The changing face of gestational diabetes: the effect of the shift from risk factor-based to comprehensive screening

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Abstract

Objective: To evaluate the effect of the change in the gestational diabetes (GDM) screening policy from risk-factor based to comprehensive screening on the prevalence and type of GDM and characteristics of GDM pregnancies.

Design: Population-based register study in Finland. Subjects were GDM women who gave birth before (2006, $n=5185$) and after (2010, $n=6683$) the policy change. All the other women in those years without pre-pregnancy diabetes acted as controls (51 759 and 52 398 respectively).

Methods: GDM women with singleton pregnancy were identified through The Finnish Medical Birth Register by abnormal oral glucose tolerance test or initiation of insulin. Main outcome measures were prevalence of GDM (total and insulin/diet-treated), and caesarean section rate.

Results: The proportion of screened mothers increased from 27.5 to 51.3% and the total prevalence of GDM from 9.1 to 11.3%. This increase consisted mainly of diet-treated mothers, while the number and proportion of insulin-treated mothers decreased (21.8% vs 13.3%, $P<0.001$). The proportion of primiparous women increased (34.5–39.4%, $P<0.0001$) and mean pre-pregnancy BMI decreased (28.6–28.2, $P<0.001$). The overall caesarean section rate remained the same but increased among women with GDM (20.8–22.1%) adjusted odds ratios being 1.22 (95% CI 1.14, 1.31) during comprehensive and 1.10 (95% CI 1.02, 1.19) during risk factor-based screening.

Conclusions: The shift to comprehensive screening led to a significant increase in women with GDM, who were more often primiparous and had a lower BMI. Comprehensive screening did not perform better in diagnosing women needing insulin treatment.

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Introduction

Gestational diabetes mellitus (GDM) is a common pregnancy-related disorder, which, depending on screening policies, diagnostic cutoffs and study populations, affects 2–24% of pregnancies (1, 2, 3). Its detection offers benefits to both mother and her offspring during and immediately after pregnancy (4, 5, 6). In the long term, mothers with a history of GDM are more likely to develop type 2 diabetes

and other metabolic disturbances (7, 8, 9). In addition, their offspring have a higher risk of obesity and abnormal glucose metabolism (4, 10). While these associations have been widely documented, the challenge is to detect GDM in order to identify these high-risk groups.

Although there is increasing awareness of the impact of GDM on maternal and fetal health, there is no

consensus concerning its screening policy and diagnostic criteria. Basically, the diagnostic criteria of GDM have been set according to their ability to identify mothers at risk of subsequent diabetes (11, 12). Their ability to predict neonatal outcomes was first employed to define diagnostic criteria by the International Association of Diabetes in Pregnancy Study Groups (IADPSG). By using the data obtained from a large multicenter Hyperglycemia and Adverse Pregnancy Outcomes (HAPO) study (13), the IADPSG suggested universal screening and uniform diagnostic criteria using a 75 g oral glucose tolerance test (OGTT) at 24–28 weeks of gestation (14).

Screening guidelines vary from no routine to universal screening. In Finland, GDM screening was limited to women with risk factors until 2008. However, up to half of women with GDM have been found to have no risk factors, and thus to go undiagnosed during risk factor-based screening (15). When new national Current Care Guidelines to screen and diagnose GDM were introduced in Finland in 2008, in contrast to previous policy, it was recommended that all women except those with very low GDM risk should be tested via 75 g OGTT (16). These guidelines were expected to increase the numbers of both screened women and those diagnosed with GDM.

The aim of the present study was to evaluate the effect of the change in the GDM screening policy on the prevalence and type of GDM, maternal characteristics, and the course of pregnancy and delivery.

Subjects and methods

The Finnish Medical Birth Register

The data were based on the Finnish Medical Birth Register (MBR), which includes data on the course and complications of pregnancy, delivery, and perinatal health of the newborn. All pregnancies resulting in a live born infant or stillbirth at a gestational age of ≥ 22 weeks or weighing ≥ 500 g are reported to the MBR. For each delivery in Finland, a structured form for the MBR is completed by the delivery hospital within 7 days after delivery.

