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Pre-Pregnancy Diabetes and Obesity Increase Synergistically the Risk of Caesarean Delivery in Indigenous Australians from North Queensland Communities

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ABSTRACT

Objectives: To quantify the risk of Caesarean Delivery (CD) for pre-pregnancy diabetes among Australian Indigenous women in North Queensland.

Methods: Cohort study including 298 women who delivered babies in hospitals between 1998 and 2008 and who had pre-pregnancy measures from 1998-2002. Baseline measures included weight, height, waist circumference, blood pressure, fasting glucose, lipids, red cell folate, urine albumin creatinine ratio, chlamydia and gonorrhoea, and self-reported tobacco smoking, alcohol intake and physical activity. Delivery mode was obtained using Australian Refined Diagnosis Related Groups codes in the linked hospitalization records. The association between delivery mode and diabetes/glucose was quantified using generalized linear model.

Results: During the study period, a total of 596 deliveries from 298 women were recorded in all public hospitals in North Queensland. Of these, 199 had vaginal deliveries, 57 had CD, and 42 had both delivery modes. Women having CD were 2 years older (25.3 vs 23.4years, P<0.01), and had significantly higher baseline fasting glucose (5.1 vs 4.6 mmol/L, P<0.001) compared to those having vaginal deliveries. Pre-pregnancy diabetes tripled the risk of CD (95% CI 1.1-7.3), and obesity combined with diabetes increased the CD risk 5-fold (RR=4.8, 95% CI 1.2-19.2). Baseline fasting glucose 5.0 mmol/L and over doubled the risk of CD (adjusted RR 2.2, 95% CI 1.1-5.2).

Conclusions for practice: Pre-pregnancy diabetes and obesity increased the risk of CD 5-fold in this high risk population. Interventions aimed at improving metabolic health in young women prior to pregnancy are urgent.

Significance: The general health of Indigenous women of productive age is poorer compared to non-Indigenous ones, especially those from rural and remote communities. Yet fewer studies have reported the association between pregnancy outcomes such as delivery modes with health risk factors. We studied the delivery modes using linked hospitalization records of all women

from a community wellness screening project in North Queensland. Our results showed that Indigenous women with pre-pregnancy diabetes had an increased the risk of CD and the risk of 5 times if combined with obesity. It is evident to improve the metabolic health of young Indigenous women prior to pregnancy.

Introduction

In the past two decades, the prevalence of diabetes in Australians is more than doubled, from 1.5% to 4.2% and it becomes a health threat to 1 million people and economic burden to the country. Indigenous Australians are 3 times more likely to have diabetes, with a regional gradient from highest in remote areas to lowest in the major cities [1]. Women of reproductive age with diabetes and their off spring are at higher risk of short-term or long term morbidity, including pre-eclampsia, pre-term delivery, foetal distress, and macrosomia which are indicators for caesarean section [2-4]. In addition, diabetes appears to affect uterine contractility leading to high rates of emergency caesarean delivery (CD) [5]. Obesity, as a predictor of diabetes risk, has been reported to double the risk CD in large populations in US and Europe independently of, or synergistically with diabetes [6-8].

Australian national data shows that 97% of women gave birth in a hospital in 2013 [9]. The onset of labour was spontaneous for 53.0%, most (67%) had a vaginal birth and, of these, 82.4% did not involve the use of instruments. The remaining 33% gave birth by CD in 2013, increased from 18% in two decades [9]. One percent of pregnancies in Australia were affected by pre-existing diabetes in 2005-2007 [10]. Australian national data (National Hospital Morbidity Database and the National Perinatal Data Collection database) for 2013 reported that pre-existing diabetes in Indigenous women was 3-4 times higher than non-Indigenous women and the risk of CD was double in those with diabetes compared to those without it [10]. In rural and remote communities in North Queensland, Indigenous women of childbearing age have multiple health risks including poor nutrition, high rates of obesity and diabetes, and extremely high prevalence of tobacco and alcohol use, which impact on pregnancy outcome [11]. A 7-year follows up of 1009 Indigenous women in North Queensland found alcohol drinking doubled the risk of miscarriage; and chlamydia and gonorrhoea increased the risk by 4 times compared to those without the conditions [12].

