Primary care management of risk of type 2 diabetes in women with a history of gestational diabetes

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This dissertation is submitted for the degree of

Doctor of Philosophy

Declaration

This thesis is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the preface and specified in the text.

It is not substantially the same as any that I have submitted, or, is being concurrently submitted for a degree or diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the preface and specified in the text. I further state that no substantial part of my thesis has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the preface and specified in the text.

It does not exceed the prescribed word limit for the Clinical Medicine and Clinical Veterinary Medicine Degree Committee.

Summary

Primary care management of risk of type 2 diabetes in women with a history of gestational diabetes – *Rebecca Dennison*

Gestational diabetes (GD) is defined as diabetes with an onset or first diagnosis during pregnancy, and blood glucose returning to normal after delivery. It is one of the most common pregnancy conditions, and puts mother and baby at increased risk of pregnancy complications. After delivery, GD is associated with an increased risk of type 2 diabetes (T2D), which can lead to cardiovascular disease, renal disease, limb amputation and blindness. This thesis concerns reducing the risk of T2D in mothers with a history of GD.

Specifically, my thesis aims to inform strategies to improve care for mothers after a pregnancy affected by GD. I describe the incidence of T2D postpartum, and identify approaches to both increase uptake of diabetes screening after pregnancy and enable mothers to make behaviour changes to reduce T2D risk factors.

The first study is a literature review, meta-analysis and study-level meta-regression of the incidence of T2D after GD. I included 129 studies of 310,214 women with a history of GD. They were 8.3 (95% confidence interval 6.5 to 10.6) times more likely to develop T2D than women with normoglycaemic pregnancies. Overall 17.0% (15.1 to 19.0%) women developed T2D after GD, although there was significant heterogeneity. The relative percentage diagnosed with T2D was 12% (8 to 16%) higher for each additional year after pregnancy; a third developed T2D within 15 years. Development of T2D was significantly higher in non-White European populations compared to other populations, and in those with higher BMI at follow-up. These findings emphasise the need for both sustained follow-up after GD through screening and interventions to reduce modifiable risk factors for T2D.

Currently, screening for T2D is recommended at six to 13 weeks after a GD pregnancy, then subsequently at regular intervals. Historically, uptake of screening has been low. Through a review of medical records at Cambridge University Hospitals NHS Foundation Trust, in my

second study I identified that between October 2014 and March 2017 141/556 patients (25.4%) did not undergo a postpartum test. Women with lower parity and receiving insulin for GD were more likely to attend. To explore reasons for this in more depth, in a third study I conducted a qualitative systematic literature review and thematic synthesis of 16 studies. I found that (1) mothers' relationship with healthcare, such as the attitude of their clinicians, could conflict with or reinforce prioritisation of screening, (2) practical aspects of both the appointment and the glucose test itself affected the opportunity to attend, (3) family-related practicalities could act as barriers to attendance, and (4) level of concern regarding diagnosis of diabetes was a key factor affecting motivation to attend screening.

Despite the increased risk of T2D and associated complications, it is also known that many mothers find it challenging to maintain a healthy lifestyle after a GD pregnancy, and do not make changes to their diet or activity levels to reduce their risk. In my fourth study, a qualitative systematic literature review and thematic synthesis of 21 studies, I reported six themes that could act as barriers or facilitators to a healthy lifestyle in this population: (1) role as mother and priorities, (2) support from family and friends, (3) demands of life, (4) personal preferences and experiences, (5) diabetes risk perception and information, and (6) finances and resources.

Based on these two qualitative syntheses, I developed recommendations to promote screening attendance, healthy diet and physical activity. In my fifth study, I used qualitative interviews to elicit an evaluation of these suggestions from 20 mothers with a history of GD in Cambridgeshire and Peterborough, in addition to their own ideas for improving postpartum support (the DAiSIeS study). These mothers thought that additional advice about how to eat healthily and exercise when they were busy, and tips for sustaining these changes, would most help them to reduce their risk. Many wanted more specific information about their long term T2D risk, but they often knew enough about the universal benefits of a healthy lifestyle. Both the participants who had strategies to remember to book their annual diabetes test and those who were not aware that they were eligible for any postpartum test felt that being invited to attend by a clinician would facilitate screening, particularly if they could choose the location.

Collectively, these studies highlight that women with GD are an easily-identifiable group at high risk of T2D, and there is a need for interventions to manage this risk. In this thesis, I provide evidence to support and inform such interventions, which could include feasible adaptation to current practice, to improve care. Future research is needed to refine, test and evaluate these strategies.

Contents

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Dissemination

Publications resulting from my thesis

Dennison RA, Ward RJ, Griffin SJ, Usher-Smith JA. Women's views on lifestyle changes to reduce the risk of developing Type 2 diabetes after gestational diabetes: a systematic review, qualitative synthesis and recommendations for practice. Diabet Med. 2019;36(6):702–717.

Dennison RA, Fox RA, Ward RJ, Griffin SJ, Usher-Smith JA. Women's views on screening for Type 2 diabetes after gestational diabetes: a systematic review, qualitative synthesis and recommendations for increasing uptake. Diabet Med. 2020;37(1):29–43.

Dennison RA, Chen ES, Green ME, et al. The absolute and relative risk of type 2 diabetes after gestational diabetes: A systematic review and meta-analysis of 129 studies. Diabetes Res Clin Pr. 2020; doi: 10.1016/j.diabres.2020.108625.

Under review:

Dennison RA, Fox RA, Meek CL, Aiken CE, Usher-Smith JA, Griffin SJ. "Oh, I've got an appointment": A qualitative interview study exploring support for diabetes screening attendance after gestational diabetes.

Dennison RA, Fox RA, Meek CL, Aiken CE, Usher-Smith JA, Griffin SJ. "Post-GDM support would be really good for mothers": A qualitative interview study exploring support for healthy diet and exercise after gestational diabetes.

Conference posters and oral presentations

47th Annual Scientific Meeting of SAPC (Society for Academic Primary Care), 12 July 2018, London: Views of women with a history of gestational diabetes on lifestyle behaviour to reduce risk of developing type 2 diabetes: A systematic review and qualitative synthesis.

47th Annual Scientific Meeting of SAPC, 12 July 2018, London: Personal and general practice-related factors associated with postpartum glucose testing in women with a history of gestational diabetes.

School of Primary Care Research (SPCR) Showcase, 13 November 2018, London: Women's experiences of screening for type 2 diabetes after gestational diabetes and recommendations for increasing uptake: a systematic review and qualitative synthesis.

Cambridge Public Health Lecture, 21 October 2019, Cambridge: The incidence of type 2 diabetes after gestational diabetes: A systematic review and meta-analysis.

SPCR Showcase, 26 November 2019, London: The incidence of type 2 diabetes after gestational diabetes: A systematic review and meta-analysis in 280,000 affected women.

SAPC South East conference, 24 January 2020, Cambridge: The incidence of type 2 diabetes after gestational diabetes: A systematic review and meta-analysis in over 310,000 affected women. (Novice presenter winner.)

<u>Other publication contributions during my thesis</u>

Dennison RA, Feldman AL Usher-Smith JA, Griffin SJ. The association between psychosocial factors and change in lifestyle behaviour following lifestyle advice and information about cardiovascular disease risk. BMC Public Health. 2018;18(1):731.

Lachmann EH, Fox RA, **Dennison RA**, Usher-Smith JA, Meek CL, Aiken CE. Barriers to completing oral glucose tolerance testing in women at risk of gestational diabetes. Diabet Med. 2020;37(9):1482–1489.

Lithgow GE, Rossi J, Griffin SJ, Usher-Smith JA, **Dennison RA**. Barriers to postpartum diabetes screening: a qualitative synthesis of clinicians' views. Br J Gen Pract. 2021. doi: 10.3399/BJGP.2020.0928.

Abbreviations

ADA	American Diabetes Association
BMI	Body Mass Index
CASP	Critical Appraisal Skills Programme
CFIR	Consolidated Framework for Implementation Research
COREQ	COnsolidated criteria for REporting Qualitative Research
CI	(95%) Confidence Interval
CPRD	Clinical Practice Research Datalink
CVD	Cardiovascular Disease
DAiSIeS	Diet, Activity and Screening after gestational diabetes: an Interview Study
DPP	Diabetes Prevention Programme
FPG	Fasting Plasma Glucose
GD	Gestational Diabetes
GP	General Practitioner
GRADE-CERQual	Grading of Recommendations Assessment, Development and Evaluation-Confidence in Evidence from Reviews of Qualitative research
HAPO	Hyperglycemia and Adverse Pregnancy Outcome study
HbA_{1C}	Glycated haemoglobin
HIV	Human Immunodeficiency Virus
IADPSG	International Association of the Diabetes and Pregnancy Study Groups criteria
IDF	International Diabetes Federation
IFG	Impaired Fasting Glucose
IGT	Impaired Glucose Tolerance
IMD	Index of Multiple Deprivation
IQR	Interquartile range

LGA	Large for gestational age
MRC	Medical Research Council
NDDG	The National Diabetes Data Group
NHS	(UK) National Health Service
NICE	National Institute for Health and Care Excellence
OGTT	Oral Glucose Tolerance Test
QOF	Quality and Outcomes Framework
RCT	Randomised Controlled Trial
PALS	Patient Advice and Liaison Service
PPI	Patient and Public Involvement (and engagement)
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QOF	Quality and Outcomes Framework
T1D	Type 1 Diabetes
T2D	Type 2 Diabetes
THIN	The Health Improvement Network
VIP	Västerbotten Intervention Programme
WHO	World Health Organization

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Chapter 1 Introduction

I begin this thesis by introducing gestational diabetes, describing the epidemiology as well as diagnosis and management of the condition. Although the focus of my thesis is on postpartum management, Section 1.1 provides important context for understanding the condition itself, the magnitude of the problem as well as a brief understanding of the lived experience of gestational diabetes. I then focus on the long-term risk of type 2 diabetes after gestational diabetes, where I describe type 2 diabetes in Section 1.2 and current practices in diabetes risk management in Section 1.3.

1.1 Gestational diabetes

Gestational diabetes (GD) is defined as diabetes (hyperglycaemia or high blood glucose) that is diagnosed during the second or third trimester of pregnancy and that was not overt diabetes before pregnancy (1,2). Blood glucose control usually returns to normal after delivery, although this is not required for a diagnosis of GD (3). It was first observed in the late 1800s and later defined as 'gestational diabetes' in 1957 (4,5). Since then, the prevalence of GD has increased so that GD is considered by many as a significant public health challenge (6).

1.1.1 Pathophysiology of gestational diabetes

Hyperglycaemia is observed when the beta cells of the pancreas are unable to produce sufficient insulin to meet increased requirements during pregnancy (7). From mid-pregnancy until delivery, placental hormones, increasing maternal adiposity and changes in other organs lead to increasing resistance to insulin in the mother (summarised in Figure 1.1A) (8,9). During a normal pregnancy, pancreatic beta cells increase insulin secretion in order to compensate for insulin resistance. However, in GD, the pancreas is not able to meet this increased requirement

and hyperglycaemia is observed (10). Figure 1.1B illustrates this: insulin sensitivity is lower during the third trimester than postpartum despite insulin secretion being higher during the third trimester than postpartum, and both insulin secretion and insulin sensitivity are lower in a GD pregnancy compared to a pregnancy without GD.

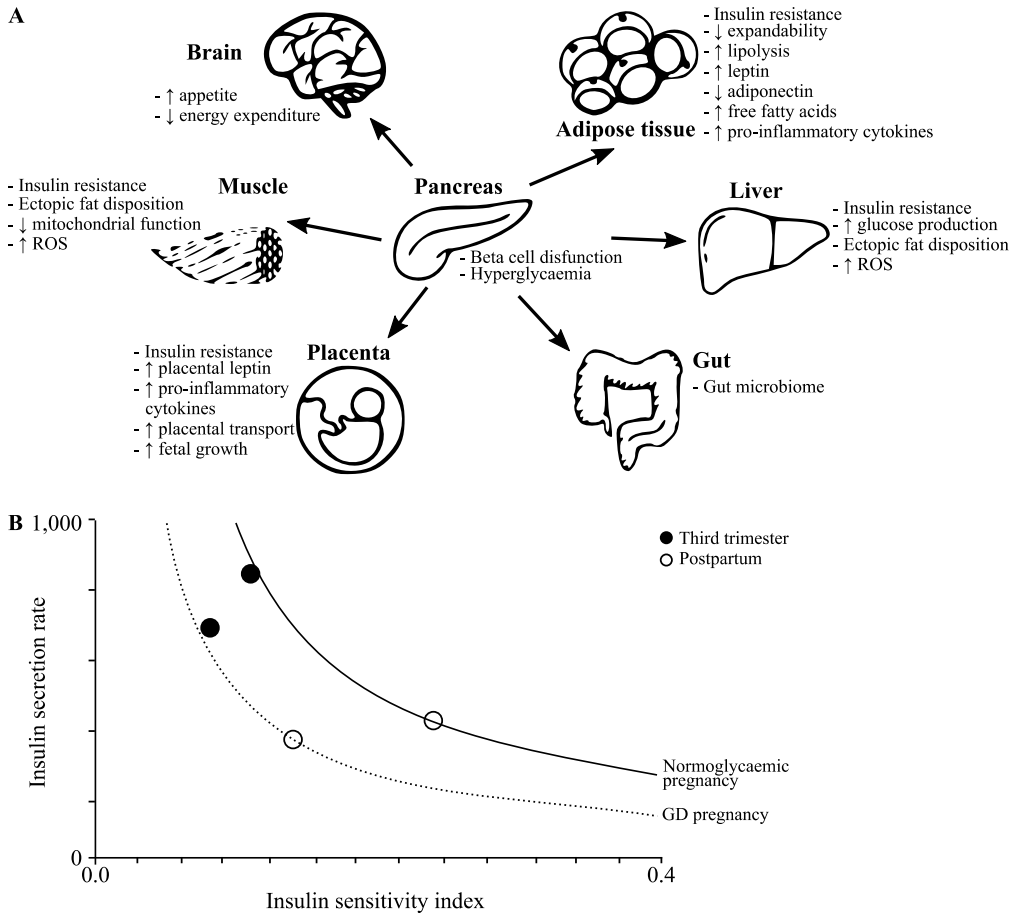


Figure 1.1: (A) Causes of insulin resistance in gestational diabetes and (B) the relationship between insulin sensitivity and insulin secretion in pregnant women affected and unaffected by gestational diabetes.

Reproduced from Plows et al. 2018 (Figure 3) (8) and Buchanan 2001 (Figure 3) (11).
ROS: Reactive oxygen species.

Different causes of insulin resistance have been suggested, but a distinction is not made between them in current practice. In 5 to 10% of cases, pancreatic beta cells are destroyed by the immune system similar to what happens in type 1 diabetes (T1D), and an even smaller proportion of cases are attributed to genetic mutations that affect the functioning of the pancreas and are first detected during pregnancy (9). Compared to autoimmune and monogenic GD, chronic insulin resistance, like type 2 diabetes (T2D) pathology, is by far the most prevalent form (9). Gestational diabetes insipidus is a very rare condition that is not related to

blood glucose control (12), therefore throughout this thesis I use the abbreviation 'GD' to refer to gestational diabetes mellitus.

GD is usually asymptomatic. Before diagnosis, affected women may experience increased thirst and tiredness, yet these symptoms are common during a healthy pregnancy. Consequently, GD is usually diagnosed through screening all pregnant women, those with risk factors or if hyperglycaemia is suspected due to accelerated fetal growth.

1.1.2 Diagnosis of gestational diabetes

GD is diagnosed using a blood test during pregnancy in women without pre-existing diabetes. However, which women are screened and the cut-offs used to define GD have changed over time and vary according to which guidelines are used.

An oral glucose tolerance test (OGTT) is usually used to diagnose GD. This requires collection of blood (plasma, serum or capillary/venous whole blood) after an overnight fast, followed by consumption of a glucose solution and blood collection at subsequent intervals. It is most common nowadays to use 75g glucose and three measurements (fasting plasma glucose [FPG], 1 hour and 2 hours) although 100g glucose and four measurements (FPG, 1 hour, 2 hours and 3 hours) were recommended previously. As described below, different glycaemic cut-offs have been defined such that a high result at one or more time points suggests a diagnosis of GD.

Early glycaemic cut-offs were based on higher-than-average results in an OGTT during pregnancy (specifically two standard deviations above mean values), which were then modified according to the risk for the mother developing T2D after pregnancy (13). Subsequently, the O'Sullivan and Mahan criteria, then the Carpenter and Coustan criteria and the National Diabetes Data Group (NDDG) criteria were developed in response to the change in laboratory practice from whole to plasma blood testing (13). Other parts of the world used different criteria to the US, and the World Health Organization (WHO) used the non-pregnant cut-offs for impaired glucose tolerance to define GD (13).

