Mini Review

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# Ten years of experience with screening for diabetes in pregnancy according to IADPSG criteria in Slovenia

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**Abstract:** This review presents analysis of gestational diabetes mellitus (GDM) in Slovenia based on national data and published research over a decade. Slovenia adopted the International Association of Diabetes and Pregnancy Study Groups (IADPSG) recommendations in 2011 and integrated them into routine antenatal care by 2023. Universal screening has increased the prevalence of GDM from 4 % before 2010 to 21 % in 2023. The analysed perinatal outcomes improved: the overall rates of large for gestational age (LGA) neonates and Erb's palsy decreased (AOR 0.93, 95 % CI 0.91–0.96 and AOR 0.72, 95 % CI 0.60–0.86 respectively) as did rates of preeclampsia (AOR 0.72, 95 % CI 0.68–0.76) and gestational hypertension (AOR 0.80, 95 % CI 0.77–0.83). The population of pregnant women changed, mean age at delivery, pre-pregnancy body mass index (BMI), proportion of obesity and parity increased. A dose-response relationship was found between pre-pregnancy BMI and GDM as there was synergistic effect of parity and maternal obesity on excessive fetal growth. Despite the nutrition interventions and tight control of blood glucose levels LGA infants could not be completely prevented. Beyond metabolic effects, GDM imposes a significant psychological burden; distinct psychological profiles were identified, emphasizing the need for tailored psychosocial support.

**Keywords:** gestational diabetes mellitus; prenatal screening; obesity; pregnancy outcomes

## Background

Gestational diabetes mellitus is a medical complication of pregnancy, defined as glucose intolerance that occurs or is first recognised during pregnancy without meeting the criteria for overt diabetes prior to pregnancy [1, 2]. Although often asymptomatic, GDM is associated with increased maternal and fetal/neonatal morbidity. The most common complications are macrosomia or birth weight too high for gestational age (LGA), increased incidence of caesarean delivery, and neonatal hypoglycaemia. Women with GDM have a higher risk of developing diabetes later in life. There is a consensus that the detection and treatment of GDM improves perinatal outcomes.

The first criteria for the diagnosis of GDM were established more than 50 years ago to identify women at high risk of developing diabetes later in life [3]. Several changes to the diagnostic criteria followed. Numerous screening and diagnostic guidelines for GDM have been published, and different countries have used different approaches with adaptations to national health systems, with one of the most important issues being cost benefit at the national level [4–11].

Given the growing evidence that maternal hyperglycaemia even below the diabetic threshold can adversely affect pregnancy outcome, internationally agreed diagnostic criteria for GDM were needed. The Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study, a multinational, multicultural and ethnically diverse study with a cohort of 25,000 women, showed that there is a continuous, graded relationship between higher maternal blood glucose levels and increased incidence of perinatal complications, independent of other risk factors (primary outcomes being birth weight>90th percentile, primary caesarean delivery, clinically defined neonatal hypoglycaemia, and umbilical cord C-peptide >90th percentile) [12].

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The IADPSG, founded in 1998 connected regional and national groups focusing on diabetes in pregnancy and facilitated a common international approach to diagnostic criteria for GDM. In 2008, IADPSG Consensus Panel reviewed the results of the HAPO study and in 2010 published international recommendations for the diagnosis and classification of hyperglycaemia in pregnancy [13].

Slovenia, a member state of the European Union, has a population of approximately 2 million and just under 20,000 births per year. Perinatal health care is part of the public health service. Since 1987, the Slovenian National Perinatal Information System (NPIS) registers all deliveries in Slovenia at ≥ 22 weeks gestation or when the birth weight is ≥ 500 g. Registration is mandatory by law in all 14 maternity wards and more than 140 variables are entered into a computerised database by the attending midwife and physician. Patient demographics, family, medical, gynaecological and obstetric history, data on the current pregnancy, labour and delivery, the postpartum period and neonatal data are collected. The complete list of variables with definitions and methodological guidelines was published online by the Slovenian Institute of Public Health [14].