To date, except for national administrative data, few follow up studies have reported delivery mode and its associations with pre-pregnancy diabetes or obesity or other risk behaviours among Indigenous women. Here we report pre-pregnancy health profiles and birth mode in a cohort of Aboriginal and Torres Strait islander women from rural and remote communities in Queensland over a 7 year period.

Methods

1. Population

The study population was a subgroup of a community-based wellness screening project (Well Person Health Check) conducted in 1998-2000 in 23 North Queensland communities. The project invited all Indigenous residents of the communities to attend a health check [13]. Baseline data of all consented 298 women who gave birth after screening was linked to hospitalisation records from 1998 to 2008. The study was approved by the Cairns Base Hospital Human Research Ethics Committee with support from the peak Indigenous Health Organizations, Apunipima Cape York Health Council and the Torres Strait and Northern Peninsula Area Health Council.

2. Measurements

Weight was recorded with light clothing to the nearest 0.1 Kg. Height and Waist Circumference (WC) were recorded to the nearest centimeter by technicians. Physical Activity (PA) was measured using a 7-day recall method and PA sufficient was defined using the WHO criteria. Daily consumption of tobacco and alcohol were self-reported. Blood pressure (BP) was the average of three measurements using a Dinamap model 800 automated blood pressure monitor (Critikon; Tampa FL, US). Baseline hypertension was ascertained either by detection of high BP at examination (measured BP >=140/90 mmHg) or previous confirmed diagnosis or

currently prescribed antihypertensive medication (by medical record review).

Total cholesterol, High Density Lipoprotein Cholesterol (HDLC), triglycerides, glucose, and Red Cell Folate (RCF) were measured following at least 8 hours fast. Blood glucose and lipids were measured using photometric enzyme endpoint assay with Cobas Integra 700/400 (Roche Diagnostic, USA). RCF was measured using the Bayer Advia Centaur automated immunoassay system (Bayer, Australia) by Queensland Health Pathology Service in Brisbane. Diabetes was defined as either clinical diagnosis verified by the participants' medical records or a 2 hour glucose tolerance test, or fasting blood glucose level >=7.0 mmol/L.

Urine Albumin Creatinine Ratio (UACR) was measured by immunoassay in g/mol from spot urine collected in the early morning after at least an 8 h fast. in Cairns Base Hospital. Polymerase Chain Reaction (PCR) testing (Roche Amplicor CT/NG, Branchburg NJ) for Chlamydia trachomatis and Neisseria gonorrhoea was conducted on all urine specimens.

Hospital separations for all consenting participants were obtained from North Queensland hospitals (Cairns, Weipa, Thursday Island, Bamaga, Mount Isa, Mornington Island, Townsville, Bowen and Ayr) and linked using probabilistic matching with name, date of birth, sex and address, which linked WPHC reference number, hospital facility code and local unit record number. Delivery mode was obtained using Australian Refined Diagnosis Related Groups (AR-DRGs) [14].

AR-DRGs are Australian inpatient classification system. It groups patients into both clinically meaningful and homogeneous in terms of resource utilization based on relevant diagnoses and procedures for each admitted patient episode. The combination of codes for each episode guides its assignment to a DRG(AIHW). Delivery mode is classified in the 14th group of "Pregnancy, Childbirth and the puerperium" in a total of 23 major diagnostic categories. Delivery resource use was grouped as "Low" or "High" based on the indicator or ranking codes. Specifically, "A-C, and Z" marks the "High" with "Moderate or Major Complexity" and "D" for "Low" with "minor complexity" based on delivery complexity. (Table 1) lists the DRGs for generating delivery modes and subgroups within each mode used in this study during 1998-2008.

