women with GDM cannot be attributed directly to the diagnosis itself, and unmeasured pre-existing or concurrent factors may have contributed to the observed differences. Second, participants were recruited from a single clinical setting using convenience sampling, which may have introduced selection bias and limits the generalizability of the findings to women receiving care in other healthcare settings or populations. The requirement for participants to speak and understand Greek may also have underrepresented migrant or linguistically diverse women, who may experience different barriers to care and HRQoL outcomes. No formal a priori sample-size calculation was performed; consequently, the study may have had limited statistical power to detect small associations, particularly in subgroup and correlational analyses.

The use of the WHOQOL-BREF also requires consideration. Although its generic structure enabled direct comparison between women with GDM and women with uncomplicated pregnancies, it may not fully capture GDM-specific concerns such as dietary restrictions, glucose-monitoring burden, treatment satisfaction, fear of treatment escalation, or perceived fetal risk. In addition, residual confounding cannot be excluded despite multivariable adjustment, as potentially relevant factors such as social support, illness acceptance, health literacy, self-efficacy, dietary adherence, and access to specialist care were not comprehensively assessed. The primary covariate-selection strategy also included a data-driven component, which may increase the risk of model instability. However, the sensitivity analysis using a fixed clinically and epidemiologically informed covariate set produced highly similar estimates, supporting the robustness of the principal findings. Finally, GDM treatment characteristics were not systematically available and could not be examined as potential determinants of HRQoL. These limitations indicate that the findings should be interpreted as evidence of association rather than causation and should not be taken to demonstrate an independent effect of GDM on maternal quality of life.

## 5. Conclusions

The present study showed that pregnant women with GDM reported lower HRQoL across physical health, psychological health, social relationships, environmental well-being, and overall quality of life compared with women with uncomplicated pregnancies. These differences remained statistically significant after adjustment for selected measured covariates and were consistent in sensitivity analyses. However, given the cross-sectional design and the possibility of residual confounding, the findings should not be interpreted as demonstrating a causal or independent effect of GDM on maternal quality of life. Glycemic indicators did not consistently explain HRQoL differences after correction for multiple comparisons, suggesting that maternal well-being may reflect a broader combination of psychological, behavioral, treatment-related, and contextual factors in addition to

metabolic status. These findings support the consideration of HRQoL assessment as a complementary component of antenatal GDM care and highlight the need for longitudinal studies to clarify temporality, causal pathways, and modifiable determinants of maternal well-being.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The raw data supporting the conclusions of this article are available from the corresponding author upon reasonable request. The data are not publicly available due to participant privacy and ethical restrictions.

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## Abbreviations

The following abbreviations are used in this manuscript:

| | |
|---|---|
| GDM | Gestational diabetes mellitus |
| HRQoL | Health-related quality of life |
| QoL | Quality of life |
| WHOQOL-BREF | World Health Organization Quality of Life-BREF questionnaire |
| SD | Standard deviation |
| IQR | Interquartile range |
| GLM | General linear model |
| SPSS | Statistical Package for the Social Sciences |
| $R^2$ | Coefficient of determination |
| df | Degrees of freedom |
| CI | Confidence interval |

## Appendix

**Table A1.** Full Coefficient Table for All Predictors in Each Adjusted Model.

| Outcome | Predictor | B (Coefficients) | SE | 95% CI | *p* |
|---|---|---|---|---|---|
| Overall QoL | GROUP (GDM vs. Control) | −1.534 | 0.329 | [−2.183, −0.885] | <0.001 |
| | Education (Level 2 vs. 1) | 3.849 | 1.428 | [1.035, 6.663] | 0.008 |
| | Education (Level 3 vs. 1) | 4.570 | 1.422 | [1.767, 7.372] | 0.002 |
| | Education (Level 4 vs. 1) | 4.967 | 1.447 | [2.115, 7.819] | <0.001 |
| | Age | −0.058 | 0.029 | [−0.116, −0.001] | 0.047 |