In this review we present analysis of gestational diabetes mellitus (GDM) in Slovenia based on national data and published research in the period of integration of the IADPSG recommendations into routine antenatal care.

## Content

In Slovenia, a two-step approach for screening and diagnosis of GDM in high-risk women was used. It consists of administering an oral glucose load of 50 g, after which the glucose level in plasma is determined after 1 h. Women whose glucose levels meet or exceed a screening threshold are then subjected to a diagnostic oral glucose tolerance test (100 g OGTT) over 3 h, according to the Carpenter-Coustan criteria [15, 16]. The test was performed in pregnant women who have risk factors for developing GDM, such as obesity, advanced maternal age or a previous macrosomic child or complications in the current pregnancy.

In June 2011, Slovenia began introducing universal screening based on the recommendations of the IADPGS [13]. All pregnant women are tested at the first prenatal visit (in the first trimester) and those who do not meet the criteria for GDM are tested again between the 24th and 28th week of pregnancy with the diagnostic 75 g 2-h OGTT. Diagnosis of GDM is made if at least one of the 75 g OGTT thresholds is met or exceeded: fasting plasma glucose ≥ 5.1 mmol/L, 1-h glucose ≥ 10.0 mmol/L, 2-h glucose ≥ 8.5 mmol/L. During the first prenatal visit, the laboratory criteria for detecting pre-existing diabetes include fasting glucose ≥ 7.0 mmol/L, or random glucose ≥ 11.1 mmol/L or $HbA_{1c}$>6.5 %. Fasting glucose between 5.1 and 6.9 mmol/L is categorised as GDM.

In some populations there are up to 39 % of pregnant women who are diagnosed with GDM in the first trimester and have normal OGTT values in the second trimester [17]. Nevertheless, testing fasting blood glucose at the first prenatal visit enables early detection of both overt diabetes and hyperglycaemia that would remain hidden, would be detected too late or was already present before conception (impaired glucose tolerance, elevated fasting blood glucose, undiagnosed diabetes, monogenic diabetes). It detects hyperglycaemia following a reduced insulin secretion capacity (developing type 1 diabetes) or increased insulin resistance (polycystic ovary syndrome, obesity, in certain ethnic groups) or hyperglycaemia because of a combination of factors (genetic predisposition).

Since 2023, IADPSG recommended protocol has been included in the national prenatal care package covered by compulsory health insurance, ensuring that all pregnant women undergo a diagnostic assessment. The system of prenatal health care in Slovenia includes regular visits of pregnant women to the gynaecologist at the primary level. Uncomplicated GDM is thus managed as an uncomplicated pregnancy, with additional ultrasound examinations of fetal growth. All women with GDM visit diabetologist and receive dietary and lifestyle counselling. Regular physical activity is recommended and there is no automatic sick leave. They can deliver at any of the 14 maternity wards in Slovenia, the delivery is planned between 39 and 41 weeks. About 86 % of GDM cases in Slovenia are treated with non-pharmacological measures (nutritional support, healthy lifestyle support). In cases of complicated GDM, poor glycaemic control, comorbidities, or high risk of adverse outcome, referral is made to one of the two tertiary centres in Slovenia as part of a team approach: perinatologist, diabetologist, diabetes educator, dietitian, psychologist and, if necessary, hospitalisation and delivery in the tertiary maternity ward.

In the years following the introduction of the IADPSG criteria in 2011, the prevalence of GDM in Slovenia has increased significantly (Figure 1). The selective, two-step approach resulted in a prevalence of GDM in approximately 4–6 % of pregnant women. Over a 12-year transition period to the universal IADPGS criteria screening, the incidence of GDM increased steadily, exceeding 20 % of all pregnancies and stabilising at around 21 %.