Table 1: DRGs for delivery modes and delivery resources consumption categories.

	Version 4 (1998-2002)	Version 5 (2002-2008)
Vaginal delivery		
Low	674	O60D
High	675, 676, 677, 688	O02A, O02B, O02Z, O60A, O60B, O60C
Cesarean section		
Low	670	O01D
High	671, 672, 687	O01A, O01B,O01C

3. Data analysis

The first delivery recorded in hospitalization after baseline screening date was included in the analysis. Baseline characteristics of this cohort were summarized by delivery modes and the categories of delivery resource use. Percentage of women with diabetes or high fasting glucose levels was compared by delivery mode using chi-square test or Fisher's exact test. The relative risk of CD and high delivery resource consumption with pre-existing diabetes or glucose quartiles was investigated using Generalized Linear Model (GLM) excluding those having both delivery modes during 1998-2008. The family in the models was "binomial" (or "Poisson" when not converging) and the link was "log". The association was further adjusted for age, BMI, other biomedical factors (BP, lipids, UACR, STIs), and lifestyle factors (smoking, drinking, physical activity). The association of combined diabetes/obesity was accessed by stratification analysis including "None, Either, and Both". All analysis was carried out using STATA 13 (STATAcorp, College Station, Texas, USA) and significance level was set at two-sided $P<0.05$.

Results

Among the 298 Indigenous women aged 15-37 years (mean age 23.9 years) who delivered babies in public hospitals in North Queensland, 56% were Aboriginal. At baseline, 29% were obese, 6.4% had hypertension and

nearly 3% had diabetes; 2% were diagnosed as having both obesity and diabetes. Almost 70% were smokers and/or alcohol drinkers. Only 16% met daily physical activity recommendations by self-report (Table 2).

Table 2: Baseline characteristics of women giving birth in hospitals during 1998-2008 in North Queensland.

	Vaginal n=199	C section n=57	Both types n=42	Total N=298
Age (years)	23.4 (22.6-24.1)	25.3 (23.7-26.9)	24.5 (22.6-26.3)	23.9 (23.2-24.5)
Aboriginal %	53.8 (46.8-60.6)	62.5 (49.1-74.2)	58.5 (42.9-72.6)	56.1 (50.3-61.6)
BMI (Kg/m²)	26.4 (25.4-27.3)	28.3 (26.2-30.4)	26.1 (24.0-28.1)	26.7 (25.9-27.5)
BMI>=30 Kg/m²	26.6 (20.9-33.2)	31.6 (20.8-44.8)	33.3 (20.7-49.0)	28.5 (23.7-33.9)
WC (cm)	89.0 (86.8-91.1)	96.0 (91.1-101.0)	90.0 (84.8-95.3)	90.5 (88.6-92.4)
WC >88 cm	47.7 (40.8-54.7)	59.6 (46.4-71.6)	47.6 (32.9-62.7)	50.0 (44.3-55.7)
SBP (mmHg)	114.4 (112.7-116.1)	117.9 (113.7-122.1)	115.1 (110.9-119.4)	115.2 (113.7-116.7)
DBP (mmHg)	60.8 (59.6-62.0)	64.2 (61.4-67.1)	64.5 (58.9-66.0)	61.7 (60.6-62.8)
Hypertension %	4.0 (2.0-.9.0)	12.3 (5.9-23.8)	9.5 (3.6-23.1)	6.4 (4.1-9.8)
Cholesterol (mmol/L)	4.3 (4.2-4.5)	4.5 (4.2- 4.7)	4.4 (4.2-4.7)	4.4 (4.3-4.5)
UACR (g/mol)	4.7 (0.6-8.6)	13.0 (1.2-25.0)	2.8 (0.7-4.9)	6.0 (2.5-9.5)
UACR>=3.5 g/mol %	13.5 (9.0-20.0)	29.3 (17.3-45.1)	16.7 (7.0-34.8)	16.8 (12.5-22.3)
RCF (nmol/L)	407.8 (386.7-428.9)	412.1 (356.7-467.5)	446.5 (371.1-521.8)	414.0 (393.8-434.2)
Chlamydia %	13.6 (9.4-19.1)	17.5 (9.6-29.8)	14.3 (6.5-28.6)	14.4 (10.9-18.9)
Gonorrhea %	2.5 (1.0-5.9)	5.3 (1.7-15.3)	7.1 (2.3-20.2)	3.7 (2.0-6.6)
Smoker %	65.7 (58.7-72.0)	70.2 (57.0-80.7)	73.8 (58.3-85.0)	67.7 (62.1-72.8)
Alcohol drinker %	70.5 (63.6-76.5)	69.6 (56.3-80.3)	56.1 (40.6-70.5)	68.3 (62.7-73.4)
PA sufficient %	16.6 (12.0-22.5)	15.8 (8.4-27.8)	16.7 (8.1-31.3)	16.4 (12.6-21.1)

Figures in the table are means or % (95% CI);
SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; WC: Waist Circumference; BMI: Body Mass Index; UACR: Urine Albumin Creatinine Ratio; RCF: Red Cell Folate; PA: Physical Activity
Hypertension was defined as BP >=140/90 mmHg, or an established hypertension diagnosis in clinic files; Diabetes was defined as either clinical diagnosis verified by the participants' medical records or a 2 hour glucose tolerance test, or fasting blood glucose level >= 7.0 mmol/L; Chlamydia and gonorrhoea detected using PCR for Chlamydia trachomatis and Neisseria gonorrhoea on all urine specimens; PA sufficient defined as having moderate to vigorous physical activity for more than 30min/d for 5 days in the week before the survey

During 1998-2008, a total of 596 deliveries from 298 women were recorded in all public hospitals in North Queensland. Of those, 199 women had vaginal deliveries, and 57 had caesarean section, and 42 had both modes of baby deliveries. 122 of 199 women in the vaginal delivery group and 22 in 57 with C section had multiple same mode deliveries.109 women in the vaginal delivery group (55%) had moderate to severe complexity that required high delivery care involving repair of vaginal and cervical laceration, vacuum extraction, postpartum evacuation or manual removal of placenta, medical or surgical augmentation, vertex or breech delivery, medical or surgical induction, surgical termination of delivery. 28 in the CD group (50%) had elective or emergency lower segment C section.

The corresponding principle diagnoses for 57 women having CD included the following: foetaldistress, mal-presentation, preterm or post-term; prolonged first stage or abnormal forces of labour, premature rupture of membrane, abnormality of tissues and pelvic organs, placenta praevia with haemorrhage, severe pre-eclampsia. Maternal health conditions included pre-existing diabetes, gestational diabetes, circulatory complications, and urinary tract infection. In addition, 12 women had "uterine scar from previous surgery".

Women having CD were approximately 2 years older (23.4 vs 25.3 years, P<0.01), and more likely to have hypertension (12.3% vs 4.0%, P=0.02) than those having vaginal deliveries. Ethnicity, BMI, lipids, RCF, UACR, STIs and lifestyle factors were not otherwise

different by delivery mode (Table 2). Women who had higher delivery care were not different in age, ethnicity, BMI, BP, RCF, STIs and life style factors (Supplementary Table 1).

Mean fasting glucose was 0.5 mmol/L higher for women having CD (95% CI glucose difference 0.2-0.8, P<0.001), and pre-existing diabetes was more prevalent compared to women having vaginal deliveries (8.8% vs 1.0%, P<0.01).Women with both obesity and diabetes were more likely to have CD (7.0% vs 0.5%, P<0.001) (Table 3). Fasting baseline glucose was higher in those using high delivery resources (mean difference 0.2, 95% CI 0.1-0.4 within vaginal group and 1.2 mmol/L, 95% CI 0.4-2.0 within CD group) compared to women with low resources use in both delivery groups and all women with diabetes had high delivery care (Table 3).

