

TITLE: Prevalence of gestational diabetes mellitus (GDM) among Indigenous women and comparison with non-Indigenous Australian women: 1990-2009

SHORT TITLE: GDM prevalence among Indigenous women 1990-2009

Corresponding and first author:

Ms Catherine CHAMBERLAIN
PhD candidate
Global Health and Society Unit
Department of Epidemiology and Preventive Medicine
Faculty of Medicine, Nursing and Health Sciences
Monash University
L3/89 Commercial Rd
Prahan. Victoria. 3181. AUSTRALIA
Catherine.chamberlain@monash.edu
Ph: +61 (0)3 99030021
Fax: +61 (0)3 9903 0556

Other authors:

Prof Emily BANKS
Professor of Epidemiology and Public Health
National Centre for Epidemiology and Population Health.
Australian National University. Canberra. ACT. AUSTRALIA.
Emily.Banks@anu.edu.au

Dr Grace JOSHY
Research Fellow
National Centre for Epidemiology and Population Health.
Australian National University.
Canberra. ACT. AUSTRALIA.
grace.joshy@anu.edu.au

Dr Ibrahima DIOUF
Postdoctoral Research Fellow
Preventive Health, Baker IDI.
Melbourne. Victoria. AUSTRALIA.
Ibrahima.Diouf@bakeridi.edu.au

Prof Jeremy J N OATS
Professorial Fellow
Melbourne School of Population and Global Health.
University of Melbourne.
Melbourne. Victoria. AUSTRALIA.
Jeremy.oats@thewomens.org.au

Dr Lina GUBHAJU
Research Fellow
Preventive Health, Baker IDI.
Melbourne. Victoria. AUSTRALIA.
Lina.Gubhaju@bakeridi.edu.au

Prof Sandra EADES
Professor of Public Health
School of Public Health, University of Sydney.
Sydney. New South Wales. AUSTRALIA.
sandra.eades@sydney.edu.au

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CONFLICTS OF INTEREST:

The authors declare they have no commercial or other conflicts of interest in this research.

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ABSTRACT:

Background:

Evidence on long-term trends in gestational diabetes mellitus (GDM) prevalence in Australia is lacking.

Aims:

To assess and compare trends in GDM prevalence among Indigenous and non-Indigenous Australian women.

Materials and methods:

Analysis of crude and age-adjusted GDM prevalence over time by Indigenous status and age, using routinely-collected midwives data from Australian states and territories on mothers giving birth from 1990-2009.

Results:

Despite considerable data variation, particularly in 1990-1999, and likely underestimation of GDM prevalence; crude and age-adjusted GDM prevalences were higher in Indigenous than non-Indigenous women at all time-points (4.7% versus 3.1% in 1990-1999; 5.1% versus 4.5% in 2000-2009, $p < 0.0001$). Data variability precluded quantitative assessment of trends and changes in prevalence ratios before 2000. From 2000-2009, GDM prevalence increased significantly among Indigenous women by a mean 2.6% annually ($p_{\text{trend}} < 0.0001$), and non-Indigenous women by 3.2% annually ($p_{\text{trend}} < 0.0001$), with no significant trend in the age-adjusted Indigenous:non-Indigenous prevalence ratios (PR) ($p = 0.34$). GDM prevalence increased significantly with age ($p < 0.0001$), although the increase with age was significantly greater among Indigenous women (PR 5.34 (4.94-5.77), ≥ 35 versus < 25 years) compared to non-Indigenous women (PR 3.72 (3.64-3.81), ≥ 35 versus < 25 years), $p_{\text{interaction}} < 0.0001$.

Conclusions:

Bearing data quality concerns in mind, GDM prevalence is increasing rapidly among Australian women, more than doubling in non-Indigenous women between 1990 and 2009. Prevalence is consistently higher in Indigenous versus non-Indigenous women, with statistically consistent differences between the groups in recent years. The marked increase in prevalence with age highlights an important period for prevention, particularly for Indigenous women.

INTRODUCTION

Gestational diabetes mellitus (GDM), broadly defined as diabetes diagnosed during pregnancy^{1,2}, is increasing in prevalence internationally, in line with type 2 diabetes mellitus (T2DM)³, with Indigenous women particularly affected^{4,5}. GDM causes serious complications during pregnancy and birth, including caesarean section and neonatal hyperglycaemia⁶, and identifies women at high risk of developing T2DM in the longer term⁷. Exposure to diabetes in-utero also increases risk of developing T2DM for the infant⁸, hence the emergence of diabetic disorders among young child-bearing women represents an ominous ‘tipping point’ in the diabetes epidemic, compounding the risk for the next generation⁸. Internationally, Indigenous women have an elevated risk of T2DM and GDM⁷⁻⁹, experience onset at a younger age on average⁹, and progress more quickly from GDM to T2DM¹⁰, compared to non-Indigenous women in the same country.

Strong evidence about the risks in pregnancy¹¹ has led to changes in international^{1,12} and national¹³ GDM screening guidelines. The changes include: offering screening in early pregnancy for women at high risk of T2DM, in addition to 24-28 weeks as is currently recommended; identifying ‘probable’ undiagnosed T2DM; and changing GDM diagnostic thresholds. These changes have particular implications for Indigenous women who are categorised as having a high risk of T2DM, and are likely to significantly increase GDM prevalence¹⁴.

While the early detection of GDM offers a unique ‘window of opportunity’¹⁵ for public health interventions, essential criteria to be considered when introducing population-based screening include “having a clear understanding of the prevalence of the condition”^{16,17}. To our knowledge there are no long-term trend analyses of national GDM prevalence in Australia. This study aims to assess trends in GDM prevalence among Indigenous women giving birth from 1990-2009 in Australia, and to compare these with prevalence and trends in non-Indigenous women.

MATERIALS AND METHODS

Study design and setting

This retrospective study includes data from women who gave birth in Australia from 1990-2009, reported in the Midwives Perinatal Data Collection (MPDC), which monitors patterns of pregnancy care, services and pregnancy outcomes in each Australian state or territory (jurisdiction). The items included in the MPDC are based on the National Health Data Dictionary¹⁸, and birth attendants are statutorily required to complete notification forms for all live births, and stillbirths of at least 400 grams birthweight or 20 weeks gestation.

Data collection

Data on women giving birth over a range of time periods were provided from all eight Australian jurisdictions including the Australian Capital Territory (ACT), New South Wales (NSW), Northern Territory (NT), Queensland (QLD), South Australia (SA), Tasmania (Tas), Victoria (Vic) and Western Australia (WA) (Table 1). Each Australian jurisdiction provided data separately for Indigenous and non-Indigenous women on the total number of births and the number of women reported as having GDM, in five-year age groups (<20, 20-24, 25-29, 30-34, 35-39, ≥40 years), for each year data were available between the years 1980-2009, inclusive. Most jurisdictions provided combined data for Aboriginal and Torres Strait Islander women. Only QLD provided separate data for Aboriginal women and Torres Strait Islander women, which has been combined in this analysis.

There are variations in MPDC reporting between jurisdictions over time¹⁸, hence data are not considered comparable by state and territory⁹. First, Indigenous status measures whether a person identifies as being of Aboriginal and/or Torres Strait Islander origin and this is recorded in the birth record^{19,20}, and there have been increases in the number of people identifying as Indigenous over time¹⁹ with variations between jurisdictions in the Indigenous status question and recording categories²¹. Women categorised as non-Indigenous include all women without identification of Indigenous status recorded. Second, GDM definitions have also changed over time, with variation between jurisdictions in validation methods, collection methods and coding of diabetes⁹. For example, in Victoria, women were reported as having ‘any Diabetes in Pregnancy (DIP)’ (including pre-existing T2DM and type 1 diabetes) from 1990-1999, and then GDM specifically from 2000-2009. In NSW,

GDM data prior to 2000 were not released due to these inconsistencies. In the NT, inconsistencies in GDM data prior to 2000 were noted, but data were released with this disclaimer. In Tasmania, Indigenous-specific data were not available prior to 2005. Sensitivity analyses were conducted to evaluate effects on trends when the data were restricted to jurisdictions which provided data over the whole study period (Vic, NT, SA). Data prior to 1990 were not included in this study due to concerns about reliability, and data after 2009 were not included as they were not provided by four jurisdictions.

Dealing with missing data

Data were not provided from most MPDC Units for cells where there were fewer than five births or women with GDM. Cells labeled '<5' were recoded as '3', as the midpoint between one and five, unless the sum of individual age-group data was greater than the 'all ages' data, in which case the cell estimates were reduced to make an equal sum.

Analysis and statistical methods

The primary outcome was GDM prevalence, calculated by dividing the number of women with GDM (numerator) by the total number of births (denominator). Data are reported in four age-groups (<25, 25-29, 30-34, ≥ 35 years). Where GDM-specific data were provided, these were preferentially included in analyses, otherwise 'any DIP' data were included.

Crude GDM prevalences for Indigenous and non-Indigenous women were reported and Indigenous: non-Indigenous prevalence ratios were adjusted for age-group category using log-binomial regression²² (Figure 1; Table 2). Crude GDM prevalences for each year and age-group category were also illustrated with 95% confidence intervals (Figures 2 and 3). Year (time) was included as a continuous variable, controlling for age (as a categorical variable), to assess the trend over time in GDM prevalence. Cumulative residual plots were used to investigate the linear functional form of year in the models. To assess the relationship of age and GDM prevalence by Indigenous status, prevalence ratios were calculated using the <25 age-group as the reference category for each decade. The overall difference in GDM prevalence between Indigenous and non-Indigenous women in each time period

and age-group was assessed using a likelihood ratio test (comparing the fit of regression models with and without interaction terms). All statistical tests were two sided, using a significance level of 5%. All analyses were carried out using SAS© 9.2²³.

Ethics

This research was approved by the Monash University Human Research Ethics Committee (CF11/0554 – 2011000234).

RESULTS

Overall, data were available for 121,736 Indigenous women and 3,433,839 non-Indigenous women giving birth, including 6,121 Indigenous women and 142,689 non-Indigenous women with GDM.

GDM Prevalence and Indigenous: non-Indigenous differences over time

Overall, for each decade, the crude prevalence of GDM was significantly ($p < 0.0001$) higher among Indigenous compared to non-Indigenous women. The crude prevalences among Indigenous women were 4.74% (95% CI 4.47-5.01), and 5.10% (4.96-5.24) in 1990-1999, and 2000-2009, respectively; compared to 3.06% (3.03-3.10) and 4.54% (4.51-4.56), respectively, among non-Indigenous women (Figure 1).

Indigenous women also had significantly higher prevalences of GDM than non-Indigenous women at all time-points when adjusted for age (Table 1; $p < 0.0001$), and summary age-adjusted prevalence ratios (PRs) showed significantly elevated GDM prevalence in Indigenous versus non-Indigenous women for both decades: 2.18 (2.05-2.31) in 1990-1999 and 1.58 (1.53-1.62) in 2000-2009. However there was considerable variation in prevalences among Indigenous women, particularly during 1990-1999.

Although the differences in GDM prevalence between Indigenous and non-Indigenous women from 1990-1999 appear greater than the differences in later years, concerns about data reliability and the

linear functional form of the time variable “year” for Indigenous women in the models from 1990-1999, mean that statistical analyses of changes over time were restricted to 2000-2009. From 2000-2009, GDM prevalence increased significantly among Indigenous (average annual increase=2.57% (1.63-3.52%) from 4.58% in 2000 to 5.54% in 2009, $p_{\text{trend}} < 0.0001$) and non-Indigenous women (average annual change=3.20% (3.00-3.39%) from 3.87% in 2000 to 5.17% in 2009, $p_{\text{trend}} < 0.0001$), (Figure 1). Bearing in mind data variability in 1990-1999, there was no significant change in age-adjusted prevalence ratios between Indigenous and non-Indigenous women from 2000-2009 (Figure 1; $p_{\text{trend}} = 0.34$). Sensitivity analyses with data restricted to Vic, NT and SA, showed similar trends over time and changes in ‘risk difference’ between Indigenous and non-Indigenous women.

GDM Prevalence by jurisdiction

There was considerable variability in crude GDM prevalences between jurisdictions from 1990-2009 and in prevalences and prevalence ratios between Indigenous and non-Indigenous women within each jurisdiction (Table 1); therefore statistical comparisons between jurisdictions were not made. QLD data provided separately for Aboriginal and Torres Strait Islander women (not shown), illustrated a higher prevalence of GDM among Torres Strait Islander women in 2000-2009 (7.92%, 7.24-8.61), compared to Aboriginal women (5.90%, 5.59-6.22).

GDM prevalence in Indigenous and non-Indigenous women by age-groups

GDM prevalence was significantly higher in Indigenous versus non-Indigenous women in all age-groups (Figure 2). While there was clear evidence of increasing GDM prevalence within each age-group for non-Indigenous women ($p < 0.0001$), greater data variability among Indigenous women precluded statistical analysis of age-group specific trends and comparisons.