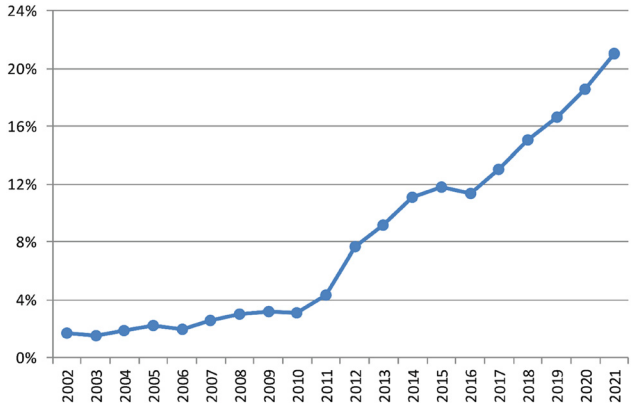


**Figure 1:** The prevalence of GDM in Slovenia. Data from NPIS [14]. GDM, gestational diabetes mellitus; NPIS, Slovenian National Perinatal Information System.

The impact of the new screening criteria was analysed by comparing national perinatal data between 2004–2010 and 2011–2017 [18]. The prevalence of GDM in Slovenia increased from approximately 4 % to almost 10 % in two time periods during the transition period of adoption of the IADPSG criteria. The population of pregnant women has changed over the two time periods. The mean age at delivery (29.3±4.8 vs. 30.1±4.8 years; p<0.001) increased significantly over time, as did the pre-pregnancy BMI (23.3±4.2 vs. 23.7±4.5 kg/m$^2$; p<0.001) and the proportion of women who were obese (BMI ≥ 30 kg/m$^2$) at the beginning of the pregnancy (10.551 [7.8 %] vs. 13.424 [9.6 %]; p<0.001). The proportion of women with previous caesarean delivery (6,205 [4.6 %] vs. 9,801 [7.0 %]; p<0.001) was higher (Table 1).

Most perinatal outcomes analysed in the present study improved after the implementation of the IADPSG criteria. The overall rates of LGA neonates and Erb's palsy decreased (AOR 0.93, 95 % CI 0.91–0.96 and AOR 0.72, 95 % CI 0.60–0.86 respectively) and a decrease in preeclampsia (AOR 0.72, 95 % CI 0.68–0.76) and gestational hypertension (AOR 0.80, 95 % CI 0.77–0.83) was also observed, even though maternal age and pre-pregnancy obesity increased over time. The comparison of overall perinatal outcomes between the two study periods is presented in Table 2. There were no significant changes in the rates of small-for-gestational-age infants, shoulder dystocia, or stillbirth.

**Table 1:** Basic characteristics of pregnant women in Slovenia before and after 2011 [18].

| | 2004-10 | N | 2011-17 | N | p |
|---|---|---|---|---|---|
| Age, years | 29.3 | 135,786 | 30.1 | 140,524 | <0.001 |
| Pre pregnancy BMI, kg/m$^2$ | 23.3 | | 23.7 | | <0.001 |
| BMI>30, % | 7.8 % | 10,551 | 9.6 % | 13,424 | <0.001 |
| Previous CS, % | 4.6 % | 6,205 | 7.0 % | 9,801 | <0.001 |

BMI, body mass index; CS, caesarean section.

We compared pregnant women with and without GDM in the time period from 2013 to 2023 in Slovenia using the data from NPIS. Women diagnosed with GDM were on average older than those without GDM, with a higher proportion of women over 35 years of age (Figure 2). The presence of comorbid chronic diseases – including thyroid dysfunction, hypertension and obesity – further increases the risk of adverse outcomes and rates of preeclampsia, caesarean delivery and LGA infants are significantly increased (Figure 3). Obesity is closely associated with GDM. Less than half of women with GDM had a normal BMI. Almost 50 % of women with GDM were overweight or obese. A normal BMI was found in 70 % of women without GDM (Figure 4). Slovenian data have shown a clear dose-response relationship between increasing pre-pregnancy BMI and complications such as: GDM, chronic or gestational hypertension and preeclampsia (Table 3) [19]. Interestingly, pre-pregnancy BMI has a stronger influence than weight gain during pregnancy [20].