The risk of CD was tripled in women with pre-pregnancy diabetes (95% CI 1.1-7.3) after adjusted for age, ethnicity, BMI, hypertension, STIs and lifestyle factors. Obesity added the risk of CD to nearly 5 times (95% CI: 1.2-19.2). Baseline fasting glucose level of >=5.0 doubled the risk of CD (95% CI 1.1-5.2) (Table 4).

Within each delivery mode stratum, increased baseline glucose was associated with high hospital care, particularly in the CD subgroup with risk ratios of 1.5 for the 2st quartile and 1.7 for the 3nd and 2.2 for the 4th quartile (P for trend <0.001, Supplementary Table 2).

Table 3: Mean baseline fasting glucose and number (%) of women with pre-pregnancy diabetes by delivery mode during 1998-2008 in North Queensland.

	Vaginal delivery n=199			C Deliveryn=57		
	Low n=89	**High n=110**	**subtotal**	**Low n=29**	**High n=28**	**subtotal**
Glucose (SD)	4.4 (0.5)	4.6 (0.9)	4.6 (0.7)	4.5 (0.5)	5.7 (2.0)	5.1 (1.6)
Diabetes						
No	89 (100.0)	108 (98.2)	197 (99.0)	29 (100.0)	23 (82.1)	52 (91.2)
Yes	0 (0)	2 (1.8)	2 (1.0)	0 (0)	5 (17.9)	5 (8.8)
Glucose quartile						
1st (<4.3 mmol/L)	38 (42.7)	24 (22.0)	62 (31.3)	9 (31.0)	3 (11.5)	12 (21.8)
2nd (4.3-4.5)	10 (11.2)	31 (28.4)	41 (20.7)	8 (27.6)	6 (23.1)	14 (25.5)
3rd (4.6-4.9)	27 (30.3)	33 (30.3)	60 (30.3)	6 (20.7)	6 (23.1)	12 (21.8)
4th (>=5.0 mmol/L)	14 (15.7)	21 (19.3)	35 (17.7)	6 (20.7)	11 (42.3)	17 (30.9)
Diabetes/obesity						
Neither	63 (70.8)	82 (74.6)	145 (72.9)	22 (75.9)	16 (57.1)	38 (66.7)
Either	26 (29.2)	27 (24.6)	53 (26.6)	7 (24.1)	8 (28.6)	15 (26.3)
Both	0 (0)	1 (0.9)	1 (0.5)	0 (0)	4 (14.3)	4 (7.0)

Diabetes defined as either clinical diagnosis verified by the participants' medical records or a 2 hour glucose tolerance test, or fasting blood glucose level >=7.0 mmol/L; obesity as BMI>=30 Kg/m^2.

Discussion

We have demonstrated a high rate of case are an section deliveries related to pre-pregnancy obesity and diabetes in Aboriginal and Torres Strait Islander women in far north Queensland remote communities. National data show that Indigenous mothers tend to be younger than non-Indigenous ones, with average ages of 25.3 years and 30.2 years respectively [9]. The CD rate in this population was 33%, the same as the rate in the general population reported in 2013 despite the younger age profile [9]. Prevalence of obesity, pre-existing hypertension, and diabetes was 1.5, 2.8 and 3 times the rate of Non-Indigenous mothers using national data [9].

Baseline glycaemia of 5mmol/L or more appeared to double the risk of CD and pre-existing diabetes tripled that risk, independently of age and other factors such as obesity, hypertension, blood lipids, STIs, or lifestyle factors. The risk was increased to 5 times if pre-pregnancy diabetes was combined with obesity, indicating a synergistic impact on risk of CD delivery. The impact of pre-existing diabetes and maternal obesity on outcomes such as intervention decisions,

neonatal complications and macrosomia, will vary according to prenatal management of gestational diabetes, hypertension, early labouras well as the type and severity of diabetes [7].

Table 4: The association between Caesarean delivery and diabetes/obesity in women in North Queensland (RR and 95% CI).