The data are checked at the MBR and the hospitals are contacted to correct missing or supposedly incorrect information. Data are completed by linkage to the Central Population Register on live births and to cause-of-death data compiled by Statistics Finland on stillbirths and early neonatal deaths. The coverage of the register is complete, and in general, the quality of the data is high (17, 18). The study was approved by the regional Ethics Committee

in Northern Ostrobothnia Hospital District, Number 2008/43, date of approval 2008-6-19.

Study population

Since 2004, the MBR has also included information on whether an OGTT was performed, whether it was abnormal (the criteria are described in the following section) and whether insulin treatment was initiated. In the present study, a woman was defined to have GDM if she was recorded to have an abnormal OGTT result or initiation of insulin therapy during pregnancy. After exclusion of multiple births and mothers with pre-existent type 1 or type 2 diabetes, 5185 (9.1%) women in 2006 and 6683 (11.3%) in 2010 fulfilled the GDM criteria. All other non-GDM women served as controls (51 759 in 2006 and 52 398 in 2010; Fig. 1). Preterm infants with abnormally high birth weight for length of gestation (< 37 weeks and > 3 s.d. according to Finnish standards (19) were excluded from birth weight analyses ($n=35$).

Screening and treatment for GDM

Until 2008, GDM risk factor-based screening was used in Finland (risk factors are shown in Table 1). According to the new national Current Care Guidelines launched in 2008, all women except those with very low risk should be screened for GDM (16). In both time periods, the screening of GDM was performed and diagnosis set by a standard 2 h 75 g OGTT with samples obtained at baseline after overnight fast and at 1 and 2 h after the glucose load. The test was mainly performed between the 24th and 28th weeks of gestation. In both screening policies, it was recommended for an OGTT to be performed for the first time between the 12th and 16th

Figure 1
Flow chart of the study.

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Table 1 Comparison of risk-factor based and comprehensive screening.

Screening method	Indication for screening	OGTT performed (n) (%)	Gestational diabetes diagnosed (n) (%)	Number needed to screen GDM (OGTT/GDM)
Risk factor-based screening (2006)	Risk factor-based screening Prior GDM Overweight (BMI > 25 kg/m ²) Glucosuria Age over 40 years Previous macrosomic offspring 4500 g or more) Suspected macrosomia in the current pregnancy	15 688 (27.5%)	5185 (9.1%)	3.13
Comprehensive screening (2010)	All women except those with very low GDM risk Primiparous: age <25 years, BMI <25 kg/m ² , no family history of diabetes Multiparous: age <40 years, BMI <25 kg/m ² , no previous macrosomic babies	30 372 (51.4%)	6683 (11.3%)	4.71

The OGTT test is mainly performed between the 24th and 28th week of gestation. In both screening policies, an OGTT is recommended for the first time between the 12th and 16th gestational week for high-risk groups (before 2008 prior GDM; after 2008: prior GDM, BMI > 35, polycystic ovary syndrome with insulin resistance), and if this test was normal, to be repeated at 24–28 weeks.

weeks of gestation for high-risk groups (before 2008: prior GDM; after 2008: prior GDM, BMI > 35, polycystic ovary syndrome with insulin resistance). If this test was normal, it would then be repeated between the 24th and 28th weeks of gestation.

GDM was diagnosed during both screening periods if the venous plasma glucose concentration was 5.3 mmol/l or more at baseline, 10.0 mmol/l or more at 1 h, or 8.6 mmol/l or more at 2 h after the glucose load. Before 2008, the cutoffs were specified in an expert statement given in 1993. After 2008, when the cutoff was explicitly stated in the new national Current Care Guidelines, these cutoffs were uniformly adopted to our knowledge by virtually all service providers. During both periods, the diagnosis of GDM was based on one or more abnormal value in OGTT.

After the diagnosis of GDM, the patients received dietary and lifestyle counselling and began self-monitoring of glucose concentrations. According to the prevailing treatment guidelines, insulin therapy was initiated if plasma glucose concentrations exceeded the target levels repeatedly (before 2008: 5.3 mmol/l fasting and 6.7 mmol/l 1.5 h postprandial; after 2008: 5.5 and 7.8 mmol/l 1 h postprandial). The use of oral glycemic agents was occasional and not recommended by the guidelines.