Women who develop preeclampsia often gain more weight during pregnancy, whereas those with GDM tend to gain less weight but start pregnancy with a higher BMI. Underweight women with GDM are more likely to be nulliparous and have infants with lower birth weight. This demonstrates that both ends of the BMI spectrum influence perinatal risk [21].

Comparative analyses show that pre-pregnancy obesity alone is often more strongly associated with adverse perinatal outcomes – including LGA, preterm birth before 33 weeks' gestation and low Apgar scores – than GDM alone or the combination of obesity and diabetes ("diabesity") [22]. This observation suggests that the focused glycaemic and dietary counselling routinely offered to women with GDM is insufficiently emphasized in obese pregnant women without diabetes. This gap represents an opportunity to expand structured nutritional counselling.

Nutritional behaviour before and during pregnancy also has a significant impact on perinatal outcomes. Women with a normal BMI before conception were more likely to consume fruit, eggs and dairy products than overweight or obese women. During pregnancy, all groups adopted healthier eating habits, including increased intake of complex carbohydrates, more frequent meals and reduced consumption of fried foods [23]. Despite improvements in

**Table 2:** The comparison of adverse outcomes in two time periods in Slovenia [18].

| | 2004–2020 (n=135,786) | 2011–2017 (n=140,524) | OR (95 % CI) | AOR (95 % CI) |
|---|---|---|---|---|
| Prevalence of GDM | 3,484 (2.6) | 13,596 (9.7) | 4.06 (3.92–4.22) | 3.92 (3.78–4.08) |
| Prevalence of GDM on insulin | 881 (0.6) | 2,476 (1.8) | 2.75 (2.54–2.57) | 2.50 (2.32–2.71) |
| Macrosomia (birthweight>4,500 g) | 1,615 (1.2) | 1,511 (1.1) | 0.9 (0.84–0.97) | 0.88 (0.82–0.94) |
| LGA (birth weight>90th centile) | 15,010 (11.1) | 14,963 (10.6) | 0.95 (0.93–0.98) | 0.93 (0.91–0.96) |
| SGA (birth weight<10th centile) | 9,464 (7.0) | 9,748 (6.9) | 1.00 (0.97–1.02) | 1.00 (0.97–1.03) |
| Stillbirth | 673 (0.5) | 715 (0.5) | 1.03 (0.92–1.14) | 1.00 (0.90–1.12) |
| Caesarean delivery | 20,869 (15.4) | 26,903 (19.1) | 1.30 (1.28–1.33) | 1.18 (1.15–1.20) |
| Emergency caesarean delivery | 12,392 (9.1) | 15,102 (10.7) | 1.19 (1.17–1.23) | 1.13 (1.10–1.16) |
| Shoulder dystocia | 423 (0.3) | 393 (0.3) | 0.90 (0.78–1.03) | 0.90 (0.78–1.03) |
| Erb's palsy | 271 (0.2) | 203 (0.1) | 0.72 (0.60–0.87) | 0.72 (0.60–0.86) |
| Neonatal hypoglycemia | 1,448 (1.1) | 1,886 (1.3) | 1.26 (1.18–1.35) | 1.23 (1.15–1.32) |
| Excessive gestational weight gain (according to IOM) | 74,766 (55.1) | 74,421 (53.0) | 0.92 (0.91–0.94) | 0.92 (0.91–0.94) |
| Insufficient gestational weight gain (according to IOM) | 20,135 (14.8) | 23,728 (16.9) | 1.17 (1.14–1.19) | 1.15 (1.13–1.18) |
| Gestational hypertension | 5,849 (4.3) | 5,253 (3.7) | 0.86 (0.83–0.90) | 0.80 (0.77–0.83) |
| Preeclampsia | 2,957 (2.2) | 2,364 (1.7) | 0.77 (0.73–0.81) | 0.72 (0.68–0.76) |
| Postpartum hemorrhage, transfusion | 1,057 (0.8) | 1,021 (0.7) | 0.93 (0.87–1.01) | 0.91 (0.83–0.99) |

GDM, gestational diabetes mellitus; LGA, large for gestational age; SGA, small for gestatioanl age; IOM, National Academy of Medicine (previous Institute of Medicine); OR, odds ratio; AOR, adjusted odds ratio; CI, confidence interval.