The most significant change in GD criteria came as a result of the multinational Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study published in 2008, which found a continuous relationship with no obvious threshold between the results of the 2 hour OGTT and adverse pregnancy outcomes (including macrosomia, neonatal hypoglycaemia and caesarean section) (14). The International Association of Diabetes In Pregnancy Study Groups (IADPSG)

therefore determined cut-offs associated with an odds ratio of adverse pregnancy outcomes of 1.75 (15). This was controversial because studies that use the IADPSG criteria consistently report a significantly higher GD prevalence than other studies (16), and may double or triple the prevalence of GD (17,18). This is associated with more women experiencing medicalisation of pregnancy and significant investment of resources, despite questionable benefits of GD treatment at that time (19). Furthermore, the trustworthiness of a single test result was discussed. Many but not all organisations have adopted or adapted these guidelines including the American Diabetes Association (ADA) and WHO (13,20). Table 1.1 shows the most frequently used guidelines and their different glycaemic cut-offs.

Table 1.1: Diagnostic criteria used for estimating gestational diabetes.

	Fasting		**1 hour**		**2 hours**		**3 hours**	
Criteria	mg/dl	mmol/l	mg/dl	mmol/l	mg/dl	mmol/l	mg/dl	mmol/l
Early								
O'Sullivan and Mahan (21)*	90	5.0	165	9.2	143	7.9	127	7.1
NDDG (22)	105	5.8	190	10.6	165	9.2	145	8.1
Carpenter and Coustan (23)	95	5.3	180	10.0	155	8.6	140	7.8
Current								
ADA/ACOG[iii] 2003 (3)	95	5.3	180[i]	10.0[i]	155	8.6	140	7.8
ADA/ACOG[iii] 2018 (1)	95	5.3	180[i]	10.0[i]	155	8.6	140	7.8
ADIPS 2014 (24)	92	5.1	180[i]	10.0[i]	153	8.5	-	-
DCCP[iv] 2018 (25)	95	5.3	-	10.6	-	9.0	-	-
DIPSI[v] 2014 (26)	-	-	-	-	140	7.8	-	-
EASD 1991 (27)	110[i]/126	6.1[i]/7.0			162[i]/180	9.0[i]/10.0		
FIGO 2015 (28)	92	5.1	180[i]	10.0[i]	153	8.5	-	-
WHO 1998 (29)	110[ii]/126	6.1[ii]/7.0	-	-	120[ii]/140	6.7[ii]/7.8	-	-
WHO 2013 (30)	92	5.1	180[i]	10.0[i]	153	8.5	-	-
IADPSG 2010 (24)	92	5.1	180[i]	10.0[i]	153	8.5	-	-
NICE 2015 (2)	-	5.6	-	-	-	7.8	-	-

Early guidelines reproduced from Coustan 2013, Table 1 (13). Current guidelines reproduced from International Diabetes Federation Diabetes Atlas, 9th Edition, 2019 (31).

ACOG: American College of Obstetricians and Gynaecologists; ADA: American Diabetes Association; ADIPS: Australasian Diabetes in Pregnancy Society; DCCP: Diabetes Canada Clinical Practice; DIPSI: Guidelines Diabetes in Pregnancy Society Group India; EASD: European Association for the Study of Diabetes; FIGO: International Federation of Gynaecology and Obstetrics; IADPSG: International Association of the Diabetes and Pregnancy Study Groups; NDDG: National Diabetes Data Group. NICE: National Institute for Health and Care Excellence; WHO: World Health Organization.

**Using venous whole blood.*
[i] There are no established criteria for the diagnosis of diabetes mellitus in pregnancy based on the 1-h post-load value.
[ii] Refers to whole blood glucose level.
[iii] Recommends either the IADPSG one-step or two-step approach; initial screening by measuring plasma or serum glucose concentration after 1 h 50g oral glucose load (GCT). Those exceeding the cut-off perform either a 100g OGTT or 75g OGTT, requiring two or more venous plasma concentrations to be met or exceed the threshold.
[iv] Listed is the preferred approach, the alternate approach is the IADPSG uses a non-fasting 75g OGTT.
[v] Uses a non-fasting 75g OGTT.

In light of the HAPO study, the National Institute for Healthcare and Clinical Excellence (NICE) updated the UK guidelines for GD diagnosis in 2015 (2). The cut-off for GD based on a FPG of 5.6 mmol/l is higher than that of the IADPSG criteria, whereas the 2 hour cut-off of 7.8 mmol/l is lower (Table 1.1). NICE considered the economic impact of diagnosing a higher percentage of pregnancies with GD as well as the findings of the HAPO study; a recent economic evaluation confirmed that the NICE guidelines are more cost-effective than the IADPSG criteria given the prevalence of these risk factors in the UK (32). This has also been controversial; one study found that 387 of 25,543 pregnancies examined would have been diagnosed with GD using the IADPSG criteria but not the NICE 2015 criteria, but more importantly that these pregnancies had a significantly higher risk of macrosomia (large for gestational age [LGA] baby), caesarean delivery and polyhydramnios compared to clearly non-GD pregnancies (33).

Further disparities remain across guidelines regarding whom to screen for GD, such as pregnant women with risk factors, those who fail a preliminary test, or everyone. NICE recommends screening with a 2 hour OGTT for GD in women with one or more of the following risk factors: BMI greater than 30 kg/m^2, previous LGA baby (weighing 4.5 kg or more), previous pregnancy affected by GD, family history of diabetes, and ethnicity with a high prevalence of diabetes (2). Screening usually takes place at 24 to 28 weeks gestation. Conversely, the ADA recommends either a single 2 hour OGTT (one-step strategy) or a non-fasting glucose challenge test followed by a 3 hour OGTT in those identified with hyperglycaemia initially (two-step strategy) (1). A recent Cochrane review suggested there is currently insufficient evidence (based on two studies) to compare the benefits of universal versus risk factor-based screening based on outcomes for mothers and babies (34).

The changing diagnostic criteria and outstanding controversy mean that trends in GD prevalence are unclear. Increasing sensitivity of the definition of GD (lower glycaemic cut-offs) as well as in increase in risk factors and changes to screening protocols over time has contributed (31). This adds complication to longitudinal research into GD. I have taken the pragmatic approach of considering GD by any definition throughout this thesis; that is, any woman who has been treated and managed as having GD in her pregnancy.

1.1.3 Prevalence of gestational diabetes

GD is one of the most common disorders of pregnancy, although a wide range of prevalence estimates have been reported. This is partly explained by differing diagnostic protocols, as discussed above, in addition to increasing risk factors that mean that the 'true' prevalence of GD is increasing.

Across the world, an estimated 17.8 million live births were affected by GD in 2015 (35). According to a systematic review of GD prevalence (shown in Figure 1.2, including 77 studies from 36 countries), it is clear that estimates vary within and between regions and countries (36). The Middle East and North Africa have the highest prevalence at a median 12.9% of pregnancies affected (range 8.4 to 24.5%) and Europe had the lowest prevalence at 5.8% (range 1.8 to 22.3%). More recent systematic reviews have estimated similar prevalences in more precisely-defined regions, such as 9% in sub-Saharan Africa (95% confidence interval [CI] 7 to 12%) (37), 10.1% in Eastern and South-Eastern Asia (95% CI 6.5% to 15.7%) (37), and 11.7% in the Eastern Mediterranean region (95% CI 10.7 to 12.6%) (38).

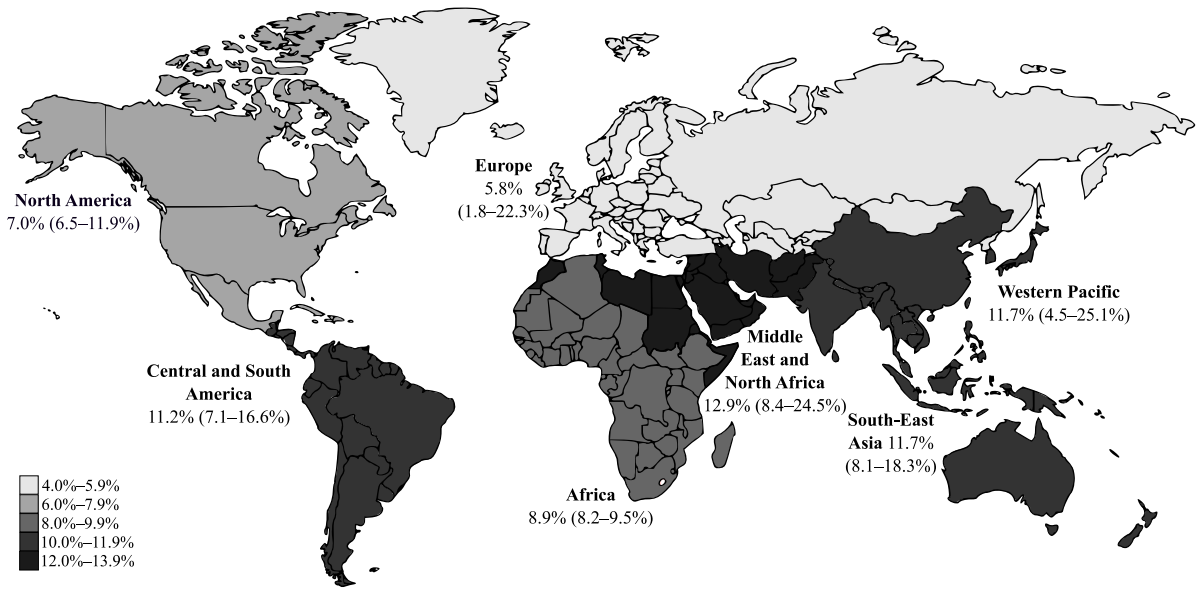


Figure 1.2: Estimates of the prevalence of gestational diabetes by World Health Organization region, 2005 to 2015.

Median prevalence and interquartile range are reported. Reproduced from Zhu and Zhang 2016, Figure 1 (36).

In the UK in 2015, NICE reported that approximately 4% of pregnancies were affected by GD: of the estimated 700,000 pregnancies in England and Wales each year, 5% were affected by diabetes, of which 88% was GD (2). A range from 1.1% prevalence (95% CI 0.9 to 1.3, using

the WHO 1980 criteria in a cohort of 12,005 White European and Asian participants receiving routine pregnancy care in Leicester, 1980s) (39) to 24.3% prevalence (95% CI 22.6 to 26.0, using the more sensitive IADPSG criteria in a cohort of 2,376 participants taking part in a study in Manchester, 2000 to 2006) (40,41) have been reported. The prevalence of GD in women accessing maternity care at the Rosie Hospital in Cambridge in 2018 and 2019 was 10.0% (of 1,906 women tested) (42).

The prevalence of GD continues to rise as a consequence of increasing levels of obesity, sedentary lifestyles and poor quality diet (31,43). Comparisons between studies are challenging for a number of reasons: changing or poorly recorded screening strategies (screening of pregnant women has increased in recent years), diagnostic cut-offs (which have been increasing in sensitivity) and assessment of whether GD was in fact pre-existing, undiagnosed T2D (43). Screening more women and using more sensitive diagnostic criteria leads to more GD diagnoses. Nevertheless, increases in prevalence are consistently observed in individual longitudinal studies with more consistent testing protocols.

For example, the Northern California Kaiser Permanente study reported the age- and ethnicity-adjusted yearly prevalence of GD as 3.7% in 1991 and 6.6% in 1997, remaining at 6.2% in 2000; an increase of 68% (total 14,175 pregnancies) (44). This study used laboratory glucose results in order to apply consistent GD diagnostic criteria and assessed changes in screening practices. Prevalence also increased in one study in South Australia from 1988 to 1999 by 72% in non-Aboriginal women and 12% in Aboriginal women (although the diagnostic criteria changed during this period) (45). Using a medical database, the Colorado Kaiser Permanente study reported that GD prevalence nearly doubled between 1994 and 2002 (total 36,403 pregnancies) (46).

Approximately half of women with GD have GD again in a subsequent pregnancy (95% CI 41 to 54%; based on a random-effects meta-analysis including 18 studies and 19,053 participants) (47). Perhaps unexpectedly, this reoccurrence rate is notably lower in women of non-Hispanic White ethnicity and primiparous women (47). These findings may reflect the GD risk factors and the cumulative effect of GD pregnancy on insulin resistance.

1.1.4 Risk factors for gestational diabetes

Modifiable and non-modifiable risk factors for GD reflect those for T2D (Section 1.2.3) and include ethnicity, advanced maternal age, elevated body mass index (BMI), and a family history of diabetes (48). Overweight and obesity has recently been found to be most strongly associated with GD (49), and are considered to be important before pregnancy as well as during it due to the impact on insulin resistance (50). The risk factors interact, such that age and BMI are particularly important in women of non-White European ethnicity (51). In the absence of risk factors, the incidence of GD is low (48).

Ethnicity has long been recognised to be associated with risk of GD. In 1992 in the UK, Indian women were found to have a relative risk of GD of 11.3 (95% CI 6.8 to 18.8) compared to White European women; in South East Asian women this risk was 7.6 (95% CI 4.1 to 14.1) and in Black women it was 3.1 (95% CI 1.8 to 5.5) (52). These associations have been observed consistently and are independent of other risk factors and particularly BMI (53–55).

Higher BMI is associated with higher prevalence of GD (Figure 1.3A) (56). A meta-analysis reported that overweight women had over double the odds of a GD diagnosis: compared to women with a normal BMI, the unadjusted odds ratios were 2.1 for overweight women (95% CI 1.8 to 2.5), 3.6 for obese women (95% CI 3.1 to 4.2), and 8.6 (95% CI 5.1 to 16.0) for severely obese women (57). It has been suggested that half of the cases of GD could be prevented if all pregnant women were of normal weight (55,56).

Similarly, increasing maternal age is associated with significantly higher GD risk (Figure 1.3B) (58). One meta-analysis reported an adjusted relative risk of 10.9 (95% CI 7.7 to 15.3) for women aged 35 to 39 years, and 15.9 (95% CI 10.6 to 23.8) for women over 40 years compared to 20 to 24 year olds (58). Although the risk is higher with increasing age, the highest number of cases is still contributed by younger women due to the greater numbers of pregnancies among younger women (59).

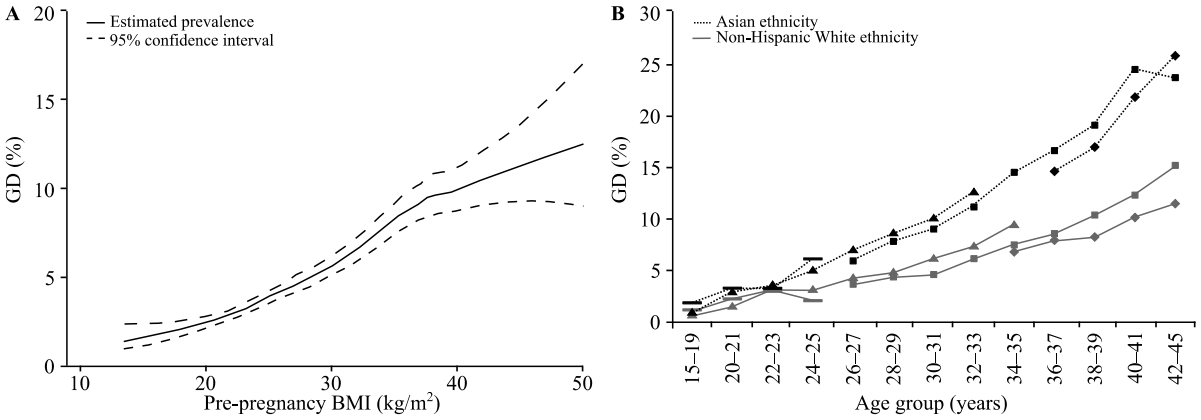


Figure 1.3: Prevalence of gestational diabetes according to (A) mothers' pre-pregnancy BMI and (B) age category.

(A) Pregnancy Risk Assessment Monitoring System, 7 US states, 2004–2006. Reproduced from Kim et al. 2010, Figure 1 (56).

(B) Northern California Kaiser Permanente, 1991–2000. Birth cohort years: ♦: 1946–1955, ▪: 1956–1965, ▲: 1966–1975, —: 1976–1985. Grey line: non-Hispanic White (n=136,673), black line: Asian (N=40,493). African American and Hispanic ethnicities are also reported in the paper. Reproduced from Ferrara 2007, Figure 2 (43).

More recently, lifestyle GD risk factors have been investigated, although many of these studies have methodological limitations such as the error and bias associated with self-reported lifestyle measures (50,60). The Nurses' Health Study II found that a diet high in fruit, green leafy vegetables, poultry and fish was associated with lower GD risk than a diet that was high in red and processed meat, refined grains, fast food and sweets (61). Similarly, higher fat intake and lower carbohydrate, vitamin C and vitamin D intake during pregnancy have also been associated with increased risk of GD (62,63). Physical activity increases insulin sensitivity to protect against T2D in the general population (64). The women who were most active before pregnancy had up to half the likelihood of developing GD compared to women who were least active; the association is weaker for exercise performed during pregnancy (50,60,65).

