
ORIGINAL RESEARCH

Gestational diabetes in Manitoba during a twenty-year period

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Abstract

Purpose: This retrospective cohort study was designed to examine the prevalence and risk factors of gestational diabetes mellitus (GDM) in Manitoba.

Methods: A total of 324,605 deliveries by 165,969 women were reported to Manitoba Health in the years 1985-2004. Data on maternal ages, delivery dates, GDM, self-declared First Nation (FN) status, rural or urban residence and previous GDM were collected for the study. Data were analyzed using multivariate logistic regression models.

Results: The prevalence of GDM during the 20-year period was 2.9%, which was 2.3% in 1985-1989 and 3.7% in 1999-2004 ($P < 0.01$). The trend of increase in the prevalence of GDM continued after major modifications on the screening and diagnostic criteria for GDM in 1998. The prevalence of GDM in FN women was 3-times greater than that in non-FN women. Higher prevalence of GDM was detected in FN pregnant women living in rural areas compared to those in urban areas ($P < 0.01$), which was opposite for non-FN pregnant women living in rural and urban areas. The prevalence of GDM in pregnant women ≥ 35 yr was 2.3-fold higher than that in those < 35 yr ($P < 0.01$). The recurrent rate of GDM was 44.4%. Adjusted odds ratios of GDM for FN status, advanced age, a history of GDM and rural living were 2.2, 2.4, 25.1 and 0.8, respectively.

Conclusions: The prevalence of GDM is increased in Manitoba. FN status, advanced age and a history of GDM, but not rural living, are independent predictors for GDM.

Diabetes mellitus (DM) is a leading cause of morbidity and mortality in developed and many developing countries.¹ Manitoba has been noted as one of provinces with the highest prevalence of DM in Canada. Near 5.7% of Manitoban had DM in 2006, and the predominant form of DM in Manitoba is type 2 DM.^{2,3} The prevalence of type 2 DM is considerably higher in Native Indians, Aboriginal or First Nations (FN or Aboriginal people in Canada) adults or adolescents compared with general populations.⁴⁻⁶ Obesity has been recognized as a critical etiological factor for type 2 DM in all age categories.^{7,8} The rapid increase of obesity or overweight in children in Canada is alarming.⁹ Gestation diabetes mellitus (GDM) is associated with maternal obesity, macrosomia (large baby), future obesity and diabetes in mothers and their offspring. Macrosomia is associated with adolescent obesity and type 2 DM.¹⁰ Previous studies demonstrated that the prevalence of GDM was higher in some ethnic groups, including Native Indians or Aboriginal people, and those with advanced age, obesity and a history of GDM.¹¹⁻¹⁸ The largest ethnic group in Manitoba is FN people, which represent approximately 13% of the population in the province.³

Prevention or early management of GDM in populations with high risks may help to reduce obesity and diabetes in the next generation.

In order to determine the trend and risk factors of GDM in Manitoba, we conducted a retrospective cohort study for the prevalence of GDM in the province during the time frame of 1985-2004. The impact of confounding factors: FN status, rural residence, advanced age or a history of GDM was assessed.

Methods

Study population and database

Since 1985, Manitoba Health and Healthy Living has requested all physicians or midwives in the province to complete a standardized prenatal form for every pregnant woman living in the province. The prenatal forms were submitted to Manitoba Health after delivery and prenatal information was input to a database. Prenatal information on 324,605 deliveries from 165,969 women living in Manitoba between 1985 and 2004 was analyzed in the present study. The study was approved by the Health Information Privacy Committee of Manitoba Health and the Research Ethics Board of the University of Manitoba.

Screening for and diagnosis of GDM

The screening for and diagnosis of GDM were conducted according to the latest criteria in Canada. No national guideline was available for the screening for or diagnosis of GDM before 1992. In 1992, the Society of Obstetricians and Gynecologists of Canada recommended screening for GDM in all pregnant women at the 24th week of pregnancy using a 50 g glucose tolerance test (GTT).¹⁹ In the case of an abnormal increase in plasma glucose (≥ 7.8 mmol/L at 1 h after glucose load), GDM was verified using a 100 g oral glucose tolerance test (OGTT). GDM was diagnosed from ≥ 2 occurrences of the following abnormal values out of 3 tests: fasting blood glucose (FBS) ≥ 5.8 mmol/L, the 1 h glucose ≥ 10.6 mmol/L, the 2 h glucose ≥ 9.2