GDM prevalence in Indigenous and non-Indigenous women with age, by decade

GDM prevalence increased significantly with age among both Indigenous and non-Indigenous women (Figure 3; $p < 0.0001$). However, the absolute prevalence was higher and the rate of increase with age was significantly greater among Indigenous women, compared to non-Indigenous women

($p_{\text{interaction}} < 0.0001$). In 2000-2009 (where data were the most comprehensive and reliable), GDM prevalence among Indigenous women increased more than five-fold (PR 5.34, 4.94-5.77), from 2.66% in women aged <25 to 13.86% in women aged ≥ 35 . Among non-Indigenous women, GDM prevalence increased less than four-fold (PR 3.72, 3.64-3.81), from 2.06% in women aged <25 to 7.51% among women aged ≥ 35 (Figure 2). The variability in the data underlines the need for caution interpreting GDM prevalence prior to 2000.

DISCUSSION

The prevalence of GDM is consistently and significantly higher among Indigenous than non-Indigenous women. From 2000-2009, GDM prevalence increased significantly among Indigenous women by an average of 2.6% annually, and non-Indigenous women by around 3.2% annually, with evidence of a steady risk differential over this time. Bearing in mind the considerable data variability and likely underestimation of GDM, particularly affecting the earlier period of analyses, GDM prevalence has more than doubled among non-Indigenous women from 1990-2009. While data variation precluded assessment of trends within age-groups among Indigenous women, there was a significant increase among non-Indigenous women in all age groups, suggesting the increase in maternal age is unlikely to account for these trends over time. GDM prevalence increased significantly with age among both groups, with a steeper age-related increase among Indigenous women.

The GDM prevalences reported in this study are consistent with those reported in previous cross-sectional studies 9, 24. Analyses of national MPDC data from 2005-2006 and 2005-2007; reported GDM prevalences among Indigenous women of 4.8% and 5.1%, respectively, and of 4.6% and 4.7% among non-Indigenous women, respectively. These yielded corresponding age-adjusted Indigenous versus non-Indigenous ratios of 1.5 24 and 1.6 9, and individual jurisdictions report similar findings 25, 26. These ratios are similar to those reported among NSW women in the three lowest socio-

economic quartiles, relative to those in the highest quartile (1.54, 1.74 , and 1.65), as well as women in other high risk ethnic groups¹ within a diverse non-Indigenous Australian population.

The strengths of this study include the low risk of selection bias, with all births included, and the long time frame, which illuminates trends and is important for service planning. However there are limitations (in addition to those described in the methods), which are likely to impact on data variability and lead to underestimation of true GDM prevalence rates. First, between 1990-2009 there has been variation in the GDM diagnostic criteria, across states and individual health services²⁷⁻²⁹. Second, there have been many changes in GDM screening practice from 1990-2009. Universal GDM screening has been recommended in Australia since 1991³⁰, although this has not been universally implemented, including among Indigenous women, despite Indigenous status being a ‘risk factor’ for selective screening. While some authors report screening rates among Indigenous women ranging from 70-99.5%³¹⁻³³; others suggest <50%, from population-based data^{28, 34}. In the latter scenario, the expected prevalence could be more than twice that reported, had all women been screened. . A prospective study among non-Indigenous women in NSW, in which all women were screened for GDM, measured a GDM incidence of 6.6%, while a prevalence of 5.7% was reported in the MPDC data³⁵. Any differential screening in Indigenous and non-Indigenous women may affect assessment of health differentials. This may also account for some of the observed difference in Queensland between Aboriginal and Torres Strait Islander women, with some mainland areas reporting <50% screening² and > 99% was reported in the Torres Strait Islands³. Third, GDM coding in MPDC reports has changed over time. Data prior to 1999 probably combines GDM and pre-existing diabetes, whereas data after 2000 is more likely to exclude diabetes diagnosed prior to pregnancy. This may ‘artificially’ attenuate trends in GDM prevalence in years where pre-existing T1DM and T2DM were separated from GDM, and is likely to have a larger effect on trends among Indigenous women who experience higher rates of pre-existing T2DM⁹. Finally, there is likely to be a degree of under-identification of Indigenous status, with data linkage studies suggesting Indigenous mothers in the NSW MPDC may under-enumerated by around 40%³⁶. Furthermore, we were not able to adjust

for any clustering effect for women who had more than one birth, as individual identifiers were not available, though it is unclear how this might influence trends.

There are a number of potential confounding factors which may contribute to the observed trends over time and with maternal age, which may warrant investigation in future studies. First, increasing Body Mass Index (BMI) and obesity is a well-established risk factor for GDM^{4,5}, and may be a contributing factor to the higher risk with increasing maternal age. BMI is poorly reported in the MPDC but may be available in more recent data. . Second, Indigenous women have higher parity than non-Indigenous women, and some evidence suggests this may increase the risk of GDM^{50,51}. We also suggest future GDM prevalence studies among women over time should include concurrent analyses of pre-existing T2DM to assess the impact of T2DM being excluded from GDM prevalence, particularly with recent guidelines differentiating ‘probable T2DM’ identified in early pregnancy¹³.

This study provides a timely update of GDM prevalence among Australian women, prior to the introduction of national screening guidelines¹³, which are likely to have a significant impact on the prevalence of GDM¹⁴ and have particular implications for Indigenous women. The rapid increase in GDM in both Indigenous and non-Indigenous women, over the last two decades highlights an issue of growing concern, with serious consequences for the health of women and their children, and future generations, as well as on health services.

GDM prevalence increases more markedly with maternal age among Indigenous women, which highlights an important target period for primary prevention. GDM is a preventable, identifiable, and treatable condition, therefore it is very important that all the criteria for population-based screening¹⁴ are met, including that primary prevention strategies are implemented³⁷, acceptable and effective screening are provided, and that effective treatment, secondary prevention, and follow-up strategies are available. Unfortunately, there is currently limited evidence that these criteria are being met³⁷, particularly for Indigenous women³⁸, reflecting the lack of evidence for effective diabetes interventions among Indigenous peoples more generally³⁹. GDM offers opportunities during

predictable frequent interactions with health services to minimise avoidable complications during pregnancy and birth, and evidence is urgently needed to inform targeted strategies to reduce the risk of developing T2DM in the longer term, including breastfeeding, healthy lifestyle changes, and other measures. Any effective support is likely to have significant benefits for many generations to follow

CONCLUSION

GDM is an important public health problem, with serious short-term consequences during pregnancy and birth, as well as life-long effects for the mother, infant and future generations. GDM prevalence is increasing rapidly in both Indigenous and non-Indigenous women but remains consistently higher among Indigenous women, high variability in prevalences due to poor data quality. There is no indication of a reduction in the risk difference between Indigenous and non-Indigenous women with GDM over the past decade. The marked increase in GDM with age, particularly among Indigenous women, demonstrates that pregnancy represents an important period for prevention. Recent changes to GDM screening are likely to further increase the prevalence of GDM. There is an urgent need to develop acceptable and effective primary and secondary GDM prevention strategies, particularly for Indigenous women.

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Figure 1: Crude GDM prevalence and ratios from available jurisdictional data for each year among Indigenous and non-Indigenous women