| | | | | | |
|---|---|---|---|---|---|
| **Physical Health** | GROUP (GDM vs. Control) | −1.303 | 0.294 | [−1.882, −0.723] | <0.001 |
| | Education (Level 2 vs. 1) | 3.476 | 1.284 | [0.946, 6.005] | 0.007 |
| | Education (Level 3 vs. 1) | 4.351 | 1.280 | [1.827, 6.875] | <0.001 |
| | Education (Level 4 vs. 1) | 4.283 | 1.307 | [1.707, 6.859] | 0.001 |
| **Psychological Health** | GROUP (GDM vs. Control) | −1.686 | 0.298 | [−2.274, −1.098] | <0.001 |
| | Marital Status (Level 2 vs. 1) | −0.255 | 0.796 | [−1.824, 1.314] | 0.749 |
| | Marital Status (Level 3 vs. 1) | −1.965 | 0.996 | [−3.929, −0.001] | 0.050 |
| | Marital Status (Level 4 vs. 1) | −1.497 | 0.554 | [−2.589, −0.404] | 0.008 |
| | Living Situation (Level 2 vs. 1) | 1.223 | 0.478 | [0.281, 2.166] | 0.011 |
| **Social Relationships** | GROUP (GDM vs. Control) | −1.671 | 0.359 | [−2.380, −0.963] | <0.001 |
| | Marital Status (Level 2 vs. 1) | −1.425 | 0.961 | [−3.319, 0.469] | 0.140 |
| | Marital Status (Level 3 vs. 1) | −5.302 | 1.203 | [−7.673, −2.931] | <0.001 |
| | Marital Status (Level 4 vs. 1) | −1.368 | 0.669 | [−2.687, −0.050] | 0.042 |
| | Living Situation (Level 2 vs. 1) | 1.614 | 0.577 | [0.476, 2.751] | 0.006 |
| **Environment** | GROUP (GDM vs. Control) | −1.034 | 0.300 | [−1.625, −0.443] | <0.001 |
| | Education (Level 2 vs. 1) | 1.553 | 1.307 | [−1.024, 4.129] | 0.236 |
| | Education (Level 3 vs. 1) | 2.508 | 1.305 | [−0.064, 5.080] | 0.056 |
| | Education (Level 4 vs. 1) | 2.634 | 1.338 | [−0.003, 5.270] | 0.050 |
| | Living Situation (Level 2 vs. 1) | 1.295 | 0.491 | [0.327, 2.263] | 0.009 |

Note: B represents the unstandardized regression coefficient. For GROUP, the control group was the reference category; therefore, negative B values indicate lower HRQoL scores in women with GDM. Reference categories for categorical covariates were Education Level 1, Marital Status Level 1, and Living Situation Level 1. Education categories were coded as Level 1 = Primary, Level 2 = Secondary, Level 3 = University/TEI, and Level 4 = Postgraduate. Marital status categories were coded as Level 1 = Married/cohabiting, Level 2 = Single, Level 3 = Divorced/separated, and Level 4 = Other. Living situation was coded as Level 1 = Alone and Level 2 = With others. SE, standard error; CI, confidence interval; GDM, gestational diabetes mellitus; HRQoL, health-related quality of life.

**Table A2.** Sensitivity Analysis Using a Fixed Covariate Set.

| HRQoL Outcome | N | B | SE | 95% CI | *p* |
|---|---|---|---|---|---|
| Overall QoL | 220 | −1.438 | 0.330 | [−2.088, −0.787] | <0.001 |
| Physical Health | 219 | −1.249 | 0.306 | [−1.853, −0.645] | <0.001 |
| Psychological Health | 219 | −1.708 | 0.306 | [−2.311, −1.105] | <0.001 |
| Social Relationships | 220 | −1.632 | 0.369 | [−2.360, −0.905] | <0.001 |
| Environment | 220 | −1.078 | 0.310 | [−1.688, −0.467] | <0.001 |

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