In addition, some studies have reported associations, albeit less convincingly or consistently, between GD and maternal birth weight, parity, smoking during pregnancy, socioeconomic status, stature, and weight gain during pregnancy (66).

1.1.5 Management of gestational diabetes during pregnancy

Once diagnosed with GD, a pregnant woman is closely managed with the aim of reducing glycaemia and therefore minimising the consequences of hyperglycaemia, particularly with

regards to the baby's growth (13,67). This involves blood glucose monitoring, diet and exercise, and sometimes insulin and metformin medication. They are also invited to additional monitoring such as of fetal growth and gestational weight gain (2).

Women are required to test their own capillary blood glucose, usually four times a day, and should aim for a fasting reading of less than 5.3 mmol/l taken first thing in the morning and 7.8 mmol/l or 6.4 mmol/l one or two hours after a meal (2). A major benefit of self-monitoring is the opportunity to record blood glucose levels during the normal daily life and routine, rather than on one unrepresentative day when the woman needs to attend the laboratory (13).

Diet has been described as the 'cornerstone of management of a GD pregnancy', aiming to balance blood glucose control, weight gain and avoid ketones in the urine (68). Compared to usual diet, a modified diet has been associated with improved glycaemic control and lower medication requirements (69). Again, there is controversy over recommended calorie intake and composition: more recent studies suggest that although the traditional approach of reducing total calorie intake can be effective, more careful macronutrient control through complex carbohydrates and low fat can improve blood glucose control in a more acceptable and manageable way (70,71). Exercise during GD is also recommended to improve glycaemic control and general wellbeing, although there is no clear evidence for improvements in pregnancy outcomes (72). In the UK, all women with GD are referred to a dietician where they are advised to eat a healthy, low glycaemic index diet and to exercise regularly (walking for 30 minutes after a meal to improve blood glucose control is suggested in the NICE guidelines) (2).

If women are not able to achieve the blood glucose targets through diet and exercise within a couple of weeks of diagnosis, they are offered metformin and then insulin if this does not lead to sufficient improvement in accordance with the NICE guidelines (2). Metformin is an oral antidiabetic agent, making it much more acceptable than insulin, which needs to be injected. Metformin has been reported to be effective for glycaemic control and safe (with the exception of an association with preterm delivery) (73,74). However, the authors of these recent systematic reviews highlighted that many women go on to require treatment with insulin (half of the population in one of the largest trials (75)), plus that large randomised controlled trials (RCTs) with long-term follow-up of children as well as mothers are required to understand the long-term implications (73,74). Other pharmacological agents such as sulfonylureas (e.g.

glibenclamide/glyburide) and alpha-glucosidase inhibitors (e.g. acarbose) may also be used during pregnancy (13).

1.1.6 Experience of gestational diabetes

The experience of GD is frequently described as distressing and lonely (76–78). Affected women report moving from a healthy pregnancy to being under specialist care very quickly, and have a short window of time to try to control blood glucose by diet before some move onto medication (79). These feelings are often stronger in populations with low health literacy and language barriers, and if following the recommendations is challenging to their cultural norms (80,81).

Many women feel initial shock and fear at a GD diagnosis, particularly if they lose their identity as someone who was healthy and low risk before pregnancy (76,79,81–85). Initially, they might deny their own test result or question the trustworthiness of the definition of GD due to the variation in testing protocols (83). Women with GD sometimes blame themselves for the diagnosis, and feel stigmatised if they are overweight (84). Most are anxious about the health of their baby, and worry that GD will harm them (77,78).

Most women, at least those who participate in qualitative research, learn the GD blood glucose targets and are diligent in their attempts to achieve them (85). Measurements that fall above their targets can cause them to feel as though they are failing despite their best efforts, leading to feelings of desperation (84). Healthcare providers monitor them closely, which is both reassuring and restrictive (84). In particular, the clinicians' focus on quantitative measurements (e.g. blood glucose measurements and weight gain) can contribute towards feeling out of control and that their ability as a mother is determined by their blood glucose level (78,82). One participant and her husband felt that "*it's not your child, it's their [the hospital's] child!*" (84). Support, both in education from the doctors and social support at home, are vital (76,81,86).

Attempting to control their blood glucose by diet and exercise leads many women to learn a lot about nutrition, although many struggle with hunger and feeling like they cannot eat 'anything', particularly at the beginning (85). The strict diet can be perceived as counterintuitive to the nutritional needs of a growing baby (81), yet many women follow it closely to avoid medication, particularly insulin, which would add to the medicalisation of pregnancy and

burden of GD (79,85). Others find that medication brings relief and reduces the pressure that they feel (79). Other women report a sense of empowerment to take control of their health for the sake of their baby, wider family and themselves (77,78).

These attitudes tend to continue and affect behaviour in the postpartum period, as described later in this thesis. For instance, mothers may feel guilty for having had GD so that they need to 'make it up' to their child, and some women who recognise their risk of developing T2D in the future are more likely to intend to make lifestyle changes (77,78,87).

1.1.7 Consequences of gestational diabetes

In the short term, GD doubles the risk of several adverse pregnancy outcomes for both mother and baby (15). The higher the levels of hyperglycaemia, the greater the associated risks, hence management is vital (88). Both are at long-term risk of future obesity, glucose intolerance and development of T2D (89,90). Again, the HAPO study has been key in understanding the consequences of GD.

During pregnancy, GD has similar implications for the fetus as pre-existing T2D or T1D due to higher glucose levels being transferred across the placenta (13). The fetus responds by making more insulin, which increases their rate of growth and leads to macrosomia (15). In turn, they are at higher risk of delivery injuries such as shoulder dystocia, or problems associated with prematurity if they are induced (15). Immediately after delivery, the baby is monitored for neonatal hypoglycaemia because they are no longer exposed to high blood glucose from the mother but have not yet reduced their own insulin production.

In order to avoid the risks associated with delivering a large baby, GD is associated with higher likelihood of caesarean delivery (91). In addition, there is a higher risk of gestational hypertension, preeclampsia, and eclampsia in mothers with GD (92).

The long-term increased risk of cardiometabolic disease in children after pregnancy is considered to be due to a combination of genetic susceptibility and the *in utero* environment, plus further modulation by the postnatal environment (88,93). For example, offspring of mothers with GD have a 1.4 to 2.3-times higher risk of becoming overweight and 1.5 to 3.6-times higher risk of becoming obese, and consistently higher risk of glucose intolerance conditions (94). Similarly, the HAPO study showed continuous associations between the degree of maternal hyperglycaemia and offspring outcomes in adolescence (95,96).

It has long been recognised that mothers affected by GD are at higher risk of metabolic syndrome themselves, which may be because GD is a physiological test that identifies those with increased risk. Recently, this has been estimated to be a four-fold higher risk (95% CI 3.0 to 5.3) (97). In particular, mothers' risk of future diabetes has been a focus, as discussed below; GD has been described as the single most important risk factor for the development of T2D (36,98,99). They also have a higher risk of cardiovascular disease (CVD), independent of progression to T2D and in the first ten years after pregnancy (100).

1.2 Type 2 diabetes

T2D is hyperglycaemia caused by chronic insulin resistance, whereby the body cannot effectively use insulin and, over time, pancreatic beta cells cannot meet these increased requirements (31,101). As described below, it is the most common form of diabetes and prevalence is increasing. Although the causes of T2D are not fully understood, there is a strong association between T2D and environmental or lifestyle risk factors (specifically overweight and older age) as well as genetic predisposition (such as that indicated by family history and ethnicity). In 2007, the United Nations General Assembly declared diabetes to be an international public health issue and designated World Diabetes Day to promote awareness (Resolution 61/225).

Impaired glucose tolerance (IGT) and impaired fasting glucose (IFG) are also hyperglycaemia, but that which is below the diagnostic threshold for T2D. These conditions are clinically important because they indicate individuals at high risk of progressing to T2D and who are beginning to experience the consequences of hyperglycaemia (described in Section 1.2.5). As a result, interventions to reduce blood glucose in those with IGT and/or IFG are important.

T1D results from autoimmune destruction of pancreatic beta cells, causing inadequate or no insulin to be produced (31). Because GD is primarily associated with increased risk of T2D, I will focus on T2D herein this thesis.

1.2.1 Diagnosis of type 2 diabetes

Currently in the UK, T2D is usually diagnosed by a glycated haemoglobin (HbA_{1c}) of 48 mmol/mol (6.5%) or more (102). Like for GD diagnosis, this threshold is based on the linear

risk of microvascular complications and has changed over time. In patients with symptoms (specifically thirst, polyuria, blurred vision, weight loss, recurrent infections, and tiredness), one elevated HbA_{1c} measurement is considered diagnostic, whereas those without symptoms should have a second test. In people for whom HbA_{1c} testing is inappropriate, a FPG test with a cut-off of 7.0 mmol/l or greater is used. This includes pregnant women, those who are acutely ill or have conditions such as acute pancreatic damage, chronic kidney disease and human immunodeficiency virus (HIV) infection; an HbA_{1c} result should be interpreted with caution in those with abnormal haemoglobin or red blood cells.

Previously, the OGTT was used to diagnose T2D. However, HbA_{1c} is now recommended by the WHO in light of 'moderate' quality systematic review evidence (103), which informed the NICE guidelines (102). It has a comparable sensitivity and specificity to FPG and OGTT tests for predicting diabetic retinopathy in different populations, in addition to the advantages of a reduced burden on the patient (no need to fast, take a glucose solution or wait for two hours), irrelevant day-to-day variability of blood glucose values (e.g. caused by stress or illness) because glycaemia over eight to 12 weeks is assessed, and fewer pre-analytical concerns (e.g. time to analysis). However, HbA_{1c} testing is less easily available or analysis is less standardised in some regions, it is associated with a greater cost, and it is not suitable in some individuals (as reported above) (1,102–104). Because the HbA_{1c} test measures glycaemia in the previous eight to 12 weeks, it is not appropriate for use in diagnosing GD or T2D immediately after GD.

1.2.2 Prevalence of type 2 diabetes

The International Diabetes Federation (IDF) estimated that there were 352 million adults with diagnosed or undiagnosed diabetes worldwide in 2019 (31). Figure 1.4 shows the age-adjusted prevalence of T2D, indicating a similar distribution to GD prevalence due to the shared distribution in risk factors. Asia has been described as the 'diabetes epicentre' of the world (105), with 9.1% of adults in China with T2D in 2000 to 2014 (106) and a range in prevalence from 1.9% to 25.2% in India in studies published from 1994 to 2018 (107).

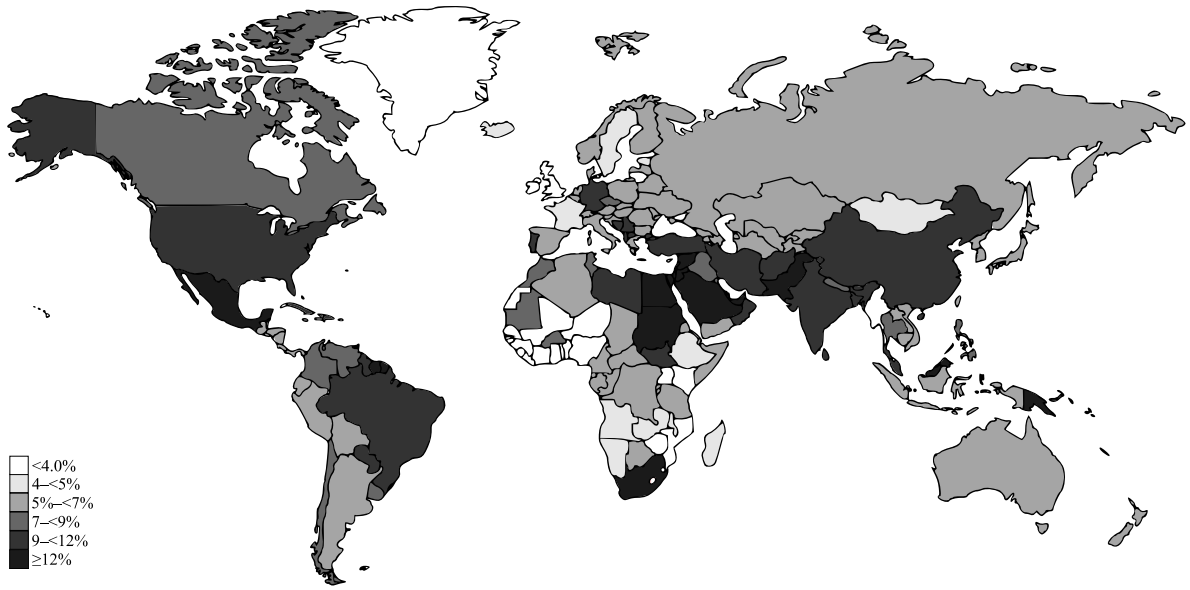


Figure 1.4: Estimates of the age-adjusted prevalence of type 2 diabetes in adults (aged 20 to 79 years) in 2019. *Reproduced from International Diabetes Federation Diabetes Atlas, 9th edition, 2019), Map 3.2 (31).*

The total number of people affected by diabetes more than doubled between 1980 and 2008, and is projected to increase by 130 million affected people in the next 25 years (to 486 million people with diabetes in 2045) (31,108). Prevalence in middle-income countries is estimated to increase the most. This is attributed to an ageing population and improved survival of patients with diabetes, but also the rise in obesity and sedentary lifestyles. Of particular concern is the increase in T2D in young adults and children due to the longer duration they will have the disease for (105), including women with GD who may progress to T2D relatively early.

NICE reported a prevalence of T2D of 6% in adults in England in 2013 (101), doubling the estimate from 2000 (109). Crude prevalence was higher in Asian (7.7%, 95% CI 7.5 to 7.9) and Black (5.6%, 95% CI 5.4 to 5.8) ethnic groups compared to White (5.0%, 95% CI 5.0 to 5.1) and Mixed/Other ethnic groups (3.4%, 95% CI 3.2 to 3.7) (110).

1.2.3 Risk factors for type 2 diabetes

A range of modifiable and non-modifiable risk factors for T2D have been reported. Due to the shared pathophysiology (Section 1.1.1), there is significant overlap with the risk factors for GD. The most important factors are reported in Table 1.2.

Table 1.2: Modifiable and non-modifiable risk factors for type 2 diabetes.

Modifiable risk factors	Non-modifiable risk factors
• Overweight or obesity • Physical inactivity • Sedentary behaviour • Dietary factors • Smoking • Previously identified IGT and/or IFG • Abnormal lipid levels • Hypertension • Inflammation • Intrauterine environment	• Age • Sex • Ethnicity (African, African-Caribbean and South Asian ethnicity in particular) • Family history of T2D • History of GD • Polycystic ovary syndrome

Adapted from Chen et al. 2012, Box 1 (105).

IFG: impaired fasting glucose; IGT: impaired glucose tolerance.

A study based on the Finnish population modelled that 82% (95% CI 70 to 90%) of diabetes cases were attributable to failure to observe a low-risk lifestyle (there defined as BMI less than 25 kg/m^2, 'adequate' exercise, 'moderate' alcohol consumption, non-smoking, and a 'satisfactory' vitamin D level) (111). Overweight and obesity was the most important risk factor with a relative risk of 5.9 (95% CI 3.5 to 9.8) (111). Similarly, a study in a Chinese population reported that 73% of incident diabetes cases were attributable to BMI, waist-to-hip ratio, diet and physical activity (112).

Importantly, maintaining a low-risk lifestyle is challenging in the present obesogenic environment, where 'the surroundings, opportunities, or conditions of life' cumulatively promote obesity (113). Those with low socioeconomic status and high deprivation face particularly obesogenic environments.

1.2.4 Management of type 2 diabetes

Management of T2D is principally undertaken in primary care, where education, screening for complications and interventions to reduce the risk of complications can occur regularly. As in T2D prevention, promotion of a healthy lifestyle is of primary importance (31). In particular, this includes a healthy diet, regular physical activity, smoking cessation and maintenance of a healthy weight. As part of individualised patient education about T2D, NICE recommends a focus on dietary advice, physical activity and weight loss of 5 to 10% of initial body weight in those who are overweight (101).

NICE also suggest a long-term target HbA_{1c} of 48 mmol/mol (6.5%), measured at up to six-monthly intervals (101). If HbA_{1c} rises to 58 mmol/mol (7.5%) or higher, metformin may be initiated or drug treatment intensified. Current NICE guidelines emphasise that these targets should be implemented on a case-by-case basis, such that a frail patient may have less stringently-controlled T2D (corresponding to higher glycaemic cut-offs) in order to avoid overtreatment, for example.

1.2.5 Consequences of type 2 diabetes

T2D is associated with a range of health implications, and a 15% increased risk of all-cause mortality (114). Hyperglycaemia affects the microvascular and macrovascular systems, increasing cardiovascular risk and reducing quality of life and life expectancy (101). Microvascular complications include retinopathy, nephropathy, neuropathy and gum or foot problems that can lead to amputation. Macrovascular complications include a wide range of CVDs.