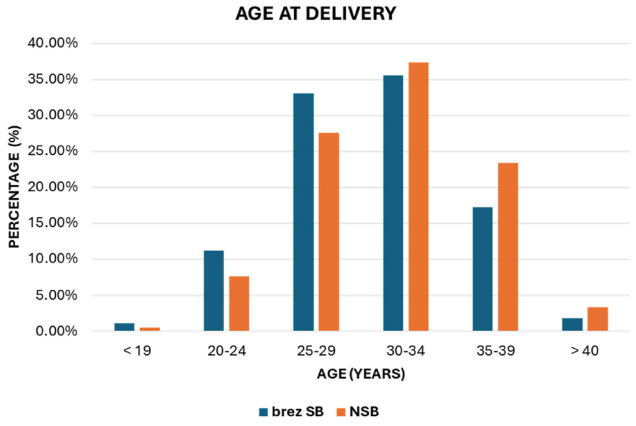


**Figure 2:** Age at delivery in Slovenian women in time period 2013–2023. Data from NPIS [14]. NPIS, Slovenian National Perinatal Information System; NSB, gestational diabetes mellitus; brez NSB, without gestational diabetes mellitus.

diet and controlled weight gain in pregnancy, tight control of blood glucose levels cannot completely prevent LGA infants [23]. Maternal BMI prior to pregnancy remains a stronger determinant of fetal overgrowth compared to GDM alone.

Using the unpublished NPIS dataset, we investigated how parity, maternal obesity and insulin therapy influence the risk of fetal macrosomia, defined as birth weight>4,000 g. Our study population included live singleton births at ≥ 38 weeks' gestation in Slovenia from 2016 to 2023. Obesity in primiparous women was associated with a threefold increase in macrosomia, while the corresponding risk was more than fivefold higher in multiparous women. Insulin treatment was more effective in reducing the likelihood of macrosomia in primiparous women than in multiparous women. Multiparous birth itself was associated with a significantly higher risk of macrosomia than nulliparous birth, regardless of pre-pregnancy BMI. These results indicate a synergistic effect of parity and maternal obesity on excessive fetal growth.

In addition to the metabolic concerns, GDM as a disease is associated with a considerable psychological burden to the pregnant women [24]. Three distinct psychological profiles were identified among Slovenian women: coping profile in 38.6 % – women have positive perception and proactive engagement, burdened profile in 49.8 % – women have high emotional stress and perceived negative impact on daily life and resourceless in 11.7 % – women lack information and low self-efficacy. A higher level of education correlated with a greater likelihood of feeling burdened, whereas younger maternal age predicted a resourceless profile. These results suggest that counselling should be tailored to individual perceptions and psychological needs. The prevalence of depressive symptoms in the second trimester is more than twice as high in women with GDM compared to women without GDM (23.4 vs. 10.7 %, p=0.022; OR=2.6). This increased risk also persists during pregnancy and emphasises the importance of integrated mental health support [25].