Definitions

The outcome measures, including gestational age at birth, birth weight, and data on pregnancy-related states and

complications such as preeclampsia were obtained from the MBR. The diagnoses of hypertensive pregnancy disorders were based on recorded ICD-10 codes (from O10 to O16). Maternal age was defined as the mother's age at the time of delivery. BMI was calculated as the mother's pre-pregnancy weight divided by the square of her height. Birth weight s.d. score, relative to length of gestation and sex was calculated based on Finnish standards (19). Antenatal visits included the number of all visits to maternal welfare clinics or the delivery hospital during pregnancy. Special care visits included only visits to the delivery hospital.

Socioeconomic status was defined using the occupation reported to the MBR. Coding was based on national standards published by Statistics Finland (self-employed persons, upper-level employees with administrative, managerial, professional and related occupations, lower-level employees with administrative and clerical occupations, manual workers, students, pensioners and others) (20). The socioeconomic groups were divided into four different categories, as follows: i) upper-level employees with administrative, managerial, professional and related occupations, ii) lower-level employees with administrative and clerical occupations, iii) manual workers, and iv) others, including stay-at-home mothers, students, pensioners, and self-employed persons. In terms of smoking, women were categorized as non-smokers, those who stopped smoking in first trimester, smokers after the first trimester and no information. Of Finnish women aged 15–49 years, 94.7% are of Finnish ancestry (21).

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Outcomes

The primary outcome was the difference in the prevalence and type of GDM. Secondary outcomes included changes in maternal characteristics, including age, parity, and pre-pregnancy BMI, as well as in the induction and mode of delivery.

Statistical analysis

All statistical analyses were carried out using the SPSS 21 statistical package. Categorical variables were reported as frequencies (%) and continuous using mean (s.d.) or median (range). Pearson's χ^2 -test was used to compare the difference in proportions, while the independent sample *t*-test was used to compare the difference in the means. A two-sided *P* value of <0.05 was considered statistically significant. Logistic regression was used to calculate odds ratios (ORs) and 95% CIs for the risk of development of outcomes associated with GDM in different study periods. Mean differences with 95% CI were calculated using linear regression. All logistic regression results were adjusted for maternal age, parity, and pre-pregnancy BMI. Interactions were tested by adding the product term between the two variables of interest into the regression model. Additional analyses adjusted further for socioeconomic status and maternal smoking during pregnancy.

Results

The study population

The total number of all deliveries in Finland was 59 051 in 2006 and 61 371 in 2010 (Fig. 1). Of these, 56 944 and 59 081 respectively, were singleton pregnancies of mothers without pre-pregnancy type 1 or type 2 diabetes and were included in the present study. The mean ages of all women giving birth in 2006 and 2010 were 29.5 and 29.6 years respectively. Over 40% of women were primiparous in both years (Table 1). The pre-pregnancy BMI increased significantly in the whole study population, from 24.1 (s.d. 4.6) in 2006 to 24.3 (s.d. 4.8) in 2010.

The effect of the change in screening policy

The proportion of mothers undergoing OGTT increased from 27.5% under the risk-factor based screening method to 51.4% under comprehensive screening (Table 1).

Together with this increase, the prevalence of GDM rose from 9.1 to 11.3%. Of all screened mothers, the number needed to screen for one GDM diagnosis was 3.13 during risk factor-based and 4.71 during comprehensive screening. Positive predictive values were 27.3% for risk factor-based screening and 20.8% for comprehensive screening.

Maternal characteristics

The baseline characteristics of the study population are presented in Table 2. During comprehensive screening, GDM women were more often primiparous (39.4 vs 34.5%), had lower pre-pregnancy BMI (28.2 vs 28.6 kg/m²) and were more often normal weight (27.0 vs 32.6%) than during screening based on risk factors. The mean age and socioeconomic status were similar in the GDM groups in both study years.

Antenatal visits

Between 2006 and 2010, the mean number of all antenatal follow-up visits decreased in both the GDM and control groups, although the decrease was more evident in GDM mothers (Table 2). In addition, the mean number of hospital outpatient visits decreased in both the GDM and control groups. However, as a result of the growth in GDM prevalence, the total number of both all antenatal and special health care visits in GDM mothers increased (Table 2).