	Crude	Model 1	Model 2	Model 3
Diabetes	3.4 (1.4-8.6)	3.3 (1.3-8.4)	2.9 (1.1-7.5)	2.8 (1.1-7.3)
Glucose quartile				
2nd (4.3-4.5 mmol/L)	1.6 (0.8-3.1)	1.7 (0.8-3.7)	1.7 (0.8-3.7)	1.8 (0.9-3.9)
3rd (4.6-4.9 mmol/L)	1.0 (0.5-2.1)	1.l (0.5-2.6)	1.1 (0.5-2.5)	1.1(0.5-2.6)
4th (>=5.0 mmol/L)	2.0 (1.1-3.9)	2.4 (1.1-5.2)	2.2 (1.1-3.5)	2.2 (1.1-5.2)
Both diabetes and obesity	3.9 (2.3-6.5)	5.1 (1.6-15.9)	5.0 (1.2-20.0)	4.8 (1.2-19.2)

Risk ratios from generalized linear model with family as binomial and link as log;
Model 1:Adjusted for age and ethnicity;
Model 2: model 1 + adjusted for BMI, blood pressure, UACR, chlamydia and gonorrhoea;
Model 3: model 2 + adjusted for smoking, drinking and physical activity

Recent synthesis of largecohort data showed a large proportion of childhood obesity tracks into adulthood and obese children were 5 times more likely to be obese in adulthood [15]. A meta-analysis of 37 cohort studies reported childhood obesity predicts adulthood diabetes incidence by 1.7 times [16]. A 6-year follow up study in Indigenous Australians in North Queensland showed that baseline obesity defined by WC or BMI or waist-hip ratio increased diabetes incidence by 2.5-3.0 times independent of age, sex, ethnicity and lifestyle factors [17]. The evidence suggest that early life intervention in Indigenous children and adolescents to prevent obesity is pivotal in interrupting the trajectory of subsequent adult obesity and diabetes, and the risks to maternal or foetal morbidity including higher rates of C section delivery. It is urgent to develop evidence-based preventive strategies and evaluate their effectiveness in high risk and socially disadvantaged groups, however very few have been reported [18].

Supplement Table 1: Baseline characteristics of women admitted in hospitals in North Queensland by delivery modes and its hospital resource consumption.

	Vaginal delivery n=199		C section n=57	
	Low n=89	**High n=110**	**Low n=29**	**High n=28**
Age (years)	24.1 (23.0-25.2)	22.8 (21.9-23.7)	24.5 (22.6-26.5)	26.1 (23.5-28.7)
Aboriginal %	55.1 (44.5-65.1)	52.7 (43.3-62.0)	64.3 (44.6-80.1)	60.7 (41.2-77.3)
BMI (Kg/m²)	26.8 (25.4-28.3)	26.0 (24.7-27.3)	26.8 (23.9-29.6)	29.9 (26.8-33.1)
BMI>=30 Kg/m²	29.2 (20.6-39.6)	24.5 (17.3-33.5)	24.1 (11.6-43.5)	39.3 (22.7-58.8)
WC (cm)	88.7 (85.4-91.9)	89.3 (86.4-92.1)	91.9 (85.2-98.6)	100.4 (93.1-107.6)
WC >88 cm	48.3 (38.0-58.7)	47.3 (38.0-56.7)	55.2 (36.5-72.5)	64.3 (44.6-80.0)
SBP (mmHg)	113.7 (110.9-116.4)	115.1 (112.8-117.4)	114.1 (109.2-119.1)	121.8 (115.0-128.6)
DBP (mmHg)	60.0 (57.9-62.0)	61.5 (60.0-63.0)	62.3 (58.9-65.7)	66.2 (61.5-71.0)
Hypertension %	3.4 (1.1-10.1)	4.5 (1.9-10.5)	6.9 (1.6-24.8)	17.8 (7.4-37.3)
Cholesterol (mmol/L)	4.4 (4.2-4.5)	4.3 (4.1-4.5)	4.3 (4.0-4.6)	4.6 (4.2-5.1)
UACR g/mol	1.4 (0.9-1.9)	7.4 (0.02-14.8)	13.0 (-5.2-31.3)	13.2 (-3.5-30.0)
UACR>=3.5 g/mol %	8.7 (3.9-18.2)	17.4 (10.7-27.1)	19.0 (6.9-42.7)	40.0 (20.6-63.2)
RCF (nmol/L)	396.5 (367.2-425.8)	417.0 (386.6-447.2)	379.0 (302.1-455.8)	449.0 (366.1-532.0)
Chlamydia %	11.2 (6.1-19.8)	15.5 (9.8-23.6)	17.2 (7.1-36.2)	17.9 (7.4-37.3)
Gonorrhea %	2.2 (0.6-8.7)	2.7 (0.9-8.2)	3.4 (0.4-22.1)	7.1 (1.7-25.6)
Smoker %	68.5 (58.1-77.4)	63.3 (53.8-71.9)	72.4 (52.9-86.0)	67.9 (48.0-82.8)
Alcohol drinker %	70.6 (59.9-79.4)	70.4 (61.0-78.3)	69.0 (49.5-83.4)	70.4 (50.1-84.9)
PA sufficient %	16.9 (10.4-26.2)	16.4 (10.5-24.6)	10.3 (3.2-28.6)	21.4 (9.6-41.1)