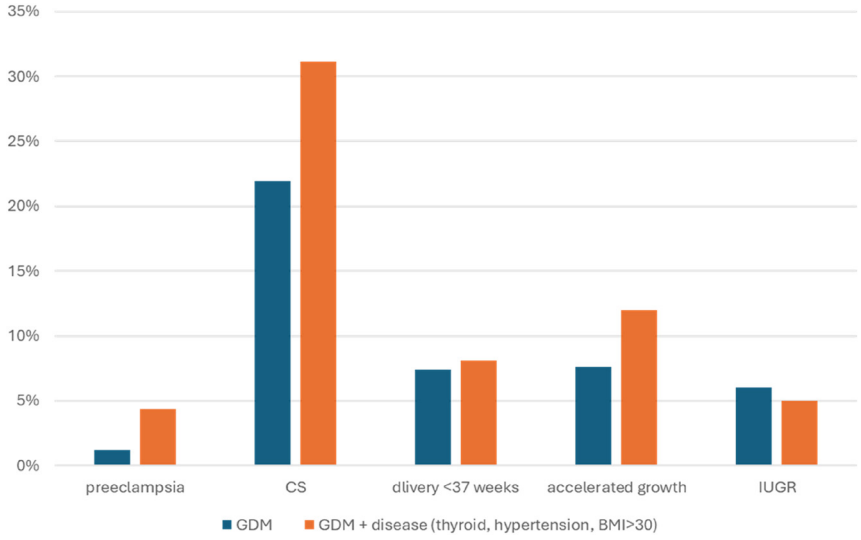


**Figure 3:** Proportion of GDM pregnancies with or without additional chronic disease and adverse pregnancy outcome. The data from NPIS [14]. GDM, gestational diabetes mellitus; NPIS, Slovenian National Perinatal Information System; CS, cesarean section; IUGR, intrauterine growth restriction; BMI, body mass index.

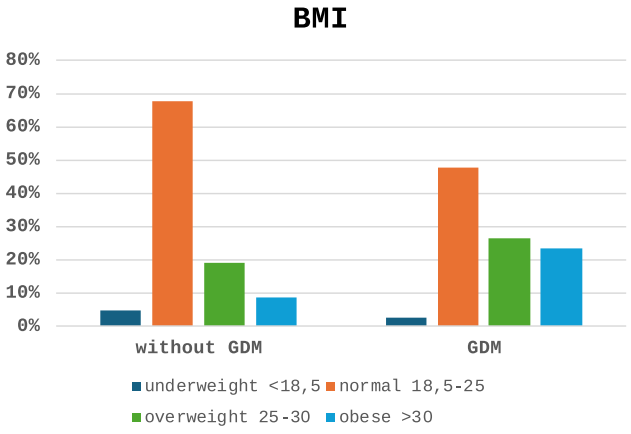


**Figure 4:** The proportion of different BMI classes in pregnant women with or without GDM. Data from NPIS [14]. BMI, body mass index; GDM, gestational diabetes mellitus, NPIS; Slovenian National Perinatal Information System.

**Table 3:** Dose-response relationship between obesity and pregnancy complications [19]. Class I obesity (moderate-risk) obesity – BMI is 30.0–34.9, Class III (high-risk) obesity – BMI is equal to or greater than 40.0.

| Obesity | Class I | Class III |
|---|---|---|
| GDM | 8.5 % | 14.4 % |
| Chronic hypertension | 2.8 % | 9 % |
| Gestational hypertension | 6.7 % | 14.2 % |
| Preeclampsia | 5.3 % | 9.3 % |

BMI, body mass index; GDM, gestational diabetes mellitus.

## Conclusions

The introduction of universal GDM screening in Slovenia using the IADPSG criteria has led to significant improvements in maternal and neonatal outcomes. At the cost of an increased prevalence of GDM (from 4 to 21 %), rates of adverse pregnancy outcomes (macrosomia, LGA, gestational hypertension, preeclampsia and Erb's palsy) decreased.

Higher complication rates of GDM are observed in women with comorbid chronic diseases and obesity. While glycaemic control and nutritional counselling improve outcomes, a significant psychological burden remains. Therefore, effective GDM management must include metabolic, nutritional and psychosocial support.

Looking to the future, a broader societal approach is necessary to address pre-pregnancy obesity, including public health measures that target unhealthy food environments. As maternal age and BMI continue to rise, it will be crucial to increase pre-conception care and interventions in early pregnancy.

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