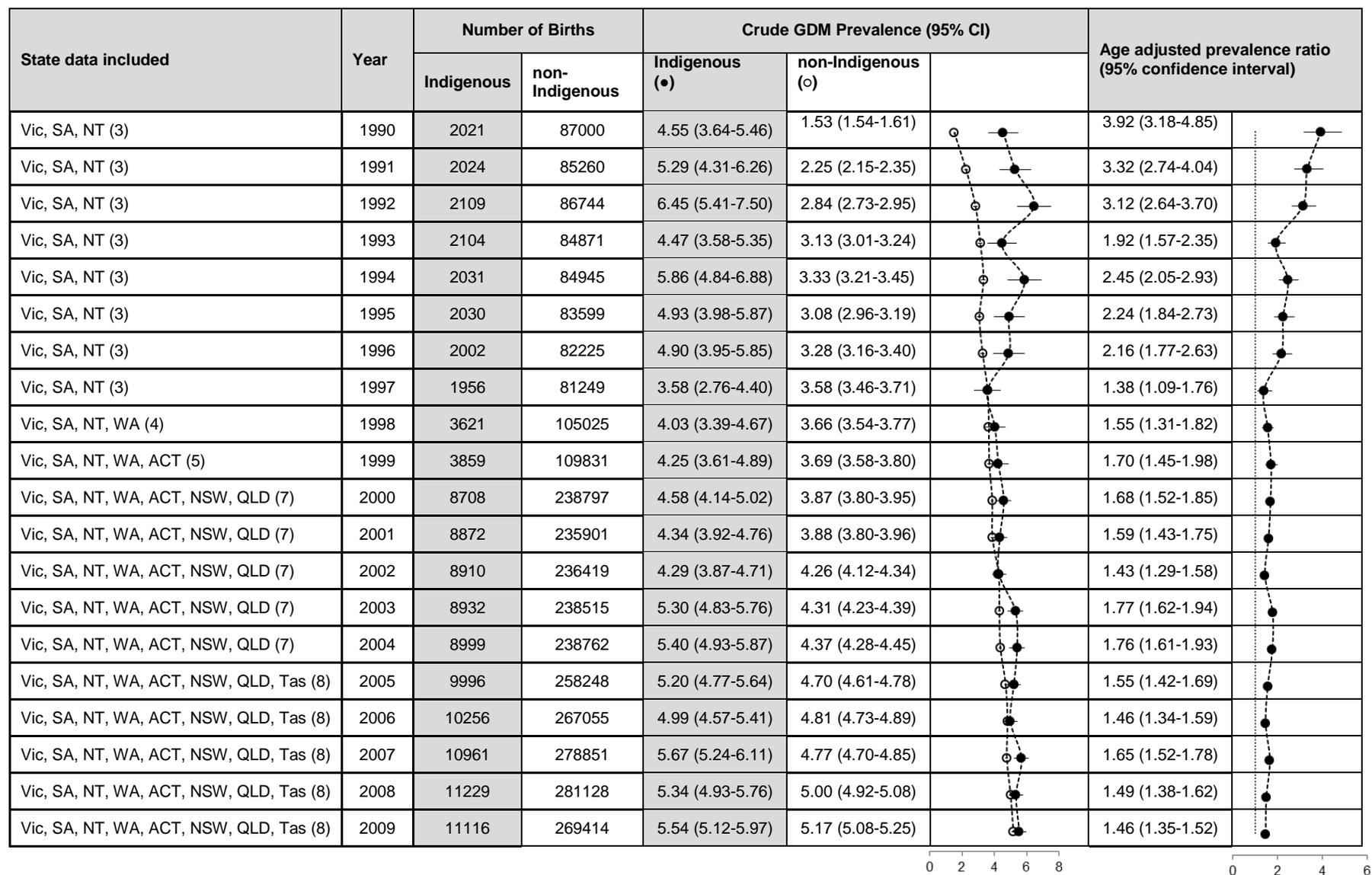


Figure 2: Crude GDM prevalence in Indigenous and non-Indigenous women, 1990-2009, by age group

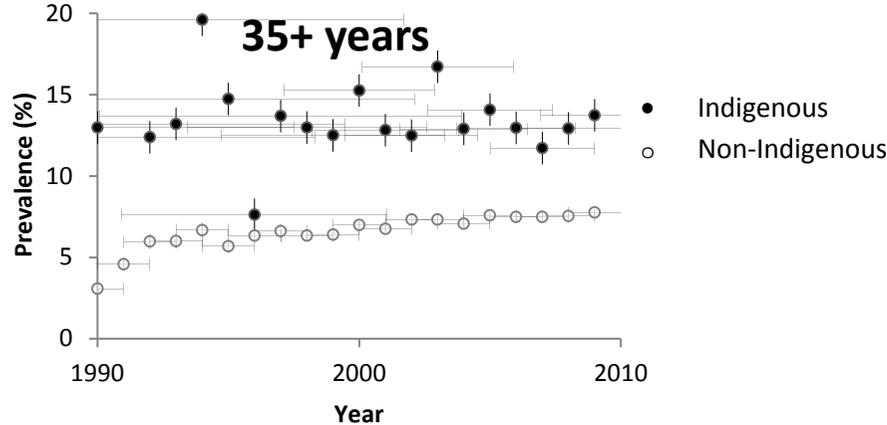
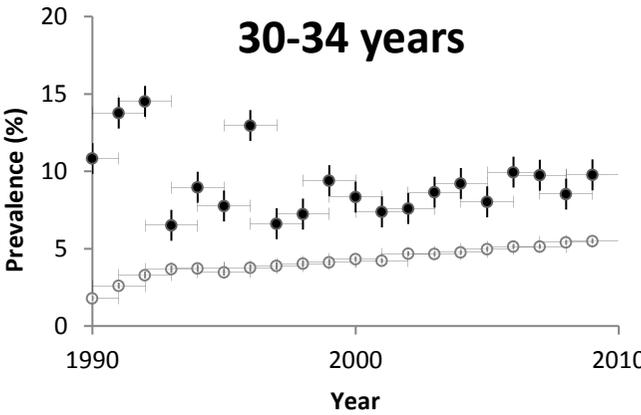
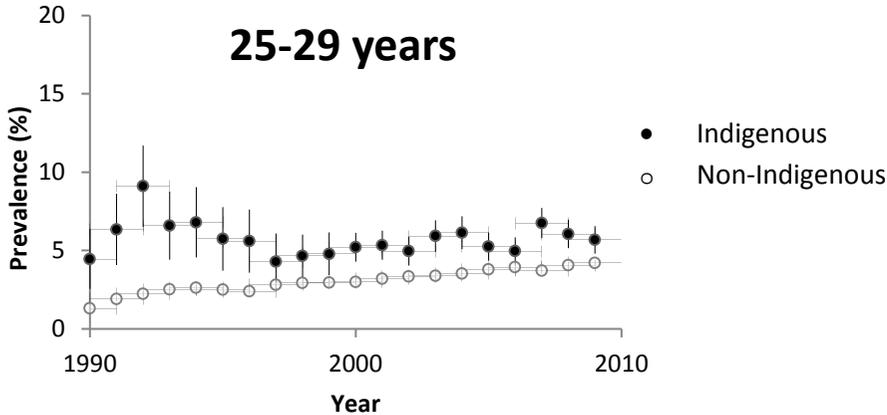
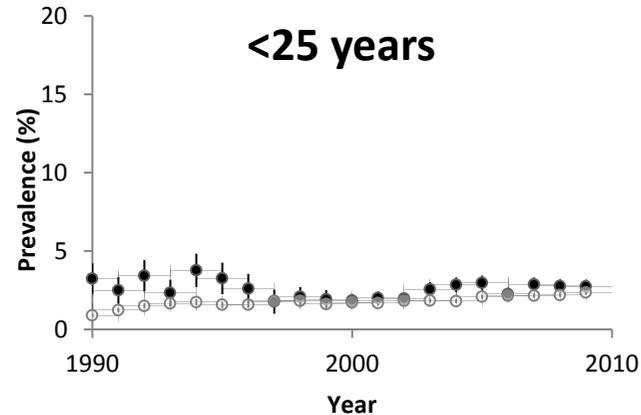
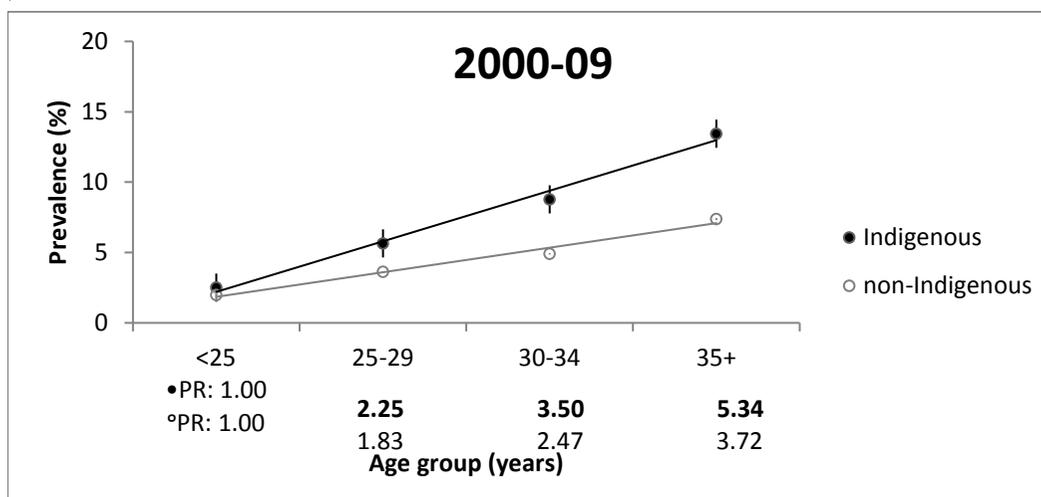
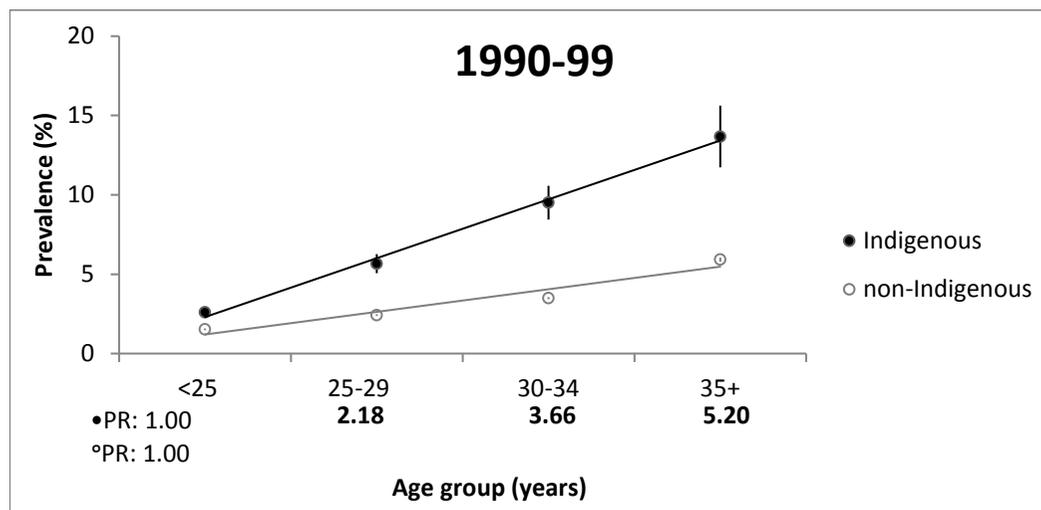


Figure 3: Crude prevalence of GDM in Indigenous and non-Indigenous women by age: 1990-99 and 2000-09



*PR=Prevalence ratio

Table 1: Crude GDM prevalence and age-adjusted prevalence ratios among Indigenous and non-Indigenous women by state and decade

State	Years data available	Indigenous/non-Indigenous Births (%)	1990-1999			2000-2009		
			Crude GDM prevalence Indigenous (95% CI)	Crude GDM prevalence Non-Indigenous (95% CI)	<i>Age-adjusted Prevalence ratio (95% CI)</i>	Crude GDM prevalence Indigenous (95% CI)	Crude GDM prevalence Non-Indigenous (95% CI)	<i>Age-adjusted Prevalence ratio (95% CI)</i>
Australian Capital Territory	1999-2009	894/54008 (1.6%)	3.39 (-1.23-8.01)	3.85 (3.29-4.41)	<i>1.18 (0.30-4.65)</i>	3.35 (2.13-4.57)	4.45 (4.27-4.63)	<i>0.98 (0.68-1.41)</i>
New South Wales	2000-2009	24679/863354 (2.8%)	.	.	.	3.38 (3.15-3.60)	4.53 (4.48-4.57)	<i>1.04 (0.98-1.12)</i>
Northern Territory	1990-2009	26623/44916 (37.2%)	5.14 (4.75-5.53)	3.31 (3.08-3.54)	<i>2.31 (2.07-2.58)</i>	6.66 (6.25-7.07)	4.43 (4.16-4.71)	<i>2.31 (2.11-2.53)</i>
Queensland	2000-2009	29723/506230 (5.5%)	.	.	.	6.15 (5.87-6.42)	4.84 (4.78-4.90)	<i>1.70 (1.62-1.78)</i>
South Australia	1990-2009	9141/364542 (2.5%)	4.09 (3.48-4.70)	2.48 (2.41-2.55)	<i>2.19 (1.88-2.55)</i>	5.76 (5.12-6.40)	4.21 (4.12-4.30)	<i>1.93 (1.72-2.16)</i>
Tasmania	2005-2009	1272/30061 (4%)				2.52 (1.66-3.38)	2.73 (2.55-2.92)	<i>1.17 (0.83-1.67)</i>
Victoria	1990-2009	9330/1266575 (0.7%)	3.98 (3.39-4.57)	3.19 (3.15-3.23)	<i>1.59 (1.37-1.84)</i>	3.72 (3.20-4.24)	4.65 (4.60-4.70)	<i>1.00 (0.87-1.15)</i>
Western Australia	1998-2009	20069/304153 (6.1%)	5.05 (4.29-5.82)	3.46 (3.30-3.62)	<i>2.06 (1.76-2.43)</i>	4.93 (4.61-5.26)	4.17 (4.09-4.25)	<i>1.69 (1.58-1.81)</i>
Total number births per decade			23867	886227		97979	2543090	

Supplementary Table 1: Crude GDM prevalence among Aboriginal and Torres Strait Islander women in Queensland, 2000-2009

Indigenous status	Proportion of births: indigenous/non-Indigenous (%)	Crude GDM prevalence (95% CI)
Aboriginal	21426/506230 (4.23%)	5.90 (5.59-6.22)*
Torres Strait Islander	5425/506230 (1.07%)	7.61 (6.91-8.32)*

*Note differential screening rates reported in Torres Straits (>99%), and lower rates reported on mainland (<70%)