One large collaboration suggested that diabetes independently doubled the risk of CVD (115). CVD was found to affect a third of people with T2D, and accounted for half of observed deaths recorded in cohorts studies (116). Furthermore, FPG level was non-linearly associated with cardiovascular outcomes, even at non-diabetic levels (115).

Management of T2D and its complications are associated with a significant economic cost. The highest proportion of healthcare spending has been attributed to diabetes (in the US), with an estimated worldwide cost of US$1.3 trillion in 2015 (117,118). NICE estimated that at least 5% of UK healthcare expenditure is spent on diabetes, and up to 10% of expenditure in the National Health Service (NHS) (101).

1.2.6 Risk of type 2 diabetes after gestational diabetes

Although maternal glucose control usually returns to normal after delivery, GD has been described as the single most important risk factor for the development of T2D in the future in this population (36,98,99,119).

As early as 1991, O'Sullivan published a review reporting that 6 to 62% women were diagnosed with T2D up to 28 years after GD, although almost no consistency in diagnostic criteria was reported at that time (120). In an influential systematic review by Kim *et al.*

published ten years later, incidence of T2D ranged from 2.6% at six weeks after GD to over 70% up to 28 years postpartum (99). Of note, this study reported that women of different ethnicities progressed to T2D at similar rates, and that that risk was highest during the first five years after a GD-affected pregnancy. This justified interventions that focused on the early postpartum period. More recently, Vounzoulaki *et al.* conversely reported that cumulative incidence of T2D increased steadily over time (121). In addition, there were non-significant differences in cumulative incidence across ethnicities: 16.5% (95% CI 16.2 to 16.8%) in mixed ethnicity populations, 15.6% (95% CI 13.3 to 17.9%) in non-White populations and 9.9 (95% CI 9.4% to 10.4%) in White populations. Both Kim *et al.* and Vounzoulaki *et al.* included twenty studies, giving low power to describe how progression to T2D varies according to co-variates such as ethnicity with statistical significance.

Relative risk of T2D after GD has been reported by several studies, suggesting that women with GD may have an up to ten-times higher T2D risk than women who did not have diabetes in pregnancy:

- Bellamy *et al.* 2009 reported a relative risk of 7.4 (95% CI 4.8 to 11.5) (98);
- Song *et al.* 2018 reported a relative risk of 7.8 (95% CI 5.1 to 11.8) (122);
- Benhalima *et al.* 2019 reported a relative risk of 7.4 (95% CI 6.0 to 9.2) (123);
- Vounzoulaki *et al.* 2020 reported a relative risk of 9.5 (95% CI 7.1 to 12.7) (121).

I describe these reviews in more detail in Chapter 4.

Maternal and pregnancy factors such as elevated BMI, multiparity, poorer pregnancy glucose tolerance, use of insulin during the pregnancy, and earlier gestational age at GD diagnosis have been suggested to further increase this risk of T2D after GD (124–126). Another meta-analysis suggested that pregnancy glucose tolerance (including OGTT results, HbA_{1c} results and use of insulin during pregnancy) and BMI are associated with the highest relative risks of T2D; for example, BMI greater than 25 kg/m^2 had a relative risk of 3.2 (95% CI 2.0 to 5.2; five studies and 4,795 women with GD) and use of insulin during pregnancy had a relative risk of 3.7 (95% CI 2.8 to 4.8; 24 studies and 7,723 women with GD) (126).

1.3 Management of type 2 diabetes risk after gestational diabetes

After the baby is born, glucose levels return to normal in the majority of affected women. However, because of the heightened risk of developing diabetes in the future, screening for glucose intolerance and behaviour change to manage risk factors are recommended.

1.3.1 Postpartum diabetes screening

After delivery, guidelines recommend that women have an OGTT, FPG test or HbA_{1c} test to identify glucose intolerance. This should take place soon after delivery, and at regular intervals going forward. Although it is improving in many settings, uptake of the test has been poor.

Postpartum screening is referred to by different terms including glucose or glycaemic testing, or by the names of the test. Throughout this thesis, I will refer to this practice as diabetes screening.

1.3.1.1 Rationale

Postpartum diabetes screening is recommended in order to detect glucose intolerance and diabetes earlier than would occur by only testing those who become symptomatic. As a result, management through lifestyle changes or medication can begin sooner, decreasing exposure to hyperglycaemia.

Although the overall benefits of screening for diabetes in the general population are unclear (127), diabetes screening and cardiovascular risk assessment has been associated with reduced risk of longer-term complications and all-cause mortality, although effective intervention is key (128). However, there have been no comparable studies in women with recent GD, who tend to be much younger than other high-risk populations. Long-term studies are yet to compare the benefits of different screening strategies, although OGTTs every three years were suggested to be most cost-effective in the US (129,130).

1.3.1.2 Guidelines

National and international guidelines recommend that pregnant women are screened for glucose abnormalities at around six weeks postpartum to exclude persisting diabetes (1,2).

They should subsequently be screened at regular intervals, in order to monitor glucose levels and to identify those at highest risk of progressing to diabetes (1,2).

There is currently little agreement between diabetes screening guidelines. As shown in Table 1.3, the guidelines vary according to which test to use, when it should be performed, T2D criteria (not reported), and whether subsequent testing is specifically recommended. This variability has been found to have a greater impact on diagnosis of glucose intolerance disorders (IGT and IFG) than on diagnosis of T2D directly (131).

Table 1.3: Diabetes screening guidelines after a pregnancy affected by gestational diabetes.

	First postpartum test		Subsequent testing	
Criteria	**Timeframe**	**Test**	**Timeframe**	**Test**
NICE 2015 (2)	6 to 13 weeks postpartum	FPG (75g 2 hour OGTT not recommended)	If normal, annually	HbA_{1c} (13 weeks postpartum and on) (75g 2 hour OGTT not recommended)
ADA 2018 (1)	4 to 12 weeks postpartum	75g 2 hour OGTT (HbA_{1c} not recommended at 4 to 12 weeks postpartum)	If normal, every 1 to 3 years (depending on risk factors)	Ongoing evaluation with HbA_{1c}, FPG or 75g 2 hour OGTT
ACOG 2018 (132)	4 to 12 weeks postpartum	FPG or 75g 2 hour OGTT	If normal, every 1 to 3 years; if IFG/IGT, annually	FPG or 75g 2 hour OGTT
5th IWCGDM 2007 (133)	6 to 12 weeks postpartum	75g 2 hour OGTT	NR	NR
CDA 2018 (25)	6 weeks to 6 months postpartum	75g 2 hour OGTT	NR	NR
RACGP 2016 (134)	6 to 12 weeks postpartum	75g 2 hour OGTT	Every 3 years	FPG or HbA_{1c}
ADIPS 2014 (24)	6 to 12 weeks postpartum	75g 2 hour OGTT	NR	NR

Adapted from Vounzoulaki et al. 2020, Table 1 (135).

ACOG: American College of Obstetricians and Gynaecologists; ADA: American Diabetes Association; ADIPS: Australasian Diabetes in Pregnancy Society; CDA: Canadian Diabetes Assicociation; IWCGDM: International Workshop-Conference on Gestational Diabetes Mellitus; NICE: National Institute for Health and Care Excellence; RACGP: Royal Australian College of General Practitioners.

FPG: fasting plasma glucose; OGTT: oral glucose tolerance test; NR: not reported.

In 2015, NICE advised that women in the UK should be screened using FPG at six to 13 weeks postpartum followed by annual HbA_{1c} testing, and not routinely offered the OGTT (2). Annual testing usually occurs in general practice, while the first postpartum test may occur at the hospital or in general practice. NICE based these recommendations on 51 studies that reported the incidence of T2D after GD at different postpartum time points in order to estimate the

screening interval that would most effectively identify those at highest risk of developing diabetes. However, all of these studies were found to be very low quality. The incidence of T2D after GD and optimal intervals for screening are therefore uncertain.

Furthermore, NICE outlined the following classification for T2D risk (2):

- FPG less than 6.0 mmol/l or HbA_{1c} less than 39 mmol/mol (5.7%) suggests a moderate risk of T2D;
- FPG 6.0 to 6.9 mmol/l or HbA_{1c} 39 to 47 mmol/mol (5.7 to 6.4%) suggests a high risk of T2D;
- FPG more than 7.0 mmol/l or HbA_{1c} more than 48 mmol/mol (6.5%) indicates that they are likely to have T2D and should be referred for T2D care (if based on FPG, they are offered a further test to confirm the diagnosis).

1.3.1.3 Comparison of tests used

The 75g 2 hour OGTT consistently diagnoses more cases of T2D than FPG and HbA_{1c} tests: for example, in two recent studies in the high risk, general population, 6% of an overweight White European population were diagnosed with T2D using an OGTT but not HbA_{1c} (1,241 participants) and 9% of an overweight Thai population were diagnosed with T2D using an OGTT but not HbA_{1c} (521 participants) (136,137). However, discrimination in postpartum women after GD varies in very small studies. Agreement between the two tests has been found to be 'poor' (114 participants, six to 12 weeks postpartum, which may have been too soon postpartum because HbA_{1c} measures glycaemia in the previous eight to 12 weeks) (138), 'fair' (54 participants, six weeks to 36 months postpartum) (139), or identified more cases than an OGTT (141 participants, up to one year postpartum) (140). Similarity, postpartum FPG after GD has been found to have inconsistent sensitivity (14 to 100%), and may miss a quarter of T2D cases (141,142).

However, single blood tests are more acceptable than the OGTT, which is an important consideration given the context of poor attendance described in the following section. They put less demands on new mothers' time, and do not require unpleasant glucose loading (143).

Other testing strategies have been discussed, such as testing women for glucose intolerance before they are discharged from hospital in order to increase coverage. A recent study suggested that a normal OGTT at this time would exclude T2D at up to three months

postpartum, but not identify women with IGT or IFG (144). Although the acceptability was not reported, this could be a beneficial approach in certain circumstances. As explained above, use of HbA_{1c} tests at this time would not be suitable.

1.3.1.4 Attendance

Uptake of postpartum screening is highly variable, but is usually suboptimal at less than 50% (130,145–148), even being described as 'abysmally low' (149). One systematic review reported that 34 to 73% women with GD were screened postpartum in 11 studies published between 2008 and 2010, considering any type of test or time since delivery (148). More recently, this range was 13 to 82% in Asian women in 27 studies published between 2003 and 2016 (150). A single large study in France reported attendance of 22% by three months postpartum and 56% within the first year in 2013 (151). Small but statistically significant increases were observed in attendance within the first year from 2007 to 2013 but not earlier time points (151).

Women at highest risk of diabetes are less likely to attend diabetes screening, therefore delaying diabetes management. Younger women with other children and of lower socioeconomic status attend less frequently, particularly if they received little perinatal care or their GD was managed by diet alone (148). Sometimes overweight and non-Asian or Hispanic ethnicity are associated with lower screening attendance (152).

Uptake of screening in the UK has been similarly variable, although reporting of different timeframes makes comparison challenging and there is a paucity of data on long term follow-up. An analysis of national primary care medical records reported that only 58% of women attended diabetes screening in the first year postpartum, and less than 40% attended in the second and third years (153). Another study in 127 general practices in England reported half of this attendance: 19% attendance up to six months postpartum, 26% attendance within a year, and 20% attendance at annual screening (154). However, half of women with GD had no diabetes screening test within five years postpartum and less than 1% were tested every year, as recommended, between 2006 and 2010 (154). Considering more recent but smaller studies, 38% women with GD in primary care in Leicester were screened by 13 weeks postpartum, and 16% had annual tests (155). In Oxford, 51% women were screened by 13 weeks postpartum, and 8% had annual tests based on hospital records (156). In Sheffield, 75% women were screened by 13 weeks postpartum according to a local maternity database (157). Within these

studies, higher risk women, particularly those with higher deprivation, were consistently reported to have lower attendance (155–157). However, interestingly, over 80% of clinicians reported to test their patients within six weeks postpartum, although general practitioners (GPs) reported challenges in knowing whether their patient had had GD and only 39% recalled women for annual testing (158).

Reasons such as the unpleasant procedure or its inconvenience have been suggested for missing testing (87,143,147). Other explanations include women not recognising the risk, being afraid of a positive diagnosis, or the demands of caring for their baby on their time. This is likely to be confounded by the transition from secondary to primary care (149). Understanding explanations of poor attendance will inform approaches to increase uptake, such as through changes to the process as a whole or to support specific groups of women with GD.

Small studies have reported some improvement in screening attendance through targeted interventions. These tend to involve more proactive contact, such as phone calls, education programs, or postal reminders (145,146,149). For example, a single counselling session during the third trimester of pregnancy increased screening attendance from 33 to 53% in one US study (159), while introduction of a central coordinator increased uptake by 12% (160). Reminders for mothers or healthcare professionals are the most frequently anticipated to increase uptake, which may be a more resource-efficient approach (145). However, some of the benefits may be a result of participation in a trial or signing up to a register, as opposed to the intervention itself (161,162). Contact from an individual general practice may be more effective than a general register in the long term (161). Further intervention development and evaluation is required to optimise the effectiveness and long-term sustainability of such approaches.

1.3.2 Postpartum behaviour change

In addition to participating in regular diabetes screening, women are advised to adopt and maintain a healthy lifestyle in order to reduce their T2D risk factors. This requires most women to make conscious changes to their habitual behaviour. A healthy lifestyle focuses on a healthy diet and increasing physical activity.

1.3.2.1 Rationale

The risk of T2D can be reduced in women with a history of GD. The American Diabetes Prevention Programme (DPP) has been a valuable RCT to provide evidence supporting lifestyle behaviour change: high risk women with a history of GD who were offered intensive lifestyle counselling had approximately 50% lower incidence of T2D over three years and 35% over ten years compared to the placebo group that received standard lifestyle recommendations (350 participants) (163,164). This was comparable to the risk reduction observed in those receiving metformin (163). The lifestyle intervention aimed to maintain a weight reduction of 7% and at least 150 min of moderate intensity exercise each week through regular personalised educational meetings, with additional support for those who did not meet the goals within the specified time frame (165).

Systematic reviews of other smaller studies, including RCTs and observational studies, similarly show a reduction in progression to T2D through dietary and lifestyle interventions (166–168). One meta-analysis of four studies (including 951 women with GD at one to five years postpartum) found a statistically significant absolute risk reduction of 5.0 cases per 100 (95% CI -9.2 to -0.8) (166), and another reported a clinically and statistically significant 25% risk reduction when eight RCTs were combined (169). However, these effects can be small or limited, particularly if engagement with the intervention is poor.

1.3.2.2 Guidelines

In the UK, NICE advises that women are given lifestyle advice about weight control, diet and exercise after GD and managed according to the guidelines for preventing T2D through primary care (2,170). Those at moderate diabetes risk (according to their current glucose control) are given advice about risk factors and offered brief interventions such as access to a weight loss programme. Those at high diabetes risk are additionally referred to intensive lifestyle change programmes. These should be person-centred and empathy-building, offer ongoing tailored advice, support and encouragement, and use established behaviour change techniques. These programmes were developed for the general population, which tends to be older and not have young families, therefore may present avoidable barriers to attendance for women who recently had GD. Furthermore, they are considered for these interventions based on the results of diabetes screening tests, assuming they have attended, rather than their history of GD.

1.3.2.3 Experiences and challenges

In practice, lifestyle behaviour change in an obesogenic environment is challenging. According to a national random-sample telephone survey in the US in 2003, approximately half of women with previous GD reported that they were attempting to lose weight, although obese women with GD were half as likely to be attempting to lose weight as obese women without GD (171). They were also inactive and more likely not to meet fruit and vegetable consumption guidelines (172), therefore maintaining lifestyles that increase their diabetes risk. Another more recent US survey (2007 to 2014) similarly reported that women with GD tended not meet healthy lifestyle guidelines (173). These observations are explained by one of the conclusions of Jones *et al.* 2009, that there is often inconsistency between T2D risk perception and diet and exercise behaviour (174). However, diet and exercise in women with a history of GD is unreported in the UK.

Qualitative or mixed methods reviews have explored women's postpartum views on reducing diabetes risk as part of broad investigations into their experience of GD (77,87,147,174). A wide variety of views and determinants have been presented: positive attitudes towards behaviour change and knowledge of how to improve T2D risk is often observed, particularly when it is understood to reduce diabetes risk and when women have support and self-efficacy for change. However, some women feel that they lack information regarding how to care for themselves while others report overwhelming barriers such as lack of time, energy and resources.

There have been many studies that aim to promote behaviour change after GD, although these have tended to be pilot or feasibility studies, and heterogeneous designs make comparisons challenging (e.g. timing postpartum, intensity, mode of delivery, target behaviours, and follow-up duration). Most have targeted both diet and physical activity, and include education, goal setting and/or monitoring (166). A recent mixed methods review identified that provision of childcare, social and community support, and culturally-appropriate interventions are likely to be most effective in promoting physical activity after GD, whereas education about the risk of T2D only and use of pedometers is less likely to be effective (175). Face-to-face recruitment during pregnancy or early postpartum may be most effective, if integrated into existing care pathways (176).

1.4 Summary

Due to increasingly unhealthy lifestyles, more women are being affected by GD during pregnancy. GD identifies women at high risk of progression to T2D, with long-term consequences for their quality of life and cardiovascular health. Despite numerous benefits of increasing dietary quality, physical activity and periodic monitoring of blood glucose, many women do not act in response to their risk. As a result, there is a clear need to reduce diabetes risk factors and therefore incidence in women who have had GD. In some ways, they represent a particularly challenging population for behaviour change due to the additional demands of raising young children, yet in other ways they may be more motivated than the general population to be healthier after experiencing GD. Current protocols and interventions can be unsuitable for women with GD, vague or absent in the UK primary care setting. We urgently need to better understand the risk factors and timescales for developing T2D in order to inform screening programmes, and to describe and understand women's behaviour after GD in order to promote changes that will improve outcomes using approaches that have been informed by this population.

Chapter 2 Aims and overview of the thesis

2.1 Aims

The overall aim of this thesis is to better describe the problem of progression to T2D after a pregnancy affected by GD, and to identify primary care-based approaches that can be used to manage the risk of T2D in this population.

I am therefore conducting this work with the view to develop recommendations and interventions related to postpartum diabetes screening so that blood glucose control can be monitored in this population, and to promote a healthy lifestyle to reduce T2D risk. I use both literature reviews and primary research using qualitative and quantitative approaches.

This thesis is composed of three streams of work:

- The aim of the first stream is to improve understanding of the magnitude and nature of this problem including risk factors for development of T2D after GD by better describing the incidence of T2D in women with a history of GD;
- The aim of the second stream is to describe and understand attendance at postpartum diabetes screening in order to inform the development of interventions to promote uptake of screening;
- The aim of the third stream is to understand determinants of and influences on healthy diet and physical activity after GD in order to inform the development of interventions to promote healthy lifestyles among women with GD.

This work falls within the first stage of the Medical Research Council's (MRC) guidelines for developing and evaluating complex interventions (177). The four key elements of this process are development, feasibility and piloting, evaluation, and implementation. The guidelines

suggest that interventions should be developed systematically, be based on the best available evidence and use relevant theory. In particular, I have strengthened the evidence base before moving on to preliminary or initial evaluations of the intervention elements identified. I have taken a person-based approach as developed by Yardley *et al.*, focusing on understanding the perspectives of the target population through systematically investigating the beliefs, attitudes, needs and individual circumstances of women with a history of GD (178,179).

2.2 Thesis outline

Figure 2.1 depicts the structure of this thesis and how the earlier work informs later studies.

In Chapter 3, I present the methods used in Chapters 4 to 8.

The next chapter of my thesis is a large systematic literature review and meta-analysis of studies published up to October 2019 that report diagnoses of T2D in women with GD (Chapter 4). This study provides more data supporting the value of this thesis by more accurately describing the seriousness of GD in terms of T2D risk, and confirming or reinforcing the importance of sustained screening for T2D after pregnancy and making lifestyle changes to reduce diabetes risk factors.

I then report two studies on the topic of postpartum diabetes screening after GD. Chapter 5 describes attendance at the six week screening test, such as what types of tests were used and factors associated with increased likelihood of attendance in a local cohort of women. The second study, Chapter 6, is a qualitative synthesis, using the same literature search used in Chapter 4, understanding women's views towards attending diabetes screening after GD. Here I also report recommendations for increasing uptake that form part of my interview schedule for qualitative data collection (Chapter 8).

Chapter 7 is a parallel qualitative synthesis to Chapter 6. I examine women's views towards making changes to their diet and physical activity to reduce their risk of developing T2D, including barriers and facilitators to behaviour change. Again, I made recommendations for promoting healthy lifestyles based on these findings, and considered these during the qualitative interviews.

Finally, Chapter 8 is an interview study where I sought to interpret some of the findings from the other projects in the context of women in the UK. In particular, I wanted to ask them what support they would suggest to improve their risk of diabetes and evaluate the suggestions that I made as a result of the qualitative syntheses. These findings are brought together in the conclusion and discussion of Chapter 9.

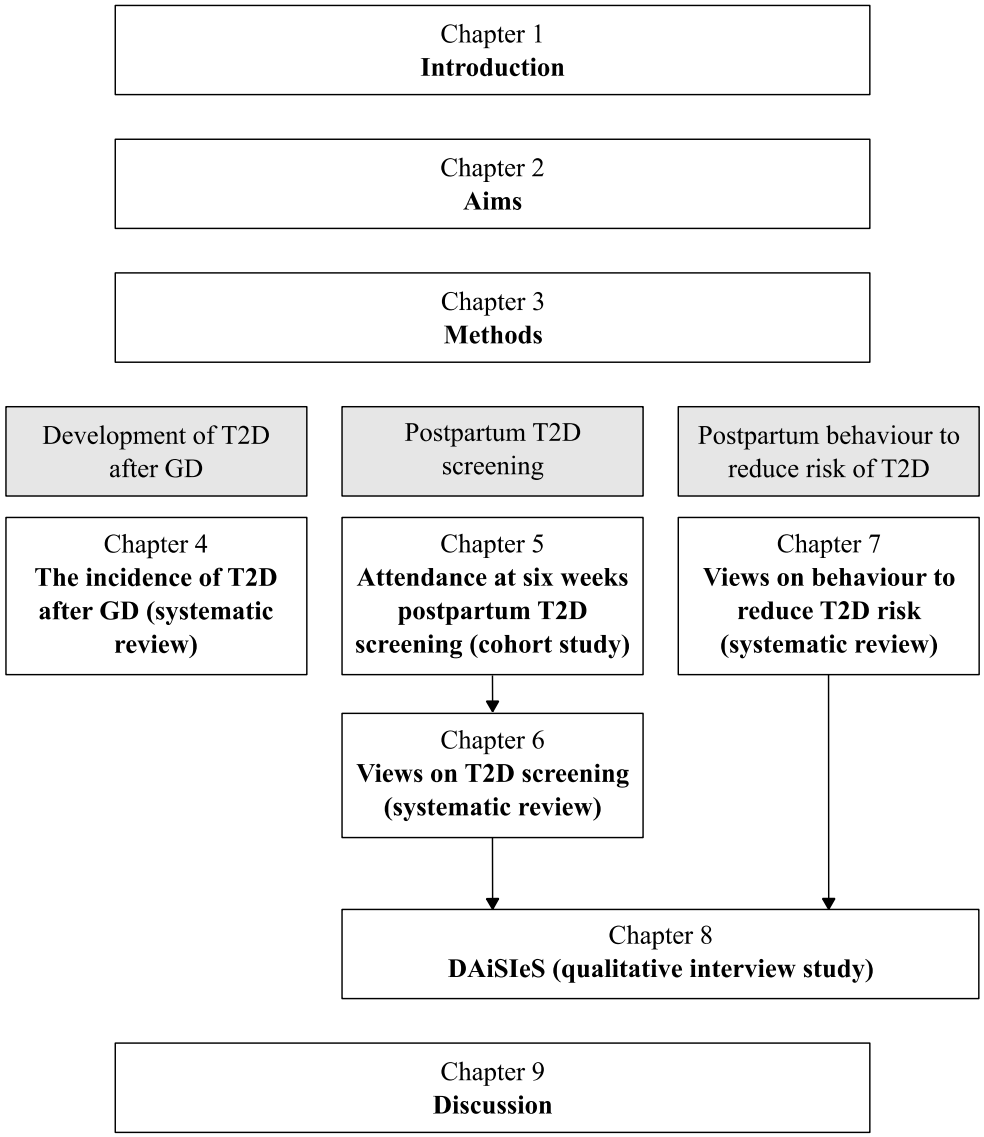


Figure 2.1: Overview of thesis structure.

Chapter 3 Methods

In this chapter, I describe the methods used to conduct the research projects that form my thesis. More specific details are provided within each chapter. Firstly, I describe the literature reviews that form the basis of Chapters 4, 6 and 7. I then describe the cohort and analyses used for the cohort study in Chapter 5, and conclude with a description of the qualitative interview study conducted for Chapter 8.

3.1 Systematic literature reviews

Each of the systematic literature reviews described in Chapters 4, 6 and 7 followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (180). This is a checklist of items to include when reporting a systematic review to ensure that the methods, findings, and strengths, limitations and potential sources of bias in the review are clear. Furthermore, I prospectively registered each review protocol on PROSPERO (www.crd.york.ac.uk/prospero). PROSPERO is a database of planned and in-progress systematic reviews. Publication of protocols on this website aims to avoid duplication and minimise reporting bias. I reference the PROSPERO record at the start of each systematic literature review chapter.

The three literature reviews presented in my thesis originated from one literature search that was conducted in September 2017. I then re-ran the search strategy in October 2019 for the incidence of T2D after GD review. Figure 3.1 shows how the reviews overlap. After planning the multiple reviews together as a research team (see Section 3.1.1), Rebecca Ward developed a search strategy to identify published studies relating to GD in the month before I started my doctoral research. These included the incidence of T2D after GD (Chapter 4) and the views of affected women on postpartum testing and lifestyle behaviours (Chapters 6 and 7), plus reviews

led by Rebecca Ward on diabetes risk factors in women with GD and interventions to prevent diabetes. This approach was taken because we anticipated that the studies included to answer each review question would overlap.

As described below, when we first reviewed the titles and abstracts of citations identified by the search, we allocated the citations a label according to the review to which they were relevant. The qualitative reviews were completed first.

3.1.1 Research team

I worked alongside multiple colleagues for these literature reviews: my PhD supervisors (Prof Simon Griffin and Dr Juliet Usher-Smith), an NIHR Academic Clinical Fellow (Dr Rebecca Ward), a senior statistician (Stephen Sharp), and six fourth and fifth year medical students from the University of Cambridge (Eileen Chen, George Farmer, Rachel Fox, Madeline Green, Deeya Kotecha, and Chloe Legard). Rachel Fox worked on the qualitative review of views towards postpartum screening, and the other medical students worked on the incidence of T2D after GD review. The contribution of each colleague is described below.

Including more than one person at each stage of a systematic review reduces bias and increases rigor. A second reviewer independently assessing citations for inclusion and exclusion, extracting data and assessing the quality helps to ensure that this is done consistently throughout the process and reduces individual error or bias. In qualitative syntheses in particular, multiple reviewers are vital for interpreting the findings.

In addition, Isla Kuhn and members of the University of Cambridge Clinical School Library supported us to develop the search strategy and access full text manuscripts. Zhirong Yang, Hannah Harrison, Julia Mannes and Parto Forouhi were valuable in helping to extract data or verify extractions from non-English language papers.

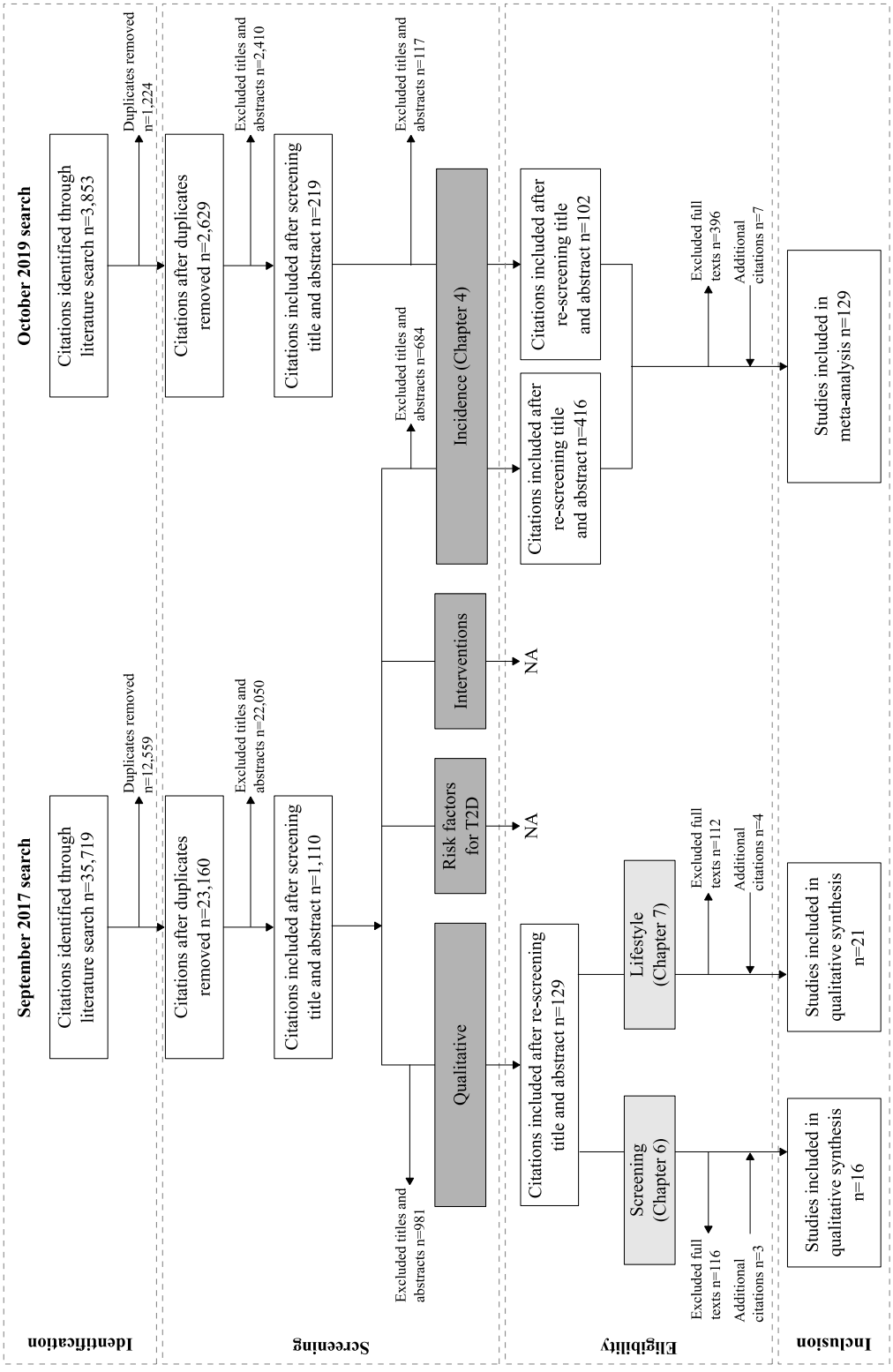


Figure 3.1: PRISMA diagram summarising the relationship between the three literature reviews included in this thesis.

NA: not appropriate as not reported in this thesis.

3.1.2 Justification

Systematic literature reviews are considered to be the highest level of scientific evidence and are useful for summarising complex issues (181). Synthesising the finding through meta-analyses can increase the precision of effect estimates and help to resolve discrepancies (181), which was particularly important for my review on the incidence of T2D after GD. Qualitative systematic reviews and syntheses draw together the findings of individual studies so that the result is greater than the sum of its parts. This is can be used to informing interventions, policy and the direction and quality of future research (182).

3.1.3 Search strategy

The search strategy was developed and performed on 28 September 2017 by Rebecca Ward to identify all published literature considering GD and postpartum T2D. As reported in Table 3.1, the first element of the search considered terms analogous to T2D therefore rows one to six were combined using 'OR'. Secondly, terms associated with GD or diabetes in pregnancy were used in rows eight to 14. The remaining rows searched for terms associated with development, or descriptors of development, of diabetes. Finally, each key element was combined using 'AND'. Explosions and MeSH headings were used to increase the likelihood of identifying all relevant studies.

Five electronic medical databases were searched: Medline, Embase, PsychInfo, CINAHL and the Cochrane Library. No limits (such as publication language) were enforced in order to access papers published in relevant journals.

Table 3.1: Medline search strategy developed for the group of literature reviews.

1. type 2 diabetes.mp. or Diabetes Mellitus, Type 2/	36. yoga.mp. or Yoga/
2. T2DM.mp.	37. postnatal.mp.
3. NIDDM.mp. or Diabetes Mellitus, Type 2/	38. diet.mp. or Diet/
4. non insulin dependent diabetes.mp.	39. healthy eating.mp. or Healthy Diet/
5. glucose tolerance.mp.	40. behaviour.mp.
6. insulin resistance.mp. or Insulin Resistance/	41. physical activity.mp. or Exercise/
7. 1 or 2 or 3 or 4 or 5 or 6	42. lifestyle.mp. or Life Style/
8. gestational diabet*.mp.	43. manag*.mp.
9. diabetes in pregnancy.mp.	44. screening.mp. or Mass Screening/
10. Pregnancy/ or pregnancy.mp.	45. hypoglycaemic agents.mp.
11. type 2 diabet*.mp.	46. hypoglycaemics.mp.
12. 10 and 11	47. health promotion.mp. or Health Promotion/
13. gestation*.mp.	48. medication.mp.
14. 11 and 13	49. medical therapy.mp.
15. postpartum diabet*.mp.	50. rate.mp.
16. postpartum.mp. or Postpartum Period/	51. predictor*.mp.

17. 8 or 9 or 12 or 14 or 15 or 16	52. risk*.mp.
18. prevent*.mp.	53. factor*.mp.
19. progress*.mp.	54. 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53
20. develop*.mp.	
21. advanc*.mp.	
22. incidence.mp. or Incidence/	
23. avoidance.mp.	55. follow-up.mp.
24. prohibit.mp.	56. postpartum.mp. or Postpartum Period/
25. establish.mp.	57. qualitative.mp.
26. health promotion.mp. or Health Promotion/	58. Interview/ or interview.mp.
27. Exercise/ or exercise.mp.	59. focus group*.mp.
28. active living.mp.	60. health service.mp. or Health Services/
29. metformin.mp. or Metformin/	61. belief*.mp.
30. weight.mp. or "Weights and Measures"/	62. opinion*.mp.
31. risk factors.mp. or Risk Factors/	63. survey.mp.
32. Insulin/ or insulin.mp.	64. 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63
33. exercise therapy.mp. or Exercise Therapy/	
34. intervention.mp.	65. 7 and 17 and 64
35. interven*.mp.	

Search strategy developed by Rebecca Ward.

The citations identified were downloaded and imported into Mendeley reference manager. Duplicates repeated in or across electronic databases were removed using the deduplication function in the reference manager. I replicated the search on 14 October 2019 to identify recent papers for the incidence review (Chapter 4).

In addition, I reviewed the list of references cited by each paper included in the qualitative reviews in order to identify additional studies. I reviewed the lists of studies included in previous reviews on the risk of T2D after GD for the incidence review (36,98,99,122), although it was not practical to review the reference lists of the included studies for this review due to the high number of studies included.

3.1.4 Inclusion and exclusion criteria

For all the reviews, I included studies that were published as a primary research article in a peer-reviewed journal. Conference abstracts, posters and comments or opinion pieces were excluded, as were protocols and literature reviews that did not report primary research data. Participants must have had a history of GD.

Specific inclusion criteria were applied to the incidence of T2D review. For inclusion, the papers needed to report:

1. Quantification of diabetes diagnoses after GD.

   The paper must have quantified development of diabetes, such as cumulative incidence, survival analyses or percentage diagnosed with diabetes at a specified time after pregnancy. The total or a random sample of a population exclusively with GD must have been followed up (that is, studies that followed up a population with a selected characteristic were excluded). It was not necessary for the study to distinguish between T2D and T1D, but diagnoses of overt diabetes must have been reported.

2. Longer than six months follow-up after GD.

   Assessment of diabetes status must have occurred at an average six months or longer after the GD-affected pregnancy in order to assess long-term development of diabetes in those whose GD resolved after delivery. Persistent postpartum glucose intolerance suggested that the participant had pre-existing undiagnosed diabetes before the pregnancy.

3. Diagnostic method and criteria for GD and T2D.

   The method and/or criteria used to diagnose both GD and T2D must have been reported. The diagnostic method described how participants were identified for the current study (for example, reviewing medical records or testing pregnant women with an OGTT). The diagnostic criteria described how GD and T2D were defined by the diagnostic method (for example, local or WHO glycaemic cut-off values in a diagnostic test). This information was required due to the different definitions of GD and T2D used over time and in different locations.

4. More than 50 participants with GD followed up.

   We introduced an *ad hoc* criterion of a sample size of 50 or more participants with GD to reduce the number of small studies relevant to the review that would have had a small impact on summary incidence estimates. Studies with any number of participants without GD (including zero) were eligible.

5. Any study design was eligible.

   We included both observational and experimental studies.

For the qualitative literature reviews, I only included qualitative research in which qualitative data were defined as data arising from qualitative methods and analysis approach. For example, interviews or free text of surveys that were analysed using thematic synthesis. For the review in Chapter 6, I included studies that examined women's views and experiences of postpartum glucose tolerance testing or T2D screening. For the review in Chapter 7, I included studies that examined women's postpartum lifestyle experiences (focusing on diet and exercise) following GD; for example, facilitators or barriers to participating in a T2D prevention programme with a lifestyle intervention. Studies exclusively reporting views of healthcare providers were excluded.

3.1.5 Title and abstract review

In the first stage of the title and abstract review, Rebecca Ward and I screened the studies for general relevance (such as excluding unrelated diseases or reporting of animal experiment studies) due to the large numbers of studies identified. We both independently reviewed approximately 10% of citations to assess discrepancies between authors' decisions when more carefully applying the inclusion criteria to the remaining studies. Any differences were discussed and if a consensus could not be reached, Simon Griffin and/or Juliet Usher-Smith were asked to provide an additional opinion. Once the inclusion criteria and their application were agreed, Rebecca Ward and I reviewed approximately half of the citations each.

We categorised the included citations for potential relevance to questions about incidence of T2D after GD, risk factors for T2D after GD, interventions to prevent T2D after GD, or qualitative studies. These citations were reviewed against the specific inclusion and exclusion criteria described above for each study. When additional researchers (the medical students) joined the title and abstract review, 10% of citations were compared to ensure consistency. Any citation where it was unclear whether it fulfilled the inclusion criteria, such as insufficient information, was included at this stage.

We conducted the title and abstract review by putting the citations in different folders in Mendeley for the earlier reviews and used Rayyan for the update to the incidence review in 2019. Rayyan is a software tool designed to facilitate title and abstract screening, and is particularly helpful for comparing inclusion decisions between team members (180,183).

3.1.6 Full text review

Full text articles were acquired (downloaded or purchased if access was not available through the existing subscriptions of the University of Cambridge) and rechecked against the selection criteria. Two authors reviewed each full text for the qualitative reviews (myself and Rachel Fox or Juliet Usher-Smith) whereas a 10% overlap in citations was again applied for the incidence review (myself, Eileen Chen, George Farmer, Madeline Green, Deeya Kotecha, or Chloe Legard). Queries were discussed with the co-authors, and any article that was not clearly relevant was excluded at this stage. Reasons for exclusion were recorded in a Microsoft Excel spreadsheet.

3.1.7 Data extraction and analysis

3.1.7.1 Meta-analysis of studies of the incidence of diabetes after gestational diabetes

I developed a data extraction form to facilitate systematic extraction of study-level characteristics, incidence and demographic information from the included citations (including a control group without GD, if reported). Data were extracted by two authors independently (primarily myself and one of Eileen Chen, George Farmer, Madeline Green, Deeya Kotecha, or Chloe Legard, but sometimes by two medical students). Any initial differences were resolved by discussion in order to minimise error.

After extracting the basic details of each study, I sought to identify whether the same study population had been reported by multiple publications, again with help from the medical students. I did this by first comparing location of the study and time of recruitment, before looking at other details such as the author lists and number of participants if it was still unclear. When overlap occurred, I only included the publication with the most person-years of follow-up of women with GD. Similarly, if progression to T2D was reported at multiple timepoints within one citation, I extracted data at the timepoint with the most person-years of follow-up.

I translated non-English language articles with the aid of an online translation tool (www.translate.google.co.uk), and verified the data extraction and details required for quality assessment with a native or fluent speaker of that language where possible. If the online translation was unclear, the native speaker completed the full text review and data extraction

using a simple form to guide them through this process. This tended to be colleagues in the University of Cambridge or their associates, as noted in Section 3.1.1.

Study-level characteristics were categorised as described in Chapter 4.3.4. The cut-offs used to define each category were based on the average (mean or median) of the study-level data or clinically-relevant cut-offs, and were discussed and agreed by the research team.

I performed the analysis using STATA 15.1, with statistical advice from Stephen Sharp. I grouped studies according to each of the characteristics, and combined these groups of studies using random-effects meta-analysis of the log odds of T2D. For absolute risk, effect estimates tended to be skewed below 50%, resulting in disproportionate weighting of studies with the lowest estimates (due to correspondingly low variance) and negative lower confidence intervals (where it is not possible to have incidence estimates less than 0%) (184). I therefore used a logit transformation to conduct the meta-analysis, then back-transformed the output to the percentage or odds ratio scales for interpretation (184,185). This transformation is very stable except for small studies (e.g. n less than 50), which were excluded according to the study selection criteria. Random-effects analyses were used due to the assumption of residual heterogeneity not explained by the potential effect modifiers (186). I used meta-regression to model the association between study-level characteristics and log odds of T2D. I then extended the model to investigate the extent to which any of the study and maternal characteristics described above explained the heterogeneity between studies, adjusting all models for ethnicity (majority White European or other) and categorised duration of follow-up. Meta-regression was weighted by the inverse of the sum of the within and between study variance, as is standard in a random-effects meta-analysis. I also calculated the relative risk of diabetes in studies that had a comparator population and combined these across studies using random-effects meta-analysis, overall and stratified by study and maternal characteristics. I used a fixed continuity correction of 0.5 where no cases of T2D were reported. Heterogeneity between studies was quantified using the I^2 statistic throughout.

3.1.7.2 Qualitative syntheses of studies of views on screening for type 2 diabetes and lifestyle behaviours after gestational diabetes

I developed a data extraction form to facilitate systematic extraction of the characteristics of each included study. This included the sample size, setting (country), relevant study aims, recruitment strategy, key inclusion and exclusion criteria, and time and method of data

collection. Myself plus Rachel Fox or Juliet Usher-Smith independently extracted data from each study and compared the data extraction forms to ensure agreement.

The qualitative findings were analysed using the thematic synthesis approach described by Thomas and Harden 2008 (187) with the aid of NVivo 11 (NVivo qualitative data analysis software; QSR International Pty Ltd, version 11 [2015]). This method for qualitative synthesis was selected in order to stay true to the content of the original data while moving beyond it in interpretation, and for the outcome to be applicable in practice (187,188). I imported the publication file into NVivo and used the software to manage the data; it allowed me to develop, modify and organise a coding scheme and review all data that I had coded under each code.

I defined data as text or tables labelled as 'Results' (or equivalent) that resulted from qualitative methods. Thomas and Harden (187) suggest also including the abstract in this definition but I soon found that such a concise summary did not contribute to my understanding of the content of the codes therefore decided not to code the abstract.

After carefully reading and re-reading each primary study, I coded the findings, organised these codes into related areas to develop descriptive themes and then developed analytical themes, as summarised in Figure 3.2. An example of each coding scheme and summary of the process are presented in the corresponding chapters of this thesis. I developed the initial coding scheme by focussing on two or three papers: I labelled or annotated the findings to develop a list of codes and discussed these codes with Rachel Fox or Juliet Usher-Smith, who had also annotated two papers. I then applied the coding scheme line by line to the rest of the data, adding new codes as necessary. Rachel Fox or Juliet Usher-Smith independently coded a subset of papers at multiple stages to check consistency. In the next stage, concepts were translated from one study to another by making summaries and comparisons, and new concepts were developed. This process allowed me to move beyond the descriptive findings to gain further insight into the phenomena reported, such as inferring barriers and facilitators to the particular behaviours, informed by other studies.

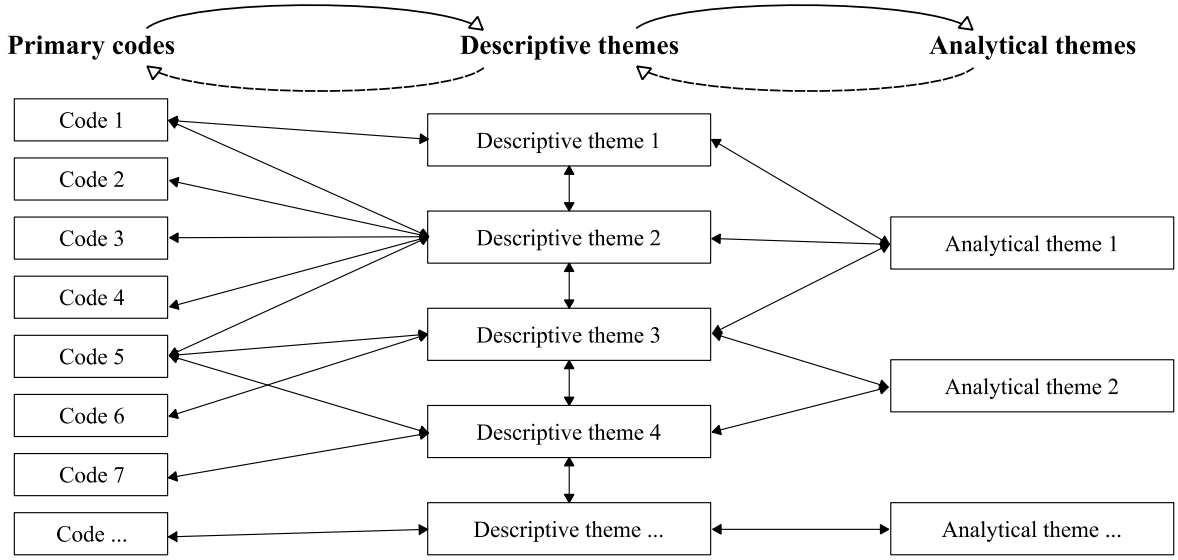


Figure 3.2: Summary of thematic synthesis used in the qualitative syntheses.

I developed the analytical themes through an iterative process involving reading each code and summarising in a few words on a hand-written note. For example, for the review on lifestyle behaviour to reduce T2D risk, I summarised similar ideas from different categories on the same note. For instance, I summarised the role of "support" from my "actual barriers to healthy diet" category then added how support could be a facilitator to healthy eating, how women thought that they could have a healthy diet if they had more support, etc. This led to the creation of approximately 20 notes. I used these notes by grouping and ordering them in different ways; trying to make connections helped me to see how different ideas fitted together and how descriptive themes contributed to the analytical themes that I was beginning to develop. However, diagrams of connections were too complicated to interpret therefore I further summarised the notes and ideas – once for healthy diet and once for physical activity (using a similar approach to the 'one sheet of paper method' (189)). I then highlighted these two summaries to indicate where influences operate in the same way for diet and physical activity, or were specific to one behaviour. This allowed me to fit the key points into six distinct but highly connected themes (plus a seventh on the format of interventions).

A very similar approach was used for the analysis of views towards postpartum testing. Data were less diverse so it was not necessary to categorise the data before coding it, and I worked closely with Rachel Fox to complete the analysis.

Finally, I developed recommendations for improving behaviour based on the findings of each review (that is, to support healthy diet and exercise, and increase attendance at diabetes screening). I did this in order to make sure that the reviews had clear practical implications. These included both where participants reported being able to carry out healthy behaviour and benefitted from support, and where they suggested that more support was necessary. I mapped these onto the standardised behaviour change technique taxonomy by suggesting mechanisms by which the recommendations could be put into practice (190). I evaluated these recommendations, as described in Section 3.1.9.

While I developed the initial and analytical themes and recommendations, I also discussed them with the co-authors at regular intervals.

3.1.8 Quality assessment

I assessed the quality of each study included in the literature reviews in order to consider biases in the conclusions. I used, or based the quality assessment on, published checklists that were appropriate to the design of each included study. The quality assessment checklist was completed independently by at least two of the authors who had completed the data extraction for each study, and any differences were discussed and the appropriate score agreed. No studies were excluded based on quality.

3.1.8.1 Quantitative studies

Shamliyan *et al.* reviewed tools used to assess the quality of observational studies of disease incidence, prevalence and risk factors (191). However, none were suitable for use in the incidence review because they could not be applied across different study designs, were not simple enough for use in many studies, and did not consider the elements we identified as most likely to introduce bias in measuring risk of T2D after GD. For example, the tool used by Nguyen *et al.* 1999 could be applied to the studies of incidence and prevalence but had 28 questions, and each had a different scoring system to give a total score out of 100 (192). We considered this to be too time consuming and complicated to apply to a high number of studies. Others such as Scholten-Peeters *et al.* 2003 had a simpler scoring system of yes/no/don't know, but had several questions that would not be relevant to progression to T2D after GD because it was developed to assess prognostic factors (such as follow-up of at least 12 months, description of treatments and data presentation of most important outcome measures) (193).

As a result, I evaluated the risk of bias in each study included in this review using a checklist adapted from the Critical Appraisal Skills Programme (CASP) and Newcastle-Ottawa Scale checklists (194,195). There is a CASP checklist for each type of study design (including randomised controlled trials and cohort studies, which were most relevant for this review). There are between ten and 12 questions addressing study validity (research question and recruitment), design (exposure and outcome assessment, confounding and follow-up) and the results (trustworthiness and implications). "Yes", "can't tell" or "no" is given in response. Similarly, the Newcastle-Ottawa Scale for cohort studies examines participant section, comparability of exposed and non-exposed cohorts, and outcomes. One or no 'stars' are given according to the response to each question, and studies are classified as good, fair or poor quality according to the number of 'stars' received across the three domains.

From these checklists, I selected six key questions (Table 3.2) to assess possible bias in the incidence estimate across all study designs. I used a simple scoring system to maintain comparability and internal validity with numerous studies. Studies scored one point for "yes" and zero points for "unclear" or "no"; scores of five or six were considered as high quality studies, three or four were medium quality, and scores less than three were low quality. Quality assessment was independently completed by at least two authors (myself and one of Eileen Chen, George Farmer, Madeline Green, Deeya Kotecha, or Chloe Legard) for each study. Queries and disagreements discussed with Simon Griffin.

3.1.8.2 Qualitative studies

For the qualitative reviews, myself and Rachel Fox or Juliet Usher-Smith assessed the quality of each study's qualitative findings against the CASP checklist designed for qualitative research (Table 3.3) (196). This checklist was selected due to its comprehensiveness and because the same questions could be applied to different qualitative methods. We awarded scores of 0, 0.5 and 1 for answering 'no', 'unclear' and 'yes' to each of the ten questions. During this process, I focused on internal consistency and recorded my justification for each answer. This facilitated discussion of the findings with a second reviewer, particularly when the assessment was uncertain.

Table 3.2: Quality assessment checklist for the incidence of type 2 diabetes after gestational diabetes review, based on the Newcastle-Ottawa Scale (194) and Critical Appraisal Skills Programmes (CASP) checklists (195).

	Score	Explanation
Recruitment		
1. Was the cohort recruited in an acceptable way? Yes – representative or somewhat representative of a defined population; e.g. a whole hospital cohort (1 point) No – selected or unrepresentative group; e.g. a population with a particular characteristic (0) Can't tell – no description of the derivation of the cohort (0)		
Exposure and outcome ascertainment		
2. Was the exposure accurately measured to minimise bias? Yes – objective measurements for study or from records (1) No – subjective measure; e.g. self-report history of GD (0) Can't tell – no description (0)		
3. Was it demonstrated that outcome of interest was not present at start of study? Yes – steps taken to exclude pre-existing T2D; e.g. self-report, medical records or 6 week postpartum test (1) No (0) Can't tell (0)		
4. Was the outcome accurately measured to minimise bias? Yes – objective measurements; e.g. independent blind assessment by call back for OGTT or HbA_{1c} (1) No – subjective measure; e.g. self-report or record linkage (0) Can't tell – no description (0)		
Follow-up		
5. Was the follow-up (for the incidence extracted) long enough for outcomes to occur? Yes – greater than approx. 5 years (1) No – less than approx. 5 years (0) [Unclear – exclude]		
6. Was the follow-up (for the incidence extracted) adequate? Yes – complete follow up with all subject accounted for (1), OR Yes – 40–80% subjects followed up and those lost to follow-up are unlikely to introduce bias (persuaded that there is no difference between followed up and lost to follow-up) (1) No – follow up rate less than 80% and no description of those lost (0) Unclear – no statement (0)		
Total		/6
Class		High (5 or 6), medium (3 or 4), or low (0, 1 or 2)

Table 3.3: Critical Appraisal Skills Programmes (CASP) checklist for qualitative research (196) used in the qualitative literature reviews.

	Score	Explanation
Are the results valid?		
1. Was there a clear statement of the aims of the research? *Hint: Consider* – *What was the goal of the research* – *Why it was thought important* – *Its relevance*	Yes/ can't tell/ no	
2. Is a qualitative methodology appropriate? *Hint: Consider* – *If the research seeks to interpret or illuminate the actions and/or subjective experiences of research participants* – *Is qualitative research the right methodology for addressing the research goal*	Yes/ can't tell/ no	
Is it worth continuing?		
3. Was the research design appropriate to address the aims of the research? *Hint: Consider* – *If the researcher has justified the research design (e.g. have they discussed how they decided which method to use)*	Yes/ can't tell/ no	
4. Was the recruitment strategy appropriate to the aims of the research? *Hint: Consider* – *If the researcher has explained how the participants were selected* – *If they explained why the participants they selected were the most appropriate to provide access to the type of knowledge sought by the study* – *If there are any discussions around recruitment (e.g. why some people chose not to take part)*	Yes/ can't tell/ no	
5. Was the data collected in a way that addressed the research issue? *Hint: Consider* – *If the setting for the data collection was justified* – *If it is clear how data were collected (e.g. focus group, semi-structured interview etc.)* – *If the researcher has justified the method chosen* – *If the researcher has made the methods explicit (e.g. for interview method, is there an indication of how interviews are conducted, or did they use a topic guide)* – *If methods were modified during the study. If so, has the researcher explained how and why* – *If the form of data is clear (e.g. tape recordings, video material, notes etc.)* – *If the researcher has discussed saturation of data*	Yes/ can't tell/ no	
6. Has the relationship between researcher and participants been adequately considered? *Hint: Consider* – If the *researcher critically examined their own role, potential bias and influence during (a) formulation of the research questions (b) data collection, including sample recruitment and choice of location* – *How the researcher responded to events during the study and whether they considered the implications of any changes in the research design*	Yes/ can't tell/ no	
What are the results?		
7. Have ethical issues been taken into consideration? *Hint: Consider*	Yes/ can't tell/ no	

– *If there are sufficient details of how the research was explained to participants for the reader to assess whether ethical standards were maintained* – *If the researcher has discussed issues raised by the study (e.g. issues around informed consent or confidentiality or how they have handled the effects of the study on the participants during and after the study)* – *If approval has been sought from the ethics committee*		
8. Was the data analysis sufficiently rigorous? *Hint: Consider* – *If there is an in-depth description of the analysis process* – *If thematic analysis is used. If so, is it clear how the categories/themes were derived from the data* – *Whether the researcher explains how the data presented were selected from the original sample to demonstrate the analysis process* – *If sufficient data are presented to support the findings* – *To what extent contradictory data are taken into account* – *Whether the researcher critically examined their own role, potential bias and influence during analysis and selection of data for presentation*	Yes/ can't tell/ no	
9. Is there a clear statement of findings? *Hint: Consider* – *If the findings are explicit* – *If there is adequate discussion of the evidence both for and against the researcher's arguments* – *If the researcher has discussed the credibility of their findings (e.g. triangulation, respondent validation, more than one analyst)* – *If the findings are discussed in relation to the original research question*	Yes/ can't tell/ no	
Will the results help locally?		
10. How valuable is the research? *Hint: Consider* – *If the researcher discusses the contribution the study makes to existing knowledge or understanding (e.g. do they consider the findings in relation to current practice or policy, or relevant research based literature* – *If they identify new areas where research is necessary* – *If the researchers have discussed whether or how the findings can be transferred to other populations or considered other ways the research may be used*		
Total		/10

3.1.9 Confidence in the findings

In the final part of each qualitative synthesis, I used the Grading of Recommendations Assessment, Development and Evaluation-Confidence in Evidence from Reviews of Qualitative research (GRADE-CERQual) approach to evaluate my confidence in each of these recommendations (197). GRADE-CERQual considers the relevance, coherence, adequacy and methodological limitations of data contributing to each recommendation, informing the confidence in its effectiveness.

I therefore had more confidence that a suggestion will support women to change their behaviour when the data that informed it came from primary studies that asked the same question as our review question in a comparable population (relevance), when most of the data available supported the point made and there were few disparities in views (coherence), when the data were reported in detail from multiple studies (adequacy), and when the contributing studies had low risk of bias (methodological limitations).

These assessments were recorded using the table suggested by Lewin *et al.* (197), and are reported in the appendices of this thesis. I completed these tables and discussed them with Rachel Fox and Juliet Usher-Smith.

3.2 Cohort study

In this cohort study, I used medical records from the Rosie Hospital to examine uptake of diabetes screening within one year after a pregnancy affected by GD.

This was a secondary analysis of a convenience sample from a dataset created for another purpose. It allowed me to report diabetes screening attendance and associations between attendance and variables recorded in the medical record. This was a quite large dataset (556 records) and no additional burden was placed on the patients or medical staff to collect data for research purposes. However, as a retrospective cohort, there were missing data and some variables that I would have included if I had designed the study were not collected.

3.2.1 Research team

The data for this study were provided by Dr Catherine Aiken, a Consultant in Obstetrics and Fetal Medicine at the Rosie Hospital. Catherine Aiken and Dr Claire Meek (Honorary Consultant Chemical Pathologist and Metabolic Physician with a special interest in GD) provided details about GD care at the Rosie Hospital. The study was designed by myself alongside Catherine Aiken, Claire Meek and my supervisors; Matthew Barclay provided further statistical advice.

3.2.2 Overview of the cohort

The Rosie Hospital is a maternity hospital that is managed by the Cambridge University Hospitals NHS Foundation Trust. It offers maternity and neonatal services to the local population and specialist services to the eastern region in the UK (such as high risk obstetrics and neonatal intensive care) (198).

As part of routine care at the Rosie Hospital, women with a history of previous GD are offered an OGTT shortly after booking at 12 to 14 weeks of pregnancy. Women at higher GD risk, such as older age or family history of diabetes, are offered an OGTT at 24 to 28 weeks while others will be offered if they become symptomatic.

All women diagnosed with GD are seen every two to four weeks at multidisciplinary clinics. They are encouraged to monitor their blood glucose levels and offered lifestyle counselling. Those with evidence of persistent hyperglycaemia are offered treatment with insulin, metformin or both. All patients are advised verbally during the antenatal period that they should attend for postpartum glucose testing at six to eight weeks following delivery. Blood collection can take place at the hospital or the women's own GP practice. All blood samples are processed by Cambridge University Hospitals NHS Foundation Trust so the results are available on the Rosie Hospital electronic records.

For this study, Catherine Aiken identified women diagnosed with GD who delivered a singleton infant at a viable gestation (over 24 weeks) at Cambridge University Hospitals NHS Foundation Trust between October 2014 and March 2017 from electronic medical records. We only included the first pregnancy if women had several eligible pregnancies.

3.2.3 Definition of variables

I defined GD according to modified IADPSG criteria (15) used at the hospital at that time: FPG ≥5.3 mmol/l, or ≥10.0 mmol/l after 60 minutes or ≥8.5 mmol/l after 120 minutes in the 75g OGTT. T2D and IGT were defined using the 2006 WHO criteria (103,199): FPG ≥7.0 mmol/l or ≥11.1 mmol/l after 120 minutes, and FPG <7.0 mmol/l and ≥7.8 and <11.1 mmol/l after 120 minutes in the 75g OGTT, respectively.

The general practice where each woman was registered was included in the dataset. I manually linked data from each participant to their general practice's characteristics that were available

on the internet, including size and deprivation score, diabetes Quality and Outcomes Framework (QOF), GP Patient Survey, and National Diabetes Audit indicators. Use of these variables are justified in Table 3.4. I used data from 2015/2016 from Public Health England's National General Practice Profiles, and the 2015 Index of Multiple Deprivation (IMD) (200).

Table 3.4: Description and justification of the variables relating to the participants' general practice for the cohort analysis.

Variable name	Description	Justification
General characteristics		
Number of registered patients	Size of the general practice in 2016	GD follow-up care may vary between size of general practice (for example, larger practices may have more specialist GPs but not know their patients so well)
Practice IMD score	Indication of deprivation of the general practice's area in 2015, including measures of income, employment, health and disability, education, skills and training, housing and services, and living environment and crime	Deprivation has been associated with healthcare availability
General performance		
Total QOF score	The percentage of all QOF points achieved, across all domains	Indication of the quality of care provided to patients
Percentage recommending practice	Percentage of general practice population who would recommend the practice	Indication of overall patient satisfaction with their general practice
Diabetes care performance		
Percentage with blood test	The percentage of patients with diabetes who received a blood test (for HbA_{1c}) within the preceding 15 months	Process measure of diabetes care
Percentage with foot examination	The percentage of patients with diabetes with a foot examination and risk classification recorded within the preceding 12 months	Process measure of diabetes care
Percentage with HbA_{1c} <59 mmol/mol	The percentage of patients with diabetes with HbA_{1c} less than 59 mmol/mol (7.5%) within the preceding 12 months	Outcome measure of diabetes care
Percentage referred for education	The percentage of patients with newly diagnosed diabetes who have a record of being referred to a structured education programme within 9 months within the preceding 12 months	Process measure of diabetes care

IMD: Index of Multiple Deprivation; QOF: Quality and Outcomes Framework.

Personal and pregnancy characteristics were extracted from the medical record. Of note, pre-pregnancy BMI was based on measurements recorded in the community at the antenatal booking visit at eight to 12 weeks. Gestational weight gain was calculated by subtracting pre-pregnancy weight from the last recorded clinic weight in pregnancy (at 36 weeks for the majority). Gestational age at delivery was calculated using the crown-rump length measured

on ultrasound scan in the first trimester. Gestation-specific birthweight z-scores were based on the INTERGROWTH-21st Estimated Fetal Weight Standards (201).

I searched the dataset for the result of any OGTT or HbA_{1c} test performed within one year after delivery, and used a test result as a proxy for attendance at testing.

The study was approved as a service evaluation, and the Institutional Review Board granted approval for further analysis of the data for research purposes.

3.2.4 Analysis

I used STATA 15.1 to run univariable and multivariable two-level mixed-effects logistic regression analyses to identify factors associated with the odds of postpartum testing for diabetes by an OGTT, HbA_{1c} or either test.

This type of model was selected to account for clustering by GP practice; i.e. to model what is actually happening rather than removing any differences between general practices. I used the 'melogit' command to predict the fixed-effect of individual-level variables (personal characteristics) on screening attendance because these were not anticipated to have differential effects across practices. The random-effect described differences across practices in the likelihood of attending screening. The odds ratio of attending screening after a caesarean delivery, for example, is therefore the conditional odds ratio of attending screening after a caesarean delivery compared to someone who did not have a caesarean delivery in the same practice.

In order to meet the assumptions for logistic regression (202), I selected variables for which the errors are independent and were not collinear (such as BMI and weight). I ensured the absence of highly influential outliers by examining the data, and ensured linearity for continuous variables by plotting each continuous variable against the logit-transformed variable in order to identify a linear relationship.

Continuous variables were centred about the mean to aid interpretation. The multivariable analyses were adjusted for variables that were significant in the univariable analysis or we had strong a priori rationale to include (explained in Chapter 5). This was a complete case analysis. No statistically significant differences between the characteristics of the original cohort and the complete case cohort were observed, therefore I did not impute missing data.

Odds ratios and 95% confidence intervals are reported.

3.3 Qualitative interview study

For the last part of my doctoral research, I completed a qualitative interview study. 'DAiSIeS' is the Diet, Activity and Screening after gestational diabetes: an Interview Study. The study materials are provided in the appendices. This study was approved by the West London and GTAC Research Ethics Committee (reference 19/LO/0441).

The methods are reported in this chapter and Chapter 8 in line with recommendations such as those by Anderson 2010 (203) and the Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist (204). The COREQ checklist ensures thorough reporting of the research team and reflexivity (personal characteristics and the relationship with the participants), study design (theoretical framework, participant section, setting and data collection), and analysis and reporting.

3.3.1 Research team

This study was designed by myself alongside Dr Juliet Usher-Smith, Professor Simon Griffin, Dr Claire Meek and Dr Catherine Aiken. Claire Meek was particularly involved in contributing to development of the study materials, gaining ethical approval and identifying research nurses to recruit participants through her clinical connections with the Rosie and Peterborough Hospitals. Rachel Fox contributed as the second author by coding a subset of the interviews, creating charts and discussing the provisional findings. All authors were involved in the final interpretation of the data.

3.3.2 Justification

A qualitative approach was used in order to explore and understand the experiences, views and opinions of women with a history of GD on the research topic (i.e. diet, exercise and screening behaviours after GD). Qualitative research is suitable for developing a deeper, detailed understanding of the phenomenon of interest than can be elicited by a survey or questionnaire that quantifies the responses. It allows the participants to open up and share their own story; that is, their thoughts on support for GD follow-up given their current postpartum context and

own experience of pregnancy. On the other hand, qualitative research utilises a small sample size that tends not to be generalizable to the wider population and is time- and resource-intensive.

Semi-structured interviews were selected for data collection. This allowed me to direct the topics covered in the interviews but also to diverge from the interview schedule to follow-up and further investigate ideas in order to develop a deeper understanding (205). Compared to focus groups, interviews were considered to be a suitable method for data collection because they allowed each participant to share their personal experiences in-depth and were anticipated to be easier for women with young children to attend since they could be conducted at a time and place of their choice. However, interviews do not allow interactions between the participants, such that they could respond and react to the other participants (206).

3.3.3 Recruitment

The study sample, women with a history of GD, was recruited via the Rosie Hospital (Cambridge University NHS Foundation Trust) and Peterborough Hospital in Cambridgeshire in the East of England. These locations were selected because they were accessible for me to travel to, enabling me to arrange the interviews at the time most suitable for the participant. In general, Peterborough has a more diverse population than the area served by the Rosie Hospital with regards to education level, income, ethnicity and therefore experience of GD.

Research nurses from the two hospitals identified eligible participants via their medical records. They posted or emailed a customised invitation letter and participant information sheet to them describing the purpose and procedure of the interviews (Appendices 1 and 2). Participants replied to research nurses if they wanted to take part, who then passed their contact details onto me using the secure 'nhs.net' email to arrange an interview and answer any questions they had. I contacted the participants using telephone calls, email and text messages and I attempted to speak directly to each participant before the interview. Potential participants were sent up to one reminder to respond, and those who initially expressed interest were sent up to three reminders to arrange the interview.

Additionally, we displayed posters (Appendix 3) introducing the study at hospital antenatal clinics so that potential participants could become aware of the study before receiving an invitation letter.

3.3.4 Inclusion criteria

Mothers over 18 years old were eligible if they had been diagnosed with GD during any previous pregnancy. They must have been 12 weeks to four years postpartum in order to have settled with their new baby and attend postpartum follow-up, and be cared for during the period covered by the 2015 NICE guidelines for GD management (2).

They needed to be considered suitable to take part in a qualitative interview by the research staff who had access to their medical records (for example, ability to understand the interview procedure and give informed consent). I did not have the resources to interview participants who did not speak fluent English in this study.

Potential participants were not invited to take part if they did not have a successful, uncomplicated pregnancy and full-term birth (over 37 weeks gestation) in order not to cause undue distress. Defining whether each pregnancy was uncomplicated was delegated to the research nurses who had the necessary information and clinical expertise. Women who had participated in a pregnancy- or postpartum-related intervention were also not invited in case this led to a very different experience of pregnancy with more contact with medical teams than the general population. They must not have been diagnosed with diabetes before having GD but those who had developed T2D following GD were eligible.

I anticipated interviewing 20 to 25 women in order to reach data saturation, based on the relatively low information power predicted (207). This is because this study had a broad aim, sparse sample specificity but used purposive sampling, was a cross-case analysis and I had not conducted qualitative interviews before. A key aspect of the interviews was structured around pre-defined recommendations.

3.3.5 Interview process

Participants were invited to a face-to-face interview at a time and private place of their choice (their home or a room in the hospital were suggested). I made clear that children were welcome to be present during the interview so that alternative childcare would not be needed, which could have increased selection bias.

I began the interview by introducing myself to the participants as a non-clinical PhD student who wanted to listen to their experiences in order to improve support for mums, not to judge

or give advice. They were told that they were welcome not to disclose anything that they did not want to, could pause or stop the interview at any time, and were given an opportunity to ask any questions. Participants then gave written informed consent by signing the consent form, confirming that they understood the purpose and procedure of the study, and permitting it to be audio-recorded.

I developed the interview guide with reference to the gaps in the literature identified in the qualitative syntheses (Chapters 6 and 7). The guide was discussed and refined with the wider researcher team, including a clinician with recent GD. Written feedback from a patient and public involvement and engagement group (PPI group; mothers with GD) was incorporated into the final version, which was further refined after reflection on the first interviews. For example, I began the first interview by asking the participant to describe their diet, expecting this to be an easy topic to begin with. However, they had been expecting to talk about their recent pregnancy, therefore I began subsequent interviews by asking participants to share their experience of GD, which helped to build rapport by allowing me to understand some of the context for participants' current behaviours and attitudes.

Participants were then asked to describe their current eating habits and physical activity, and whether they felt that having had GD had influenced these. We then moved on to discuss any support for healthy behaviours that they would like/have liked, and how this could be delivered effectively. Participants were asked about their own ideas first, then asked to provide feedback on suggestion cards I provided; for example, whether they agreed or disagreed with each suggestion and if there was anything they would add. The 20 suggestions were based on the 30 recommendations that I developed in the two qualitative literature reviews that are described in Chapters 6 and 7 (208,209). I did not use all of the recommendations developed in the literature reviews in order to reduce the burden on the participant, which could cause them to disengage with the interview, but selected or adapted recommendations that I considered to be most relevant to participants, rather than clinicians for example. I also grouped them according to similar concepts, such as information or the family, and generally presented them in the same order for each interview. During some interviews, I considered that it was not appropriate to share certain suggestion cards. Most often, this was where participants were not aware of the need for any or annual diabetes screening therefore to ask them what would facilitate attendance may be upsetting.

If participants had said that they did not want to make any changes themselves, they were asked what they thought might help others with GD based on their own experience. These questions were then repeated for attending diabetes screening: whether they had been, plans for future screening, and what might help them attend. Prompts were given as necessary.

The final interview schedule is presented in Table 3.5.

Table 3.5: DAiSIeS interview schedule and suggestion cards.

Introduction

- Introduce researcher and the purpose of the interview
- Explain the interview procedure
- Informed consent
- Begin recording

As I said, I am particularly interested in post-pregnancy, but perhaps you could start by telling me a little about what your GD pregnancy was like for you?

Understand current lifestyle

To help us understand any lasting impact GD might have had, please tell me a bit about your current diet.

What was your diet like before your GD pregnancy? [How] do you think this has changed? What helped you make these changes?

Please tell me a bit about anything that you do to stay active.

Did you do any exercise before your GD pregnancy? [How] do you think this has changed?

To summarise, do you think GD has had an impact on you, making any lasting changes?

[If any,] what other changes to your diet/exercise would you like to make? Why do you say this?

Ideal lifestyle intervention

What would help you most to have a healthier lifestyle/to make the changes we've spoken about?

Introduce suggestion cards 1–10. Are there any that would be beneficial to you? Any that wouldn't be? Anything that you would add?

Is there anything else that you would like to add about diet and exercise?

Understand current screening behaviour

Have you had a test for diabetes since your pregnancy? What made you go/what prevented you from going?

How do you feel about having regular diabetes tests in the future?

Ideal screening intervention

What would help you most to attend diabetes testing? (At 6 weeks postpartum and annually)

Introduce suggestion cards 11–20. Are there any that would be beneficial to you? Any that wouldn't be? Anything that you would add?

Close

- Today I wanted to talk to you about diet, exercise and screening for T2D after GD, and what might help with this. Is there anything else that you would like to discuss or ask?
- Complete questionnaire
- End

Suggestion cards	
1. More information about the impact of healthy diet/exercise on your diabetes risk	2. More information about the impact of healthy diet/exercise on your wider health (e.g. stress, weight)
3. More information about the impact of healthy diet/exercise on your family	4. Suggested ways for your children and wider family to be healthier
5. Help for you to exercise with others	6. Advice about how to have a healthy diet (food shopping, cooking, healthy substitutions, etc.)
7. Advice about how to exercise with a busy schedule (e.g. around the home)	8. Advice about how to keep going with healthy changes to your diet/exercise
9. Advice about saving money and healthy diet/exercise	10. Monitoring your progress
11. Doctors talking more about postpartum tests while you were pregnant	12. Invitations and reminders for tests
13. Your GP knowing more about your pregnancy	14. More opportunities to understand gestational diabetes
15. More child-friendly clinics/waiting rooms	16. Being able to get tested at a place of your choice
17. Shorter, more pleasant tests	18. Combining glucose testing with other appointments
19. A better understanding of the purpose of glucose testing	20. Not being able to monitor your blood sugar yourself

Finally, the participants were asked to complete a short questionnaire (Appendix 4) to provide background information relevant to their health-related lifestyle choices and their demographics (because no information was extracted from the medical record). This also provided an opportunity to give written feedback on the interview.

As soon as possible after each interview, I recorded field notes. These included initial reflections on the interview, such as strong or surprising opinions. I also made notes that might be relevant to interpretation of the interview but were not explicitly captured by the audio-recording or survey: such as relevant information or context discussed before the start of the formal interview (e.g. while the participant was making drinks), any disruptions or distractions that took place, and the setting. One interview took place at the participant's place of work, which may have led to the participant being distracted from the interview.

3.3.6 Analysis

Interview recordings were transcribed by a professional transcription service (www.typeout.co.uk). I checked the transcripts for accuracy against the recordings, and pseudo-anonymised them by removing names, places and dates.

The interviews were analysed using an iterative process that began after completion of the first few interviews using the framework analysis approach (210,211). Framework analysis is particularly useful for comparing within and between cases thereby allowing distinction between participants to be maintained throughout the analysis process and each perspective kept in context. It maintains transparency between the raw interview data and final interpretation.

This involved the following steps:

- Familiarisation with the data through listening to the audio-recordings, reading the transcripts and field notes, and making notes about participants and emerging themes. Familiarisation was particularly important to inform development of the framework after completing the first few interviews.

- Identifying a thematic framework. Because this analysis focused on approaches to improve support after GD to reduce T2D risk, the original framework was based on the suggestion cards and interview schedule, and then was refined upon coding the first interviews to reflect where the ideas were similar. I added codes developed inductively from repeated themes in the interviews (such as the need for advice to be given in a positive, non-judgemental way). I considered developing a framework around a behavioural theory (such as the Health Belief Model, Transtheoretical Model, Theoretical Framework of Acceptability, Social Cognitive Theory or Social Ecological Model) but found that the interview schedule itself was more appropriate to the aim of this study. I retained a distinction between suggestions initiated by participants and those in response to the suggestion cards. The thematic framework is reported in Table 3.6.

- Coding the content of each interview according to the thematic framework. I coded all of the interviews and Rachel Fox coded four interviews to ensure agreement.

- Developing charts to summarise each participant's transcript that was relevant to each section of the framework. One row was used for each participant interviewed, and one column was used for each code within the framework. After reviewing the relevant interview data, I summarised it and made references to the original transcript where there were exemplary quotes. An excerpt from one of the charts is reported in Table 8.1. Rachel Fox also charted the four interviews that she had coded in order to ensure the summary of the interview was appropriate to the data.

- Mapping and interpretation of the data to answer the research question. This involved studying each chart carefully to identify characteristic views shared between the participants or groups of participants. Where differences and deviant cases were observed, I attempted to understand in which ways they were different and why, according to the information provided. I made additional research notes and discussed the emerging interpretations with the other authors who had read some or all of the transcripts, charts and analysis notes. We considered our clinical (obstetrics and general practice) and non-clinical backgrounds. Reflexivity is reported in Section 8.5.3. Finally, I wrote up the findings in detail, describing and explaining the phenomena observed. I also invited the participants to provide feedback on a summary of the findings and incorporated their responses into the final version.

NVivo 12 (NVivo qualitative data analysis software; QSR International Pty Ltd, version 12 [2018]) was used for coding transcripts, and the 'Framework Matrix' tool was used for generating the summary charts: this allowed me to view all coding under a certain code for a transcript and concurrently summarise it by typing in the adjacent table. I then exported the charts into Excel.

Additionally, I categorised the participants' responses to the suggestion cards as 'Strongly agree', 'Agree', 'Disagree', 'Strongly disagree' or 'Not shown card and no related comments' in order to order to demonstrate overall agreement/disagreement and where there were discrepancies across the participants. Where it was unclear, I discussed the classification with a second author.

Table 3.6: Thematic framework used to analyse the DAiSIeS interviews.

A. Diet and exercise

a. Diet
   i. General comments
   ii. Prompted suggestion card #6 Advice about how to have a healthy diet
   iii. Unprompted suggestions

b. Exercise
   i. General comments
   ii. Prompted #5 Help for you to exercise with others
   iii. Prompted #7 Advice about how to exercise with a busy schedule
   iv. Unprompted suggestions

c. Information and understanding
   i. General comments
   ii. Prompted #1 More information about the impact of healthy diet/exercise on your diabetes risk
   iii. Prompted #2 More information about the impact of healthy diet/exercise on your wider health
   iv. Unprompted suggestions

d. Family
   i. General comments
   ii. Prompted #3 More information about the impact of healthy diet/exercise on your family
   iii. Prompted #4 Suggested ways for your children and wider family to be healthier
   iv. Unprompted suggestions

e. Money
   i. General comments
   ii. Prompted #9 Advice about saving money and healthy diet/exercise
   iii. Unprompted suggestions

f. Sustainability
   i. General comments
   ii. Prompted #8 Advice about how to keep going with healthy changes to your diet/exercise
   iii. Unprompted suggestions

g. Monitoring
   i. General comments
   ii. Prompted #10 Monitoring your progress
   iii. Unprompted suggestions

B. Diabetes screening

a. Why attended or did not attend
   i. Why attended or haven't
   ii. Other

b. Booking
   i. General comments
   ii. Booking first test and prompted #11 Doctors talking more about postpartum tests while you were pregnant
   iii. Prompted #12 Invitations and reminders for tests (follow-up)
   iv. Unprompted suggestions

c. Combining appointments
   i. General comments
   ii. Prompted #18 Combining glucose testing with other appointments
   iii. Unprompted suggestions

d. GP awareness
   i. General comments
   ii. Prompted #13 Your GP knowing more about your pregnancy
   iii. Unprompted suggestions

e. Self-testing
   i. General comments
   ii. Prompted #20 Not being able to monitor your blood sugar yourself

iii. Unprompted suggestions

f. Test used
   i. General comments
   ii. Prompted #17 Shorter, more pleasant tests
   iii. Unprompted suggestions

g. Child-friendly clinics
   i. General comments
   ii. Prompted #15 More child-friendly clinics/waiting rooms
   iii. Unprompted suggestions

h. Understanding GD and postpartum glucose testing
   i. General comments about understanding GD
   ii. Prompted #14 More opportunities to understand gestational diabetes
   iii. Unprompted suggestions about understanding GD
   iv. General comments about understanding glucose testing
   v. Prompted #19 A better understanding of the purpose of glucose testing
   vi. Unprompted suggestions about understanding glucose testing

i. Test location
   i. General comments
   ii. Prompted #16 Being able to get tested at a place of your choice
   iii. Unprompted suggestions

C. Other

a. Pregnancy
b. Mode of delivery
c. Source and who
d. When
e. Suggested content of a postpartum appointment
f. Sensitivity and non-judgemental attitude
g. General postpartum experience
h. Other

When reporting the findings, I was careful to maintain the anonymity of the participants. I removed data that could link the participants to a precise location, and the age and gender or their children. Pseudonyms were carefully selected to be similar to the participants' names (for example, where Chinese participants used their adopted name in English in the interview, I selected another English name that was popular at a similar time). It was not possible to ask participants to select their own pseudonyms nor to check their acceptability. Participants' ages were randomly assigned within the appropriate age category.

Chapter 4 The incidence of type 2 diabetes after gestational diabetes

A systematic review and meta-analysis in over 310,000 affected women

In this chapter, I describe a systematic review of the percentage of women diagnosed with T2D after a pregnancy affected by GD. This updates previous estimates of both absolute and relative risk by including more studies and longer follow-up, and investigates heterogeneity. The findings both inform and underscore the importance of the chapters that follow in this thesis: postpartum testing to diagnose emerging glucose intolerance (Chapters 5, 6 and 8) and behavioural changes to reduce weight as a risk factor for T2D (Chapters 7 and 8).

The study described in this chapter was published in 2020 (212): Dennison RA, Chen ES, Green ME, et al. The absolute and relative risk of type 2 diabetes after gestational diabetes: A systematic review and meta-analysis of 129 studies. Diabetes Res Clin Pr. 2020; doi: 10.1016/j.diabres.2020.108625.

4.1 Background

As described in Chapter 1, GD increases the risk of adverse pregnancy outcomes for both mother and baby. There is also an association with higher long-term risk of future obesity, glucose intolerance and development of T2D (89). Factors such as elevated BMI, multiparity and poorer pregnancy glucose tolerance have been suggested to further increase T2D risk (125,126), while breastfeeding may have a protective effect (213).

Estimates of T2D risk will be important for clinicians, patients and policy makers in postpartum care after GD. As well as highlighting the importance of follow-up, accurate estimates of risk

and time to T2D development will inform the timing and intensity of screening strategies and lifestyle interventions.

Relative risk, or the risk ratio, reports the likelihood of being diagnosed with T2D following a pregnancy affected by GD compared to the likelihood of diagnosis for women with unaffected pregnancies. Conversely, absolute risk reports the percentage chance of diagnosis. As described by Noordzij *et al.* 2017 in their paper titled "Relative risk versus absolute risk: One cannot be interpreted without the other", an exposure can have a quite large effect on the relative risk, while both populations still have low baseline incidence in absolute terms (214). As such, although the relative risk summarises the risk in both populations, it tends to exaggerate the effect of an exposure because absolute risk is concealed. Absolute risk, such as number of cases expected in a thousand people, is advised in risk communication because it is often easier to interpret (215).

Several literature reviews have described development of T2D after GD (36,98,99,121–123). Kim *et al.* previously reviewed absolute risk, