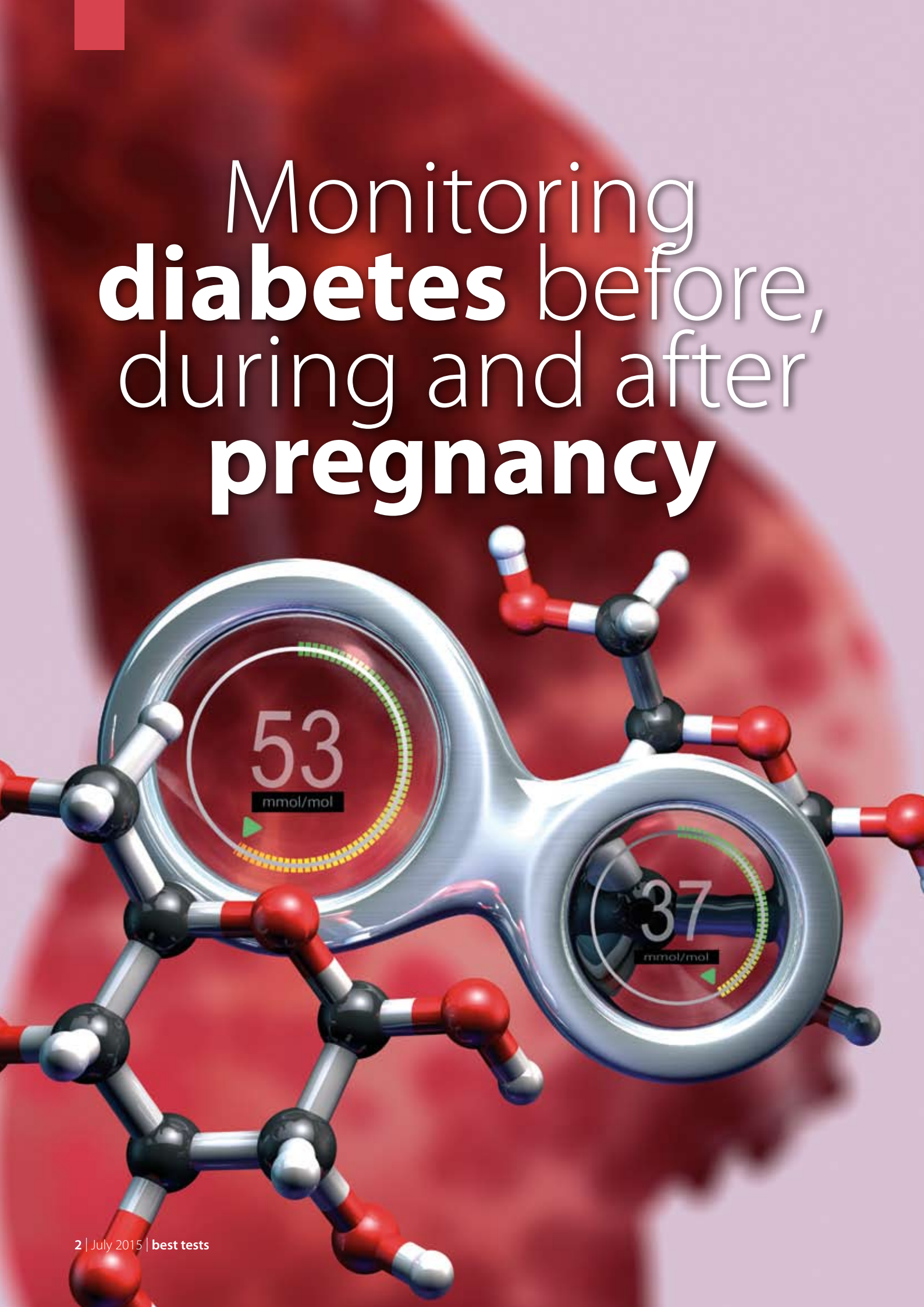
Monitoring **diabetes** before, during and after **pregnancy**



Hyperglycaemia during pregnancy is associated with a range of adverse outcomes which can affect both mother and child, and can occur during pregnancy, childbirth or later in life. Due to physiological changes associated with pregnancy, women are at increased risk of developing diabetes, or having worsening glycaemic control if they have pre-existing diabetes. In December, 2014, the Ministry of Health released the Screening, Diagnosis and Management of Gestational Diabetes in New Zealand clinical practice guideline and some changes to testing for gestational diabetes are recommended. In this article, we summarise the recent Ministry of Health guidelines, with a focus on the role of the general practitioner in testing for undiagnosed diabetes early in pregnancy and monitoring for the development of type 2 diabetes after pregnancy.

What is new?

- All pregnant women should be tested for undiagnosed diabetes using HbA_{1c} prior to 20 weeks' gestation
- Pregnant women with $HbA_{1c} \geq 50$ mmol/mol should be referred to a diabetes in pregnancy clinic
- Pregnant women with HbA_{1c} 41 – 49 mmol/mol should be offered lifestyle advice to reduce risks of adverse maternal and fetal outcomes; local protocols may recommend that these women are also referred to a diabetes in pregnancy clinic
- At 24 to 28 weeks' gestation, women are recommended to undergo an oral glucose tolerance testing regimen, which is dependent on their initial HbA_{1c} result
- HbA_{1c} is used to monitor glycaemia postpartum in women who have had gestational diabetes, beginning at three months after birth

Pregnancy is a time of significant metabolic change when a woman's physiology adapts to meet the challenges of gestation. Insulin sensitivity is decreased by as much as 50 to 60% during pregnancy, a level comparable to that seen in people with type 2 diabetes or impaired glucose tolerance.[1] This change in insulin sensitivity is thought to be caused by endocrine signals from the growing placenta, and has evolved to aid fetal development.[2] During pregnancy the mother's pancreas typically responds with beta-cell and islet hyperplasia to enable greater insulin production and regulate blood glucose levels.[1] Women who do not produce enough insulin to compensate for this transitory increase in insulin resistance develop gestational diabetes. These women often have risk factors for the development of type 2 diabetes and a higher level of insulin resistance before pregnancy.[1] After childbirth, the insulin resistance associated with pregnancy usually resolves, as does the need for treatment, if this has been required.

Maternal hyperglycaemia during pregnancy leads to fetal overgrowth (macrosomia), which is associated with an increased risk of difficulties in delivery (shoulder dystocia, third or fourth degree perineal tears, postpartum haemorrhage) and also a higher rate of caesarean section. Both maternal obesity and excessive gestational weight gain can cause macrosomia, independently of gestational diabetes. The more serious complications, such as congenital malformation and stillbirth, are largely confined to those women with previously unrecognised diabetes (usually type 2) that has come to light as "gestational diabetes" (Table 1, over page).

Pregnant women with intermediate glycaemia but without diabetes are also at risk of the same adverse outcomes

The Hyperglycaemia and Adverse Pregnancy Outcome (HAPO) study assessed the association of glucose tolerance with pregnancy outcomes in over 25,000 pregnant women in nine countries who were below the diagnostic threshold for diabetes.[3] Increasing maternal glycaemia was associated with an increased risk of the infant being above the 90th centile of birth weight and pre-eclampsia. There were modest associations with increased risks of neonatal hypoglycaemia, caesarean delivery, premature delivery, shoulder dystocia or birth injury, and the infant requiring neonatal intensive care.[3] This study shows that increasing glycaemia, even if below the threshold for diagnosis of gestational diabetes, is potentially detrimental to the fetus. The lowest risk pregnancy in terms of maternal glycaemia is one where the mother has blood glucose levels as close to normoglycaemic as possible; in this study the lowest risk category was mothers with results on a 75 g oral glucose tolerance test of fasting plasma glucose ≤ 4.2 mmol/L, one hour glucose levels ≤ 5.8 mmol/L or two hour glucose levels ≤ 5.0 mmol/L.[3]

Which women are most at risk of diabetes during pregnancy?

Females with any of the following characteristics are at increased risk of undiagnosed diabetes or developing diabetes during pregnancy:[4]

- A personal history of gestational diabetes or intermediate hyperglycaemia
- A previous infant > 4 kg at birth
- Increasing maternal age, particularly age over 35 years
- A first degree relative with diabetes
- A body mass index (BMI) ≥ 27 kg/m^2 in an Indo-Asian person or ≥ 30 kg/m^2 in other ethnicities
- Polycystic ovary syndrome
- Cardiovascular disease, hypertension, or elevated total cholesterol
- Physical inactivity
- Excessive gestational weight gain
- Long-term use of steroid (glucocorticoid) or antipsychotic medicines
- Acanthosis nigricans (hyperpigmentation of the skin)

The incidence of diabetes in pregnancy in New Zealand

The prevalence of diabetes has increased in New Zealand over recent decades and is currently around 5.8%; approximately 90% of whom are people with type 2 diabetes.[4, 7] Data from the New Zealand Adult Nutrition Survey 2008/09 show that 1.5 – 1.8% of women aged between 25 and 44 years reported a diagnosis of diabetes with another 1.1 – 2.0% having previously undiagnosed diabetes, highlighting that for every woman around childbearing age with diagnosed diabetes there is another with undiagnosed diabetes.[8] In New Zealand from 2001 to 2012 there was an annual increase of 13.9%

Table 1: Adverse outcomes for mothers with hyperglycaemia during pregnancy and their children[4, 5]

Diabetes during pregnancy increases the risk of adverse outcomes for women:	**Diabetes during pregnancy increases the risk of adverse outcomes for infants:**
Complications during pregnancy: ■ Hypertension ■ Polyhydramnios ■ Pre-term labour Complications during labour: ■ Shoulder dystocia ■ Operative vaginal delivery ■ 3rd and 4th degree perineal tear ■ Caesarean section ■ Postpartum haemorrhage In later life: ■ Type 2 diabetes	Major complications with previously unrecognised diabetes: ■ Stillbirth ■ Congenital malformation ■ Miscarriage ■ Perinatal death Fetal development complications: ■ Macrosomia* ■ Large for gestational age* Birth traumas and complications during and after birth: ■ Shoulder dystocia ■ Bone fractures ■ Brachial plexus palsy ■ Hypoglycaemia ■ Hyperbilirubinaemia ■ Neonatal hypoglycaemia
Women with intermediate glycaemia have an increased risk of: ■ Caesarean section ■ Premature delivery ■ Shoulder dystocia or birth injury ■ Pre-eclampsia	**Infants born to women with intermediate glycaemia have an increased risk of:** ■ Large for gestational age ■ Neonatal hypoglycaemia ■ Shoulder dystocia or birth injury ■ Intensive neonatal care ■ Hyperbilirubinaemia

* Macrosomia is defined as a large neonate regardless of gestational age, with cut-offs of 4000 g or 4500 g often used. Large for gestational age defines neonates with a birth weight above the 90th centile for gestational age.[6]

in the rate of gestational diabetes, with 4.9% of expectant mothers affected in 2012.[4] It is not known how many pregnancies in New Zealand are to mothers with pre-existing diabetes. Increases in the rates of gestational diabetes and type 2 diabetes are likely to be due to changes in shared risk factors, such as physical inactivity and obesity.

There are marked differences in the rate of gestational diabetes between ethnicities in New Zealand: Asian (8.1%), Middle Eastern, Latin American and African (7.5%), Pacific (7.2%), Māori (3.3%) and European (3.3%).[4] However, it has been suggested that the lower recorded rate among Māori may be due to lower rates of testing.[4] Rates appear to be increasing more rapidly in the Auckland and Northland regions.[4]

Testing for glycaemia pre-conception

In women with known diabetes or those with a previous history of gestational diabetes, the ideal scenario is for pregnancies to be planned and glycaemic control prior to pregnancy to be as optimal as possible.

Women with a history of gestational diabetes are at high risk of a having gestational diabetes during a subsequent pregnancy. Rates of recurrence from 30% to 84% have been reported, with the highest rates in women who needed insulin treatment during their previous pregnancy.[4] For women with a previous history of gestational diabetes who report that they wish to become pregnant, HbA_{1c} levels should be checked and lifestyle modification encouraged where appropriate so that their pregnancy begins with blood glucose levels as close to normoglycaemic as possible.

Women with established diabetes are at higher risk of adverse pregnancy outcomes such as congenital malformation, miscarriage, stillbirth and perinatal death (Table 1).[4, 5] Ideally, women with diabetes should use contraception until blood glucose control is established and then attempt to conceive while maintaining good blood glucose control.[5] Folate supplementation to reduce the risk of neural tube defects is recommended for all women who are trying to get pregnant, from one month before to 12 weeks after conception. Women with diabetes are recommended to take 5 g of folic acid daily (most other women can take 800 micrograms daily.[9]

For further information on pre-conception care in general practice, see: "A healthy start", BPJ 67 (Apr, 2015), available from: **www.bpac.org.nz/BPJ/2015/April/healthy-start.aspx**

Early pregnancy: the role of primary care in testing for diabetes

Recommendations for testing and diagnosis of diabetes in pregnant women have been the subject of much debate (see: "A lack of evidence hampers consensus on how to test for gestational diabetes", over page). Despite the lack of consensus on testing during pregnancy to identify women with gestational diabetes, the role of testing early in pregnancy and postpartum in women with previous gestational diabetes is much clearer:[4, 5]

- There is good evidence that hyperglycaemia in early pregnancy resulting from undiagnosed diabetes (usually type 2) results in adverse pregnancy outcomes and that treatment of women with diabetes during pregnancy improves the health of mother and child
- There is good evidence that women with a history of gestational diabetes are at increased risk of future type 2 diabetes

There is, therefore, a sound evidence base to test for undiagnosed diabetes in women who become pregnant, in order to identify those who can benefit from intervention, and for women who have had gestational diabetes to be monitored postpartum and be offered advice and support to reduce their future risk of type 2 diabetes.

Ministry of Health guidelines now recommend that all women should be tested for undiagnosed diabetes early in pregnancy (prior to 20 weeks' gestation) using HbA_{1c}. A schedule of oral glucose tolerance tests (OGTT) between 24 to 28 weeks' gestation to detect gestational diabetes is also recommended, with the specific testing regimen dependent on the HbA_{1c} test result from early pregnancy (Figure 1).[4]

Testing for undiagnosed diabetes in early pregnancy

Key practice points:

- It is now recommended that **all pregnant women undergo testing for pre-existing diabetes**
- Use HbA_{1c} prior to 20 weeks' gestation to detect pre-existing diabetes
- Women with an $HbA_{1c} \geq 50$ mmol/mol should be referred to a diabetes in pregnancy clinic (Figure 1).
- Women with an HbA_{1c} between 41 and 49 mmol/mol should be encouraged to adopt lifestyle measures to reduce their risk of adverse pregnancy outcomes; local DHB protocols may vary as to whether to refer these women to a diabetes in pregnancy clinic