Figures in the table are means or % (95% CI);
SBP: systolic blood pressure; DBP: diastolic blood pressure; WC: waist circumference; BMI: body mass index; UACR: urine albumin creatinine ratio; RCF: red cell folate; PA: physical activity.

Hypertension was defined as BP >=140/90 mmHg, or an established hypertension diagnosis in clinic files; Diabetes was defined as either clinical diagnosis verified by the participants' medical records or a 2 hour glucose tolerance test, or fasting blood glucose level >=7.0 mmol/L; Chlamydia and gonorrhoea detected using PCR for Chlamydia trachomatis and Neisseria gonorrhoea on all urine specimens; PA sufficient defined as having moderate to vigorous physical activity for more than 30min/d for 5 days in the week before the survey

The Australasian Diabetes In Pregnancy Society (ADIPS) published the consensus guidelines for management of diabetes from the time of preconception till postpartum based on limited literature from other populations, and most of these were of poor quality [19].

Supplement Table 2: Fasting glucose quartiles and high delivery resource consumption in women in North Queensland during 1998-2008.

	Virginal delivery		C section delivery	
	Crude RR	Adjusted RR	Crude RR	Adjusted RR
Glucose quartile				
2nd	2.0 (1.4-2.8)	2.0 (1.2-3.4)	1.7 (0.5-5.4)	1.5 (0.4-6.1)
3rd	1.4 (1.0-2.1)	1.4 (0.9-2.4)	2.0 (0.6-6.2)	1.7 (0.4-7.0)
4th	1.6 (1.1-2.3)	1.5 (0.9-2.8)	2.6 (0.9-7.3)	2.2 (0.6-8.1)

Risk ratios from generalized linear model with family as binomial and link as log;
Adjusted risk ratio from model including age and ethnicity

The effectiveness of these guidelines at different stages on maternal and baby outcomes has not been evaluated.

Strengths of this study include capture of all pregnancies and deliveries in this population, objective baseline pre-pregnancy clinical measurements and a cohort design. Limitations include a relatively short follow up period, lack of detailed diagnosis of diabetes, previous pregnancy history and neonatal outcomes. The small number of obstetrical conditions including mal-presentation, pre-eclampsia, baby distress, and pre-term labour limited the specific outcome analysis rather than CD as a collective outcome. And lastly, hospital admission data was potentially prone to coding errors [20].

We believe many of these CD and other undesirable pregnancy outcomes in this high risk group of young women could be prevented with better targeting of programs to improve general health, especially metabolic health, of children and adolescents.

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