Delivery

The proportion of induced deliveries increased both in GDM (25.7–28.3%) and non-GDM women (14.9–16.9%; Table 2), and the increase was similar for both groups (*P* value for interaction GDM $\times$ year of birth: unadjusted *P* value 0.6, *P* value adjusted for maternal age, parity, and pre-pregnancy BMI 0.7; Table 3). The caesarean section rate increased in the GDM group from 20.8 to 22.1%, but decreased in the non-GDM mothers (15.1 to 14.7%, respectively; Table 2). The total caesarean section rate remained similar (17.1 and 17.1% respectively). The adjusted ORs for caesarean section for GDM as compared with controls were 1.10 (risk factor-based screening) and 1.22 (comprehensive screening). *P* values for interaction between the effects of screening method and GDM on caesarean section were 0.018 (adjusted) and 0.052 (unadjusted) (Table 3).

Birth weight

During risk factor-based screening, infants of GDM mothers had 0.37 s.d. higher birth weight than infants of control mothers. During comprehensive screening, this

difference was 0.26 s.d. After adjustment for maternal age, parity, and pre-pregnancy BMI, the mean difference of the birth weight s.d. score decreased between the study periods from 0.20 to 0.11 s.d. This decrease corresponds to 50 g birth weight at term (Table 3).

Table 2 Characteristics of the mothers with and without gestational diabetes during risk factor based (2006) and comprehensive (2010) screening.

Characteristic	GDM			Controls			GDM×year P for interaction ^a
	2006	2010	P value	2006	2010	P value	
<i>n</i>	5185 (9.1%)	6683 (11.3%)		51 759 (90.9%)	52 398 (88.7%)		
Maternal age (years)	31.1 (5.7)	31.0 (5.5)	0.526	29.3 (5.4)	29.4 (5.3)	0.007	0.140
Pre-pregnancy BMI (kg/m ²)	28.6 (5.8)	28.2 (6.1)	<0.0001	23.7 (4.3)	23.8 (4.4)	<0.0001	<0.0001
BMI 18.5–24.9	1340 (27.0%)	2102 (32.6%)	<0.0001	33 358 (70.5%)	33 420 (68.7%)	<0.0001	<0.0001
BMI 25–29.9	1790 (36.1%)	2198 (34.1%)	0.023	9736 (20.6%)	10 509 (21.6%)	<0.0001	<0.0001
BMI >30	1827 (36.9%)	2154 (33.4%)	<0.0001	4205 (8.9%)	4733 (9.7%)	<0.0001	<0.0001
Parity, <i>n</i> (%)							
1	1788 (34.5%)	2635 (39.4%)	<0.0001	22 229 (43.1%)	22 293 (42.5%)	0.085	<0.0001
2	1775 (34.2%)	2180 (32.6%)	0.064	17 172 (33.2%)	17 693 (33.8%)	0.044	0.017
3	901 (17.4%)	1052 (15.7%)	0.017	7368 (14.2%)	7513 (14.3%)	0.634	0.016
4	379 (7.3%)	434 (6.5%)	0.081	2555 (4.9%)	2430 (4.6%)	0.024	0.433
≥5	342 (6.6%)	382 (5.7%)	0.047	2281 (4.4%)	2467 (4.7%)	0.026	0.008
Socioeconomic status (<i>n</i>) (%)							
Upper-level clerical officials ^b	791 (17.7%)	954 (18.7%)	0.180	9519 (21.6%)	8526 (22.1%)	0.072	0.463
Lower-level clerical officials ^c	1955 (43.6%)	2219 (43.5%)	0.919	17 685 (40.1%)	15 727 (40.7%)	0.051	0.464
Manual workers	896 (20.0%)	966 (19.0%)	0.196	7232 (16.4%)	6103 (15.8%)	0.024	0.662
Others ^d	838 (18.7%)	958 (18.8%)	0.910	9696 (22.0%)	8246 (21.4%)	0.034	0.449
Smoking (<i>n</i>) (%)							
No	4237 (81.7%)	5385 (80.6%)	0.116	42 732 (82.6%)	43 458 (82.9%)	0.100	0.043
Quit at first trimester	220 (4.2%)	400 (6.0%)	<0.0001	1963 (3.8%)	2805 (5.4%)	<0.0001	0.989
Continued after first trimester	641 (12.4%)	791 (11.8%)	0.382	5529 (10.7%)	4976 (9.5%)	<0.0001	0.178
No information	87 (1.7%)	107 (1.6%)	0.743	1535 (3.0%)	1155 (2.2%)	<0.0001	0.089
Treatment:							
Insulin	1128 (21.8%)	887 (13.3%)	<0.0001				
Diet	4057 (78.2%)	5796 (86.7%)	<0.0001				
Antenatal visits (total number)	96 449	111 583		828 583	782 619		
Antenatal visits/mother, mean (s.d.)	18.8 (6.7)	17.0 (4.7)	<0.0001	16.4 (5.2)	15.4 (4.2)	<0.0001	<0.0001
Special health care visits (total number)	24 262	28 950		132 101	135 401		
Special health care visits/mother, mean (s.d.)	4.7 (3.3)	4.5 (3.0)	0.001	2.6 (2.4)	2.7 (2.3)	<0.0001	<0.0001
Gestational hypertension or preeclampsia	422 (8.1%)	608 (9.1%)	0.066	2144 (4.1%)	2282 (4.4%)	0.089	0.341
Induction of labor	1334 (25.7%)	1893 (28.3%)	0.002	7712 (14.9%)	8875 (16.9%)	<0.0001	0.647
Gestational age (mean) (s.d.)	39.6 (1.6)	39.6 (1.6)	0.328	39.8 (1.8)	39.9 (1.8)	<0.0001	0.036
Birth weight, grams, mean (s.d.)	3695 (434)	3635 (434)	<0.0001	3516 (434)	3497 (434)	<0.0001	<0.0001
Type of delivery							
Vaginal, non-instrumental	3702 (71.4%)	4610 (69.3%)	0.005	39 386 (76.1%)	39 754 (75.9%)	0.619	0.013
Vaginal, instrumental	386 (7.4%)	573 (8.6%)	0.011	4267 (8.2%)	4584 (8.7%)	0.005	0.223
Caesarean section	1076 (20.8%)	1469 (22.1%)	0.045	7811 (15.1%)	7696 (14.7%)	0.169	0.031
Hospital stay of mother in days, mean (s.d.)	2.5 (1.76)	2.2 (1.39)	<0.0001	2.2 (1.5)	1.9 (1.3)	<0.0001	0.103

The numbers are *n* (%) or mean (s.d.). Antenatal visits=any visits at maternal welfare clinics or in specialty care.

^aInteraction between the effects of year and GDM on the outcome.

^bUpper-level officials with administrative, managerial, professional, and related occupations.

^cLower-level officials with administrative and clerical occupations.

^dStudents, pensioners, self-employed persons and others.

Table 3 Results of multivariate logistic and linear regression of peri- and neonatal outcomes factors in patients with GDM during risk factor based (2006) and comprehensive screening (2010).

Outcome	Risk factor-based screening (2006)						Comprehensive screening (2010)						P value for interaction ^a unadj./adjusted
	Unadjusted			Adjusted ^b			Unadjusted			Adjusted ^b			
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	
	Mean difference (95% CI)	P value	Mean difference (95% CI)	P value	Mean difference (95% CI)	P value	Mean difference (95% CI)	P value	Mean difference (95% CI)	P value	Mean difference (95% CI)	P value	
Caesarean section	1.47	1.36, 1.58	<0.0001	1.10	1.02, 1.19	0.019	1.65	1.55, 1.75	<0.0001	1.22	1.14, 1.31	<0.0001	0.018/0.052
Induction of labor	1.98	1.85, 2.12	<0.0001	1.50	1.40, 1.62	<0.0001	1.94	1.83, 2.05	<0.0001	1.53	1.44, 1.63	<0.0001	0.647/0.703
Birth weight S.D. score	0.37	0.34, 0.40	<0.0001	0.20	0.17, 0.23	<0.0001	0.26	0.23, 0.28	<0.0001	0.11	0.08, 0.13	<0.0001	<0.0001/ <0.0001

^aP value for interaction between gestational diabetes and year of birth, calculated by logistic regression.^bAdjusted for maternal age, parity, and pre-pregnancy BMI.

The changes in treatment of GDM

Between years 2006 and 2010, both the proportion and absolute number of insulin-treated GDM women reduced significantly, from 1128 to 887 (21.8 to 13.3% of all GDM mothers, Table 4). Regardless of the screening policy, insulin-treated GDM mothers were older, had higher pre-pregnancy BMI, and were more often parous than those with diet treatment (Table 4). During comprehensive screening, insulin-treated mothers had significantly higher pre-pregnancy BMI than during the previous study period (30.2 vs 28.8 respectively). Socioeconomic status was unrelated to insulin treatment during both screening periods.

Insulin-treated mothers attended a maternal welfare clinic or hospital outpatient care more often than diet-treated mothers in both screening periods (Table 4). In addition, induced deliveries and caesarean sections were more frequent among insulin- than diet-treated mothers, the proportions being higher during comprehensive screening (Table 4).

Discussion

The shift in GDM screening from a risk factor-based to a comprehensive policy led to a significant increase in the prevalence of gestational diabetes, which was due to the increased number of mothers who could be treated with diet. Unexpectedly, both the proportion and total number of insulin-treated women decreased significantly. Comprehensive screening seems to identify more primiparous and normal weight GDM women, but is unlikely to be more efficient than risk factor-based screening when it comes to identifying women who need insulin, which represents an essential risk group for maternal and perinatal complications. Although the number of antenatal visits per woman decreased both at the primary and secondary level, the significant increase in the number of GDM women created a rising burden for the healthcare system.

A risk factor-based policy has been considered as reliable and less expensive than a universal approach to screening GDM at the population level. However, in previous studies, 20–50% of women with GDM had no risk factors for this condition (1, 15, 22, 23). One reason for this might be the nature of the risk factors: Many of them are based on previous pregnancy history, including prior GDM or previous macrosomic newborns, but these factors do not apply to primiparous women. The increased proportion of primiparous women diagnosed by

Table 4 Maternal characteristics by GDM mothers with method of treatment in 2006 and 2010.

Characteristic	Diet		Insulin		P value for diet vs insulin	Treatment ^a year P for interaction ^b
	2006	2010	2006	2010		
n (% of all GDM mothers)	4057 (78.2)	5796 (86.7)	1128 (21.8)	887 (13.3)		
Maternal age (years)	30.9 (5.7)	30.9 (5.4)	31.6 (5.6)	32.1 (5.4)	0.064	0.877
BMI (kg/m ²)						
Pre-pregnancy BMI	28.6 (5.7)	27.9 (5.9)	28.8 (6.3)	30.2 (6.9)	<0.0001	0.010
BMI 18.5–24.9	1028 (26.6)	1903 (34.0)	312 (28.6)	199 (23.1)	<0.0001	<0.0001
BMI 25–29.9	1430 (37.0)	1939 (34.7)	360 (33.0)	259 (30.0)	0.160	0.725
BMI >30	1409 (36.4)	1750 (31.3)	418 (38.3)	404 (46.9)	<0.0001	<0.0001
Parity (n) (%)						
1	1404 (34.6%)	2325 (40.1%)	384 (34.0%)	310 (34.9%)	0.671	0.059
2	1403 (34.6%)	1900 (32.8%)	372 (33.0%)	280 (31.6%)	0.501	0.879
3	692 (17.1%)	887 (15.3%)	209 (18.5%)	165 (18.6%)	0.966	0.294
4	292 (7.2%)	368 (6.3%)	87 (7.7%)	66 (7.4%)	0.819	0.611
≥5	266 (6.6%)	316 (5.5%)	76 (6.7%)	66 (7.4%)	0.540	0.119
Socioeconomic status (n) (%)						
Upper-level clerical officials ^a	619 (17.7%)	834 (18.9%)	172 (17.4%)	120 (17.8%)	0.871	0.756
Lower-level clerical officials ^c	1533 (43.9%)	1920 (43.4%)	422 (42.7%)	299 (44.4%)	0.478	0.403
Manual workers	698 (20.0%)	853 (19.3%)	198 (20.0%)	113 (16.8%)	0.097	0.231
Others ^d	641 (18.4%)	817 (18.5%)	197 (19.9%)	141 (21.0%)	0.608	0.680
Smoking						
No	3330 (82.1%)	4685 (80.8%)	907 (80.4%)	700 (78.9%)	0.409	0.940
Stopped at first trimester	164 (4.0%)	341 (5.9%)	56 (5.0%)	59 (6.7%)	0.105	0.696
Continued after first trimester	492 (12.1%)	685 (11.8%)	149 (13.2%)	106 (12.0%)	0.399	0.569
No information	71 (1.8%)	85 (1.5%)	16 (1.4%)	22 (2.5%)	0.082	0.042
Antenatal visits (total number)	72 646	94 658	23 803	16 925		
Antenatal visits/mother, mean (s.d.)	18.1 (5.7)	16.7 (4.4)	21.4 (9.1)	19.2 (5.7)	<0.0001	<0.0001
Special health care visits (total number)	17 317	22 814	6945	6136		
Special health care visits, mean (s.d.)	4.3 (2.9)	4.1 (2.8)	6.2 (4.1)	7.0 (3.3)	<0.0001	0.860
Gestational hypertension or preeclampsia	343 (8.5%)	503 (8.7%)	79 (7.0%)	105 (11.8%)	<0.0001	0.001
Induced delivery	961 (23.7%)	1495 (25.8%)	373 (33.1%)	398 (44.9%)	<0.0001	<0.0001
Gestational age (mean) (s.d.)	39.8 (1.6)	39.7 (1.7)	39.2 (1.7)	39.3 (1.4)	0.606	0.021
Birth weight, grams, mean (s.d.)	3651 (472.0)	3580 (471.5)	3685 (472.8)	3712 (472.3)	0.200	<0.0001
Type of delivery						
Vaginal	2888 (71.5%)	4041 (70.0%)	814 (72.4%)	569 (64.6%)	<0.0001	0.006
Instrumental	305 (7.5%)	506 (8.8%)	81 (7.2%)	67 (7.6%)	0.735	0.576
Caesarean section	847 (21.0%)	1224 (21.2%)	229 (20.4%)	245 (27.8%)	<0.0001	0.001
Hospital stay of mother in days, mean (s.d.)	2.4 (1.8)	2.2 (1.4)	2.8 (1.7)	2.4 (1.5)	<0.0001	<0.0001

The numbers are n (%) or mean (s.d.). Antenatal visits = any visits at welfare clinics or hospital.

^aUpper-level clerical officials with administrative, managerial, professional, and related occupations.

^bInteraction between the effects of year and treatment of GDM on the outcome.

^cStudents, pensioners, self-employed persons and others.

^dLower-level clerical officials with administrative and clerical occupations.

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comprehensive screening may reflect this. Another reason might be the change in the definition of risk factors: during comprehensive screening, OGTT was recommended if there was a family history of diabetes, even in women who would otherwise have been exempted from the test because of a very low risk of GDM. Nowadays, every third GDM woman has first-degree relative with diabetes (23). As the prevalence of type 2 diabetes increases in Finland – 15.7% of men and 11.2% of women have been diagnosed the disease (24) – family history is also considerable as a screening indication.

Although the total number of GDM mothers increased between the study periods, the proportion and the absolute number of women treated with insulin decreased significantly. Uniform guidelines, together with revised uniform cutoff levels for insulin treatment, may be important reasons for this change: target levels for fasting glucose concentration rose from 5.3 to 5.5 mmol/l, and those for postprandial glucose from 6.7 to 7.8 mmol/l 1 h after meal, which may contribute to the decrease of the amount of insulin treated GDM women. The change to measure postprandial glucose concentration 1 h instead of 1.5 h after meal was based on a national consensus in the development of the national Current Care Guidelines and is likely to identify a similar amount of women for insulin treatment (25). On the other hand, the decrease may also reflect successful diet counseling according to the uniform guidelines. Insulin-treated GDM mothers were older, had higher pre-pregnancy BMI values and were less often primiparous than diet-treated women during the two study periods. The hypertensive disorders, need for delivery inductions and caesarean sections cumulated in this group, especially under comprehensive screening. Therefore, women with insulin treatment belong to a group requiring special antenatal care, as well as care during delivery.

The number of women screened to find one woman with GDM was higher during comprehensive than risk factor-based screening. However, these rates are difficult to compare, as a large number of women with GDM likely remained undiagnosed during selective screening. In this study setting, it is not possible to evaluate the presence and significance of risk factors in different study years. While the risk of having GDM after pregnancy with normal glucose metabolism is low, at about 1% (26), it might be worth considering the use of comprehensive screening during the first pregnancy and risk factor-based screening thereafter. However, this policy merits further evaluation.

The change in the screening protocol induced a substantial increase of performed OGTTs, diagnoses and a need for counseling and follow-up. Because Finland has low perinatal mortality and advanced perinatal care, the effect of intensive screening on short-term perinatal outcomes may be difficult to detect. The recent UK NICE Guideline of Diabetes in Pregnancy includes a detailed cost-effectiveness analysis and concludes that there is insufficient evidence to demonstrate that alternative screening strategies are more cost effective than risk factor screening recommended by earlier NICE guidelines (27). GDM increases the morbidity of the mother and baby in the index pregnancy, but also serves as an indicator of increased risks for subsequent type 2 diabetes and other metabolic disturbances (7, 8, 9, 10, 28). Thus, the proper cost effectiveness of GDM screening is reported to be mainly based on identifying these risk groups and on the possibility to prevent or delay their onset (29). Therefore, it is probable that effective screening will be repaid in the future. However, this would require effective measures to prevent type 2 diabetes, starting from overcoming the low attendance rate of *postpartum* follow-up programs (30, 31).

It has been suggested that GDM diagnosis would predispose to delivery induction, instrumental deliveries, and caesarean sections with relative medical reasons (2, 32). In previous randomized controlled studies, however, the caesarean section rate has remained unchanged (5) or even decreased (33) in groups with active treatment of recorded GDM. In our study, the percentage of caesarean sections in GDM mothers increased significantly, which was consistent with the results of some earlier studies (2). At the same time the overall caesarean section rate remained similar while the caesarean section rate decreased in the control group. Our data do not allow us to distinguish the reasons for this tendency. Our population-based study reflects 'real-life' changes in treatments with relative medical indications in a natural setting more accurately than a randomized trial. Induction of labor has been shown to be increased by active treatment of mild GDM in one but not in another study (5, 33). In our study, induction of labor was found to have increased from 2006 to 2010, but this increase was similar in women with or without GDM.

In Finland, antenatal care is free of charge and is practically universally attended. It is obligatory for the delivery hospital to report every birth to the MBR. Therefore, the study population is unselected and virtually complete. The diagnosis of GDM was set according to recorded abnormal OGTT or initiated insulin treatment,

which can be considered reliable and comparable during the 2 study years. Still, there were also some limitations in this study. For instance, our data did not allow us to define single risk factors during the study periods. We were thus unable to compare women who would have been screened because of risk factors in 2010 with women who underwent screening because of the comprehensive screening policy. Moreover, in an observational study it is difficult to distinguish between changes resulting from the new screening policy and time trends, i.e. changes that would have occurred anyway. However, the strongly statistically significant interactions between GDM and study year show that changes in characteristics such as maternal pre-pregnancy BMI and parity between the 2 study years were different in mothers with and without GDM, and argue for an effect of a policy change. While the risk factor-based screening was attended by 27.5% of women, 2 years after launching new national Current Care Guidelines, the amount of screened mothers was 51% when the estimated amount of mothers who were supposed to undergo screening was 80%. However, it takes time to reach full implementation, and we believe that the target will be approached in future years.

The change to a comprehensive screening policy led to a significant increase of GDM women, mainly with mild disease with diet treatment. They were also more often primiparous and had lower BMI levels. Caesarean sections were more concentrated in GDM mothers, while overall caesarean section rates remained similar. However, comprehensive screening did not perform better in diagnosing an essential risk group – women needing insulin treatment. Therefore, the optimal screening method for GDM remains controversial, although our study as a whole adds to accumulating evidence in favor of comprehensive screening. Further, the cost-effectiveness of a wide-scale screening should be further evaluated, with the increased pressures on maternal care balanced with possible improvements in perinatal outcomes.

Declaration of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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Author contribution statement

All authors (S Koivunen, E Kajantie, A Torkki, A Bloigu, M Gissler, A Pouta, M Väärasmäki) contributed to the design and conduct of the paper, critically reviewed manuscript details, and approved the final version.

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