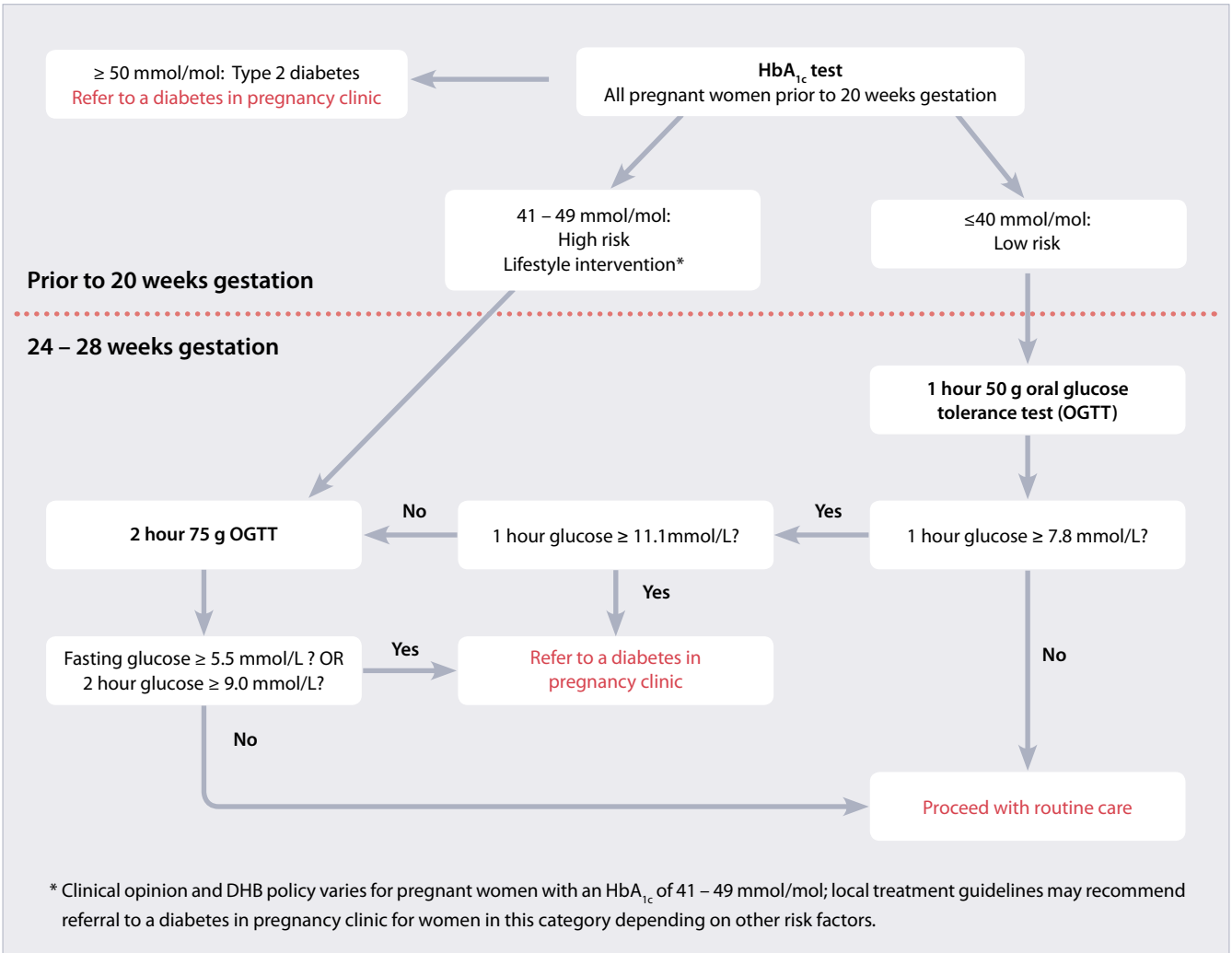


Figure 1: Screening and testing pathways for diagnosing diabetes in pregnancy[4]

Testing for pre-existing diabetes can be performed using HbA_{1c}. Physiological changes which occur during pregnancy cause red blood cell turnover to increase and HbA_{1c} levels decline, so HbA_{1c} should be performed prior to 20 weeks' gestation to improve accuracy.[4] Whenever testing for diabetes using HbA_{1c}, clinicians should keep in mind that some clinical conditions can affect HbA_{1c} levels and give misleading results (see: Factors affecting the reliability of HbA_{1c} testing, over page).

HbA_{1c} test is most easily done as part of the first antenatal blood test screen. If a patient is seen in general practice after they have enrolled with a lead maternity carer (LMC), check that the first antenatal screen, including HbA_{1c}, has been completed.

HbA_{1c} testing in early pregnancy will identify women with probable pre-existing diabetes (HbA_{1c} ≥50 mmol/mol) but also creates a new diagnostic entity – that is women with an HbA_{1c} of 41 to 49 mmol/mol. The HAPO study showed that mothers with elevated glycaemia below the threshold for diagnosing diabetes are at risk of some adverse pregnancy outcomes so these women should be encouraged to adopt lifestyle measures to reduce their risk of developing gestational diabetes and the adverse pregnancy outcomes associated with elevated glycaemia (see: "Lifestyle approaches", Page 9).

A recently published opinion piece argues that women with an HbA_{1c} ≥ 41 mmol/mol should be referred immediately for management to a diabetes in pregnancy clinic (rather than just those with an HbA_{1c} ≥ 50 mmol/mol).[15] There is as yet no evidence from randomised controlled trials, however, that earlier pharmacological intervention in these pregnancies improves outcomes (see: "Research into gestational diabetes testing in New Zealand", Page 11).

Caring for patients with pre-existing diabetes who become pregnant

With rates of both type 1 and type 2 diabetes increasing in New Zealand, and maternal age at pregnancy increasing, it is becoming more likely that clinicians will have under their care women with diabetes who become pregnant. In addition to blood glucose monitoring with the aim of meeting recommended treatment targets (see: "What are the treatment targets?", Page 9) these women usually require extra testing during pregnancy, in particular for retinopathy and nephropathy.

Retinopathy testing

Diabetic retinopathy can progress during pregnancy.[5] Women with diabetes who become pregnant should undergo retinal photography during the first trimester, unless they have had this performed in the previous three months.[5] Follow-up ophthalmology examinations during pregnancy may be indicated depending on the degree of retinopathy.

Renal testing

Nephropathy during pregnancy is associated with an increased risk of pre-eclampsia, fetal growth restriction and pre-term birth. Ideally, women with pre-existing diabetes should have renal function tests performed in the three months prior to pregnancy, or if not, early in pregnancy at the first point of contact with the clinician.[5] A protein:creatinine level of 30 mg/mmol reflects a daily protein excretion of 300 mg and is the recommended test for the presence of proteinuria in pregnancy.[18] A serum creatinine level > 90 micromol/L accompanied by hypertension after 20 weeks' gestation is diagnostic of pre-eclampsia.[18]

For further information on other routine laboratory testing during pregnancy, see: **www.bpac.org.nz/BT/2011/July/pregnancy.aspx**

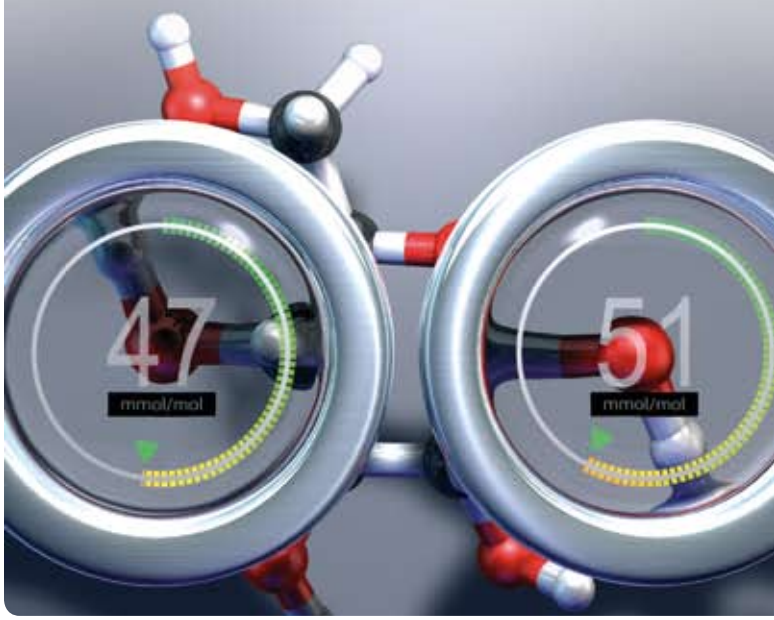
Later in pregnancy: testing and management is organised by the LMC and diabetes in pregnancy clinic

Ministry of Health guidelines now recommend that oral glucose testing later in pregnancy (at 24 to 28 weeks) be tailored to the patient's early HbA_{1c} results. This testing would usually be organised by the midwife. Most women will be at low risk of developing gestational diabetes and can undergo a 50 g oral glucose challenge test. This test has a good negative predictive value, so that women who test negative are at low risk of developing hyperglycaemia and the associated risks of adverse pregnancy outcomes. Therefore, for most women

A lack of evidence hampers consensus on how to test for gestational diabetes

In general there is a low quality of evidence available to guide recommendations for testing for hyperglycaemia in pregnancy; in particular, which screening strategies result in the best health outcomes for mother and child at the end of pregnancy has not been thoroughly assessed.[4] As a result, recommendations for how to test for hyperglycaemia during pregnancy vary, principally for which type of oral glucose tolerance test to perform during pregnancy and what glucose level cut-offs should be adopted to identify patients with gestational diabetes.[4, 10] In New Zealand, testing rates have been noted to vary across District Health Boards.[11] A National Gestational Diabetes Mellitus Technical Working Party published recommendations in 2008 to encourage alignment and standardisation across the country.[11]

The Maternity Quality Initiative Expert Working Group, formed in 2009 by the Ministry of Health, identified a need for evidence-based guidelines for the diagnosis and management of hyperglycaemia in pregnancy in New Zealand.[12] These guidelines were developed by a multidisciplinary team and published by the Ministry of Health in December 2014. The recommendations in this guideline differ from those published by other sources: for example, the Royal Australian and New Zealand College of Obstetricians and Gynaecologists (July, 2014) and Australasian Diabetes in Pregnancy Society (November, 2014) recommendations.[13, 14]



Factors affecting the reliability of HbA_{1c} testing

Measuring HbA_{1c} is an indirect method of testing glycaemia; it relies on the glycation of haemoglobin over the lifespan of an erythrocyte rather than directly measuring levels of glucose in the blood. Various clinical conditions can affect erythropoiesis or erythrocyte destruction and influence haemoglobin levels or lifespan, or can affect the chemical reactions which cause glycation of haemoglobin or used in assays to measure HbA_{1c}.[16] The best workaround for clinicians when confronted with HbA_{1c} results which do not appear to line up with a patient's presentation is to avoid the problems of indirect testing by simply ordering a blood glucose test; either a fasting plasma glucose > 7 mmol/L or a random plasma glucose > 11.1 mmol/L can be used to diagnose diabetes.[17]

Patients with haemoglobinopathies may have altered HbA_{1c} results depending on the type of assay used, with the direction of change depending on the specific diagnosis. Other factors which may potentially give erroneous HbA_{1c} results include:[16]

- Factors which can increase HbA_{1c}:
  - Alcohol intake
  - Iron or vitamin B_{12} deficiency
  - Hyperbilirubaemia
  - Renal failure
  - Opiate use
  - Splenectomy
- Factors which can decrease HbA_{1c}:
  - Erythropoietin, iron or vitamin B_{12} administration
  - Ingestion of antioxidants such as vitamin C or E
  - Very high triglyceride levels
  - Chronic aspirin use
  - Splenomegaly
  - Rheumatoid arthritis
  - Use of antiretrovirals

the burden of testing is limited to a one hour test. Women who test positive on the 50 g oral glucose challenge should undergo a 75 g two hour oral glucose tolerance test.

Women who are at increased risk of developing gestational diabetes (initial HbA_{1c} results of 41 – 49 mmol/mol) should proceed directly to a 75 g two hour oral glucose tolerance test without undergoing an initial 50 g oral glucose challenge test (Figure 1).

There is some disagreement as to whether women with additional risk factors should proceed straight to a 75 g oral glucose tolerance test even if their initial HbA_{1c} screening result is ≤ 40 mmol/mol. For example, there is concern that an obese woman may test negative on a 50 g glucose challenge as the glucose amounts are not adjusted for body weight, potentially missing a diagnosis.[15]

Women who have pre-existing diabetes or have probable undiagnosed diabetes detected with initial HbA_{1c} screening should be under the care of a diabetes in pregnancy team. Further oral glucose tolerance testing is unlikely to be indicated.

One scenario which is not covered by the Ministry of Health guidelines is which testing procedure should be performed for women who do not have an initial HbA_{1c} result available. Given that an HbA_{1c} test can be ordered with the first antenatal blood tests it is likely that women without an HbA_{1c} measurement in early pregnancy also have a lower level of engagement with health services, and as a result may be at increased risk of adverse pregnancy outcomes. A reasonable course of action would be to request that these women undergo a 75 g two hour oral glucose tolerance test.

Women with diabetes during pregnancy may require oral hypoglycaemic medicines or insulin

Women who have difficulty reaching blood glucose targets or who have high initial blood glucose levels at diagnosis are likely to require hypoglycaemic medicines, such as metformin or insulin injections (see: "What are the treatment targets?"). The regimen of medicines used to control the patient's blood glucose levels will be determined by the diabetes in pregnancy clinic, tailored to their treatment preferences and the degree of hyperglycaemia.[5, 20] Metformin is the preferred first-line treatment, as the risk of hypoglycaemia is lower than when using insulin and many patients prefer the ease of taking a tablet rather than using injections. Glibenclamide is recommended as a possible second-line oral hypoglycaemic

medicine by the Ministry of Health and National Institute for Health and Care Excellence, where blood glucose control is insufficient with metformin and the mother is unwilling or unable to use insulin, or if she experiences intolerance to metformin.[4, 5] Patients using only metformin have better outcomes than those using only glibenclamide.[4, 5]

Women with gestational diabetes should self-monitor blood glucose

Self-monitoring and laboratory measurement of glucose levels during pregnancy are used as the key tests to guide treatment, not HbA_{1c}. While HbA_{1c} is useful for monitoring long-term blood glucose control in non-pregnant patients, it does not capture fluctuations in glucose concentrations, and evidence suggests that targeting treatment to postprandial glucose levels results in the best outcomes for both mother and child in gestational diabetes. Furthermore, physiological changes affect HbA_{1c} levels during pregnancy, causing mean levels to drop compared with non-pregnant women for the same degree of hyperglycaemia.[4, 5]

What are the treatment targets?

Recommended treatment targets for self-monitored (capillary fingerprick) blood glucose levels are:[4, 20]

- Pre-prandial (fasting): ≤ 5.0 mmol/L
- Post-prandial, either ≤ 7.8 mmol/L at one hour or ≤ 6.7 mmol/L at two hours

Ministry of Health guidelines recommend that women with gestational diabetes should aim to have > 90% of blood glucose measurements in a week fall within the targets for glucose levels. If more than 10% of measurements fall outside of these ranges, treatment should be reassessed.[4]

Research suggests that the closer to normal blood glucose is during pregnancy, the lower the risk of maternal and neonatal complications. The treatment of all types of diabetes is a balancing act between attaining good glycaemic control while minimising the risk of hypoglycaemia. Maintaining blood sugars that are too low can cause intrauterine growth restriction.[5, 20]

Lifestyle approaches are the cornerstone of reducing the risk and burden of diabetes in all people

A healthy diet and regular exercise are the cornerstones of preventing hyperglycaemia in all people, regardless of whether they are pregnant. All women with diabetes during pregnancy should be offered specialist dietary advice.[4] A combined dietary and exercise approach is recommended which emphasises a balanced, healthy diet and encourages patients to be active for at least 30 minutes a day most days of the week unless there are clinical contraindications to physical activity. Limiting strenuous exercise may be necessary as pregnancy progresses and women should consult with their LMC or diabetes in pregnancy team regarding appropriate physical activity.

A key goal is to limit gestational weight gain in those who are already overweight. The United States Institute of Medicine released guidelines in 2009 for healthy ranges of weight gain during pregnancy depending on a woman's pre-pregnancy body mass index (BMI) (Table 2).[19] Women who gain more than these amounts are at increased risk of developing gestational diabetes, pregnancy-associated hypertension, complications during delivery and postnatal outcomes such as subsequent weight retention after pregnancy and unsuccessful breastfeeding.[19] Infants born to mothers with excessive weight gain during pregnancy are at an increased risk of neonatal mortality, being large for gestational age, and subsequent development of childhood obesity.[19]

Table 2: Recommended ranges of weight gain for pregnant women* [19]

Pre-pregnancy BMI (kg/m^2)	Rate of weight gain in 2nd and 3rd trimester (kg per week)	Total weight gain (kg)
< 18.5	0.44 – 0.58	12.5 – 18
18.5 – 24.9	0.35 – 0.50	11.5 – 16
25.0 – 29.9	0.23 – 0.33	7 – 11.5
≥ 30	0.17 – 0.27	5 – 9

* N.B. These ranges are for singleton pregnancies. Larger increases in weight are acceptable for women with multiple fetuses.

After pregnancy: general practitioners should reassess glycaemic status

Following a pregnancy affected by gestational diabetes, maternal hyperglycaemia may either resolve completely, or persist – either as intermediate hyperglycaemia or as established diabetes.

Women with previous gestational diabetes have an approximately six to eight-fold higher risk of developing type 2 diabetes than women who have been pregnant without diabetes, and may be at increased risk of developing type 1 diabetes.[4, 5] Five year incidence rates of type 2 diabetes of 18% to 50% have been reported in women with a history of gestational diabetes.[21] The best approach is for preventive measures to begin as soon as the mother can manage.

HbA_{1c} testing at three months postpartum or later is recommended

Clinicians should aim to assess the glycaemic status of all women who have had gestational diabetes. Research suggests that many women with a history of gestational diabetes in New Zealand are not subsequently tested.

Oral glucose tolerance testing at six weeks after birth has been, until recently, the recommended way to assess glycaemic status following gestational diabetes, and this is still recommended in many overseas' guidelines. However, the Ministry of Health guidelines now recommend using HbA_{1c} at three months after birth, with the possible addition of fasting blood glucose. It is hoped that this change will facilitate greater uptake of testing given that many patients find the oral glucose tolerance test inconvenient. This change also means that three month postnatal testing uses the same test as later annual monitoring, so that clinicians are better able to determine if glycaemic control has deteriorated.[4]

Annual testing thereafter using HbA_{1c} is recommended (Table 3). Opportunistic or scheduled patient appointments, such as seeing the clinician when they bring their infant for vaccinations, can be a good time to test the mother for diabetes, or clinicians can set up an electronic reminder to ensure HbA_{1c} testing is performed at appropriate intervals. Patient reminders such as a letter, email or text are likely to improve rates of postpartum testing for diabetes.[22]

Testing HbA_{1c} at three months postpartum has low sensitivity but high specificity for detecting type 2 diabetes in women who have had gestational diabetes compared to a 75 g oral glucose tolerance test. It is likely to detect those with the highest levels of glycaemia and most in need of treatment. Fasting blood glucose testing can also be performed at three months postpartum at the clinician's discretion, which increases the sensitivity of three month testing for detecting patients with type 2 diabetes.[4]

Table 3: Tests and appropriate follow-up at three months postpartum for women who have had gestational diabetes[4]

HbA_{1c} level (mmol/mol) at three months	Diagnosis or risk category	Patient care and testing
≥ 50 and with symptoms of diabetes	Diabetes*	Proceed to treat and follow-up as per diabetes guidelines
≥ 50 and asymptomatic	Possible diabetes*	Repeat testing with HbA_{1c} or fasting blood glucose
41 – 49	High risk of diabetes*	Provide diabetes prevention advice regarding diet and exercise measures. Metformin treatment may be considered. (see: "Patient and clinician actions that can prevent future diabetes") Re-test HbA_{1c} in six months and then annually thereafter
≤ 40	Medium risk of diabetes*	Annual HbA_{1c} testing

* In most cases this will be type 2 diabetes; occasionally patients with early stage type 1 diabetes or rarely monogenic diabetes (caused by single gene mutations) may be encountered.

Patient and clinician actions that can prevent future diabetes

Lifestyle measures are the cornerstone of preventing and treating type 2 diabetes and clinicians should encourage women with a previous history of gestational diabetes to adopt a diet and exercise regimen which can reduce their risk of future diabetes. In addition to lifestyle measures, other advice and treatments which clinicians can offer include:

Breastfeeding: Mothers who breastfeed usually lose more weight than mothers who do not, and various cohort and observational studies have found that mothers who have breastfed have reduced risks for a number of metabolic diseases across their lifetime, including obesity, diabetes, hypertension, hyperlipidaemia and cardiovascular disease.[23]

Metformin: Women with an HbA_{1c} of 41 – 49 mmol/mol who have not been successful in reducing their level of glycaemia with lifestyle measures could be offered metformin.[4] Data from the United States Diabetes Prevention Program study suggests a number needed to treat (NNT) of seven patients for ten years to prevent one case of type 2 diabetes.[24] Clinicians may wish to consult an endocrinologist or diabetes specialist when considering this treatment approach.

Research into gestational diabetes testing in New Zealand

The gestational diabetes mellitus study of detection thresholds (GEMS) study

Clinicians in any area of New Zealand may consider referring their pregnant patients to the GEMS study, currently being conducted by the Liggins Institute at the University of Auckland. This study aims to randomise pregnant females to undergo testing and treatment according to the New Zealand criteria for the diagnosis of gestational diabetes or the International Association of Diabetes and Pregnancy Study Group (IADPSG) criteria in order gather better evidence regarding which criteria produce the best outcomes for mother and child. The IADPSG recommend diagnosing gestational diabetes at lower cut-offs of oral glucose tolerance test results than the New Zealand guidelines.

For further information, see: **www.ligginstrials.org/GEMS** or email: **gems@auckland.ac.nz**

The "Pre-diabetes in pregnancy: can early intervention improve outcomes" (PINTO) trial

The aim of the PINTO trial is to examine whether blood glucose monitoring and initiating treatment for hyperglycaemia in women with HbA_{1c} levels between 41 – 49 mmol/mol in early pregnancy, can improve health outcomes compared with lifestyle advice and follow up gestational diabetes screening at 24 – 28 weeks' gestation. The first phase of the trial is a feasibility study which will inform the main randomised controlled trial.

Researchers will be recruiting women in the National Woman's Hospital (Auckland) or Christchurch Women's Hospital catchment areas from 1 October, 2015. General practitioners in these areas should refer women with an $HbA_{1c} \geq 41$mmol/mol directly to their local diabetes in pregnancy clinic as soon as possible, where dietary and weight gain advice, triage, and consent will take place. A mail out to general practitioners will take place prior to this date, to provide further information about the study.

It is hoped that this study will show that early intervention in this patient group, including blood glucose monitoring and optimisation of blood glucose levels through dietary measures and medicines as required, will reduce pre-eclampsia, neonatal morbidity and mortality without causing harm. It is also hoped that the study will reduce inequalities in health-related outcomes for Māori and Pacific women, who have high rates of pre-diabetes and are the least likely to take up conventional screening for gestational diabetes.

For further information about PINTO, contact Dr Ruth Hughes: **ruth.hughes@cdhb.health.nz**

ACKNOWLEDGEMENT: Thank you to **Professor Tim Cundy**, Endocrinologist, Auckland DHB and Professor of Medicine, University of Auckland and **Dr Cam Kyle,** Clinical Biochemist, Auckland for expert review of this article.

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