mmol/L, or the 3 h glucose ≥ 8.1 mmol/L. The Canadian Diabetes Association (CDA) modified the guideline for GDM in 1998, which required the screening for GDM in all pregnant women at the 24th-28th week of pregnancy with a 50 g GTT. If the 1 h glucose is ≥ 10.2 mmol/L, GDM is diagnosed. If the 1 h glucose is ≥ 7.8 mmol/L but < 10.2 mmol/L, a 75 g OGTT is administered. Following abnormal values from 2 out of 3 tests were required for the diagnosis of GDM (FBS ≥ 5.3 mmol/L, the 1 h glucose > 10.6 mmol/L or the 2 h glucose ≥ 8.9 mmol/L)⁽²⁰⁾. No major change was made in the 2003 CDA Clinical Practice Guidelines⁽²¹⁾ on the screening for or diagnosis of GDM compared to that of 1998.

Other studied variables

Other prenatal information of the studied pregnant women retrieved for the study include maternal age (age at first prenatal visit), delivery date, self-declared FN status, previous history of GDM, and rural or urban residence based on the criteria of Statistics Canada (<http://www.umanitoba.ca/centres/mchp/concept/dict/urban-rural.html>). Body weights and oral glucose screening results of pregnant women were not included in the computer database.

Statistics

The prevalence of GDM in indicated periods and subgroups was analyzed using Mantel-Haenszel stratified Chi-squared tests of test statistical significance. The data were analyzed using multivariate logistic regression models for examining joint effects of multiple variables on the likelihood of event outcome. No adjustments were made for significance in multivariate testing. Odds ratios (relative risks) and the 95% confidence intervals (CI) were calculated as described.²² All *P*-values were two-tailed, and the significance level selected was 0.05. Statistical analyses were performed using SAS v 9.1 (SAS Institute Inc., Cary NC).

Results

During 1985-2004, a total of 9,472 cases of GDM were diagnosed in Manitoba, which represents a prevalence of 2.9% in 324,605 births. Yearly prevalence of GDM between 1985 and 2004 in Manitoba was plotted in Fig. 1. A positive correlation between the average prevalence of GDM and time was detected ($r = 0.768$, $n = 20$, $P < 0.01$). Table 1 demonstrated the prevalence of GDM in the province within the 20-year time frame and four equal 5-year blocks (1985-1989, 1990-1994, 1995-1999, 2000-2004) in all pregnant women (general) and the subgroups divided based on FN versus non-FN status, rural versus urban residence, maternal age ≥ 35 yr of age versus < 35 yr of age, FN and non-FN with rural versus urban residence or FN and non-FN with ≥ 35 yr of age versus < 35 yr of age. The prevalence of GDM in province in the periods of 1990-1994, 1995-1999, and 2000-2004 (2.7%-3.7%) was higher than that in years 1985-1989 (2.3%, $P < 0.01$). The prevalence of GDM in FN pregnant women was 2.6 to 3.8-fold higher than that in non-FN pregnant women during the 20-year period

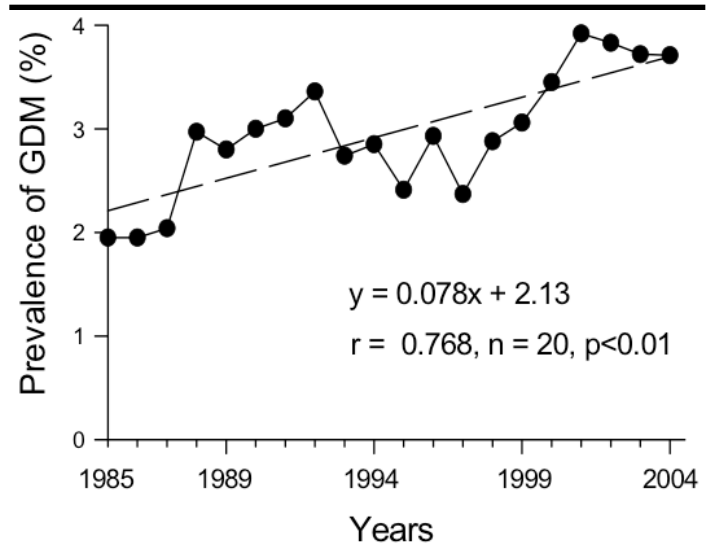


FIGURE 1. Yearly prevalence of gestational diabetes mellitus (GDM) in Manitoba between 1985 and 2004. Line with symbols: annual prevalence of GDM; dashed line: regression curve.

or within the 5-year blocks ($P < 0.01$). The prevalence of GDM in rural residents was moderately higher than that in urban residents (3.1% versus 2.7%, $P < 0.01$). FN pregnant women living in rural areas, predomi-

TABLE 1. Prevalence of GDM in Manitoba during 1984-2004

	Total deliveries/total GDM (% of GDM)				
	1985-2004	1985-1989	1990-1994	1995-1999	2000-2004
General	324,605/9,472(2.9)	88,474/2,075(2.3)	87,347/2,629(3.0)**	77,257/2,104(2.7)***	71,527/2,664(3.7)***##
FN	39,820/2,764(6.9) ^{xx}	9,108/615(6.8) ^{xx}	10,530/698(6.6) ^{xx}	9,978/627(6.3) ^{xx}	10,204/824(8.1)***## ^{xx}
Non-FN	284,785/6,708(2.4)	79,366/1,460(1.8)	76,817/1,931(2.5)**	67,279/1,477(2.2)***	61,323/1,840(3.0)***##
Rural general	131,423/4,100(3.1) ^{xx}	35,737/935(2.6) ^{xx}	34,238/994(2.9)*	31,852/928(2.9) ^{xxx}	28,596/1,243(4.2)***## ^{xx}
Urban general	178,201/4,805(2.7)	48,556/1,009(2.1)	49,336/1,485(3.0)**	42,057/1,080(2.6)***	38,252/1,231(3.2)***##
Rural FN	29,792/2,187(7.3) ^{xx}	7,095/510(7.2) ^{xx}	7,617/514(6.8)	7,500/490(6.5)	7,580/673(8.9)***## ^{xx}
Urban FN	9,992/577(5.8)	1,998/105(5.3)	2,904/184(6.3)	2,471/137(5.5)	2,619/151(5.8)
Rural non-FN	99,718/1,913(1.9) ^{xx}	28,217/425(1.5) ^{xx}	26,461/480(1.8)***	23,914/438(1.8)***	21,446/570(2.6)***## ^{xx}
Urban non-FN	163,981/4,228(2.5)	45,654/904(1.9)	45,131/1,301(2.8)**	38,643/943(2.4)***	34,553/1,080(3.0)***##
Age ≥ 35 yr	31,065/1,839(5.9) ^{xx}	6,001/358(6.0) ^{xx}	7,396/480(6.5) ^{xx}	8,698/428(4.9)*** ^{xx}	8,970/573(6.4)## ^{xx}
Age < 35 yr	293,540/7,633(2.6)	82,473/1,717(2.1)	79,951/2,149(2.7)	68,559/1,676(2.4)	62,557/2,091(3.3)***##
FN ≥ 35 yr	1,831/332(18.1) ^{xx}	281/73(26.0) ^{xx}	406/81(20.0) ^{xx}	484/61(12.6)*** ^{xx}	660/117(17.7)*** ^{xx}
Non-FN ≥ 35 yr	20,981/1,172(5.6)	3,945/224(5.7)	4,951/315(6.4)	5,893/271(4.6)***	6,192/362(5.8)##
FN age < 35 yr	37,989/2,432(6.4) ^{xx}	8,827/542(6.1) ^{xx}	10,124/617(6.1) ^{xx}	9,494/566(6.0) ^{xx}	9,544/707(7.4)***## ^{xx}
Non-FN < 35 yr	263,804/5,536(2.1)	75,421/1,236(1.6)	71,866/1,616(2.2)**	61,386/1,206(2.0)***	55,131/1,478(2.7)***##

GDM: gestational diabetes mellitus; FN: First Nations. *, **: $P < 0.05$ or 0.01 versus 1985-1989; +, +: $P < 0.01$ versus 1990-1994; ##: $P < 0.01$ versus 1995-1999; x, xx: $P < 0.05$ or 0.01 versus non-FN, urban, urban FN, urban non-FN, < 35 yr, non-FN ≥ 35 yr or non-FN < 35 yr

TABLE 2A. Prevalence of GDM in Manitoba during 1985-2004 subdivided by major changes in guidelines

	Total deliveries/total GDM (% of GDM)		
	1985-1992	1993-1998	1999-2004
General	141,550/3,747 (2.7)	96,708/2,608 (2.7)	86,347/3,117 (3.6)***
FN	15,407/1,072 (7.0) ^{xx}	12,192/734 (6.0) ^{***xx}	12,221/958 (7.8) ^{***xx}
Non-FN	126,143/2,675 (2.1)	84,516/1,874 (2.2)	74,126/2,159 (2.9)***

**: $P < 0.01$ versus 1985-1992; ++: $P < 0.01$ versus 1993-1998; xx: $P < 0.01$ FN versus non-FN

nantly in FN reserves, had a higher prevalence of GDM in the 20-year period compared with those living in urban areas (7.3% versus 5.8%, $P < 0.01$). In contrast, the prevalence of GDM in non-FN pregnant women living in rural areas between 1985 and 2004 (1.9%) was lower than those living in urban areas (2.5%, $P < 0.01$). Similar trends of difference in GDM for FN or non-FN pregnant women living in rural and urban areas were detected in each 5-year block (Table 1). Pregnancy at advanced ages (≥ 35 yr) had greater prevalence of GDM than those < 35 yr during the 20-year period and in each 5-year block ($P < 0.01$). In FN pregnant women ≥ 35 yr, the average prevalence of GDM was 18.1% within the 20 yr, which was 2.8 times the prevalence of those < 35 yr ($P < 0.01$). Similar increases were detected in non-FN pregnant women ≥ 35 yr versus < 35 yr ($P < 0.01$, Table 1).

During the years 1985-2004, two major modifications of the guidelines on screening for and diagnosis of GDM were made at 1992 and 1998 (see details in the Research Design and Methods). There was no increase in the prevalence of GDM in Manitoba during the period of 1993-1998 compared with that during the period of 1985-1992 (Table 2A). The prevalence of GDM in total, FN or non-FN pregnant women during 1999-2004 were higher than those during the 1985-1992 or 1993-1998 periods ($P < 0.01$). In order to answer the question of whether the prevalence of GDM increased after the major modifications of the guidelines in 1998, we compared the prevalence of GDM in the following 2-year periods: 1999-2000,

TABLE 2B. Prevalence of GDM in Manitoba after major changes of guideline (1999-2004)

	Total deliveries/total GDM (% of GDM)		
	1999-2000	2001-2002	2003-2004
General	29,418/956 (3.3)	28,729/1,114 (3.9)**	28,200/1,047 (3.7)**
FN	4,017/285 (7.1) ^{xx}	4,077/346 (8.5) ^{***}	4,127/327 (7.9) ^{xx}
Non-FN	25,401/671 (2.6)	24,652/768 (3.1)**	24,703/720 (2.9)**

*, **: $P < 0.05$ or 0.01 versus 1999-2000; xx: $P < 0.01$ FN versus non-FN.

2001-2002 and 2003-2004. The prevalence of GDM in total, and in FN or non-FN pregnant women during 2001-2002 or 2003-2004 were higher than those during 1999-2000 ($P < 0.05$ or 0.01), with an exception that the GDM in FN pregnant women between 2003-2004 (7.9%), which was not higher than that between 1999-2000 (7.1%) (Table 2B).

In women with a previous history of GDM, the recurrent rate of GDM in their subsequent pregnancies were 44.4% ($n = 1,290$). In FN women, the recurrence of GDM in their second pregnancy was 48.1%, which was higher than that in non-FN women (42.4%, $P < 0.01$). Only 9 women with a history of GDM had a third pregnancy during the studied time frame. Four of these had GDM in their third pregnancy (44.4%). Among them, 2 out of 4 FN pregnant women (50%) and 2 out of 5 non-FN pregnant women (40%) had recurrent GDM (no significant difference due to small sample size).

Adjusted odds ratios of GDM for FN status, advanced age, a history of GDM or rural residence were analyzed. The odds ratios of GDM for FN status and advanced age were comparable, 2.20 (95% CI:

TABLE 3. Odds ratios and 95% confidence intervals for contracture GDM in pregnancy ($n = 165,969$)

Factor	Odds ratio	95% Confidence intervals	
FN (FN=1, non-FN=0)	2.20	2.00	2.42
Age ≥ 35 yr (≥ 35 yr=1; < 35 yr=0)	2.38	2.24	2.54
History of GDM (yes=1, no=0)	25.10	23.15	27.19
Rural residence (rural=1, urban=0)	0.78	0.74	0.82

2.00-2.42) and 2.38 (2.24-2.54), respectively. The odds ratios of GDM for previous history of GDM and rural living were 25.10 (23.15-27.19) and 0.78 (0.74-0.82), respectively (Table 3).

Discussion

The present study is one of the largest population analyses for the prevalence of GDM to date with the longest length of time frame.^{11-18,23} The results demonstrate that the prevalence of GDM in Manitoba has increased during the last 20 years, which supports the recent findings in USA.²³ The trend of increase in GDM sustained in the province during the period of 1998-2004 after the major modification of the national guidelines on the diagnosis and screen of GDM.

Previous studies demonstrated that the prevalence of GDM was increased in Native Indians, Aboriginal or FN people.^{14-16,18} The results of the present study support the previous findings^{14-16,18} and demonstrate that the average prevalence of GDM in FN pregnant women during the 20-year time frame was near 3-fold of that in non-FN women in Manitoba. The prevalence of GDM in FN pregnant women in the present study (6.9%) was noticeably lower than that in a Canadian province with close population composition, Saskatchewan (11.5%), reported by Dyck et al¹⁴, but a smaller difference in the prevalence of GDM was found in non-FN pregnant women between the two studies (2.4% versus 3.5%).¹⁴ A possible explanation for lower prevalence of GDM in FN pregnant women in the present study is the lower screening rate in FN pregnant women as described previously.¹⁴ The results of multivariate logistic regression analysis indicate that FN status is an independent predictor for the prevalence of GDM with an odds ratio of 2.2 (95% CI 2.0-2.4). GDM is closely associated with metabolic syndrome and type 2 DM.^{11,17} Polymorphisms of several genes are associated with type 2 DM in FN people.²⁴⁻²⁵ Insulin receptor substance-1 and transcription factor 7-like 2 are potentially implicated in the pathogenesis of GDM.^{26,27} The genetic mechanism for

the susceptibility of FN pregnant women to GDM remains unclear.

The relationship between GDM and rural or urban living of pregnant women has not been well documented in literatures. Pregnant women living in rural areas of Manitoba had a 15% higher prevalence of GDM compared with those in urban regions. The prevalence of GDM in FN pregnant women living in rural areas was 26% higher than that in urban areas. Interestingly, non-FN pregnant women living in rural areas had a lower prevalence of GDM (-24%) compared with those living in urban regions. Relatively higher levels of physical activity in non-FN women living in rural areas compared with those in urban areas may be a possible explanation for the phenomenon. Higher proportions of other non-FN ethnic groups with increased risks of GDM live in urban areas rather than in rural areas, which may contribute to higher prevalence of GDM in non-FN pregnant women living in urban areas. Results of multivariate logistic regression analysis indicate that the odds ratio of GDM for rural residence was only 0.8. The finding suggests that rural residence alone is not an independent predictor for GDM. Over 70% of FN people live in rural reserves in Manitoba. Previous studies suggest that socioeconomic and environmental factors possibly causing GDM in FN pregnant women living in rural reserves include less access to medical services, source of healthy foods, health information and facilities for healthy lifestyle.²⁸ Measurements to improve lifestyle and prenatal care in rural reserves potentially help to reduce the prevalence of GDM in FN women in Manitoba.

Advanced age is a known risk factor for GDM.^{14,16} The results of the present study indicate that advanced age is an independent predictor for GDM in Manitoba, which is consistent to previous reports.^{14,16} FN pregnant women ≥ 35 yr had a prevalence of GDM 2.8-fold higher than those <35 yr, which was comparable to that in non-FN pregnant women (2.7-fold). Pregnant women over 35 years of age had an odds ratio of 2.4 (95% CI 2.2-2.5) for GDM.

The results of the present study indicate that a previous history of GDM is a potent risk factor for GDM in subsequent pregnancies. Nearly half of the women with a history of GDM in the province during the previous 20 years developed GDM during their second or third pregnancy. The number of pregnant women with a history of GDM may be underestimated in the present study since the database does not include the information on GDM of index pregnant women occurred before 1985. The finding of the present study is consistent with previous reports on the reoccurrence of GDM^{14,16} and suggests that additional preventative measures should be provided to pregnant women with a history of GDM during an early stage of pregnancy to prevent the reoccurrence of GDM.

In summary, the findings of the present study demonstrate that the prevalence of GDM has progressively increased in Manitoba during the previous 20 years in general. FN status is one independent predictor for GDM in Manitoba, in addition to previous history of GDM and advanced age. FN pregnant women living in rural areas are at higher risk for GDM compared to those living in urban regions. The prevention of GDM is one of the key potential approaches for the prevention of type 2 DM. Additional medical attention and resources for education on diet and physical activity to pregnant women with a history of GDM, advanced maternal ages or FN status, particularly those living on rural reserves, may help to reduce the prevalence of GDM in Manitoba. Further research to examine the causes and consequences of GDM in FN pregnant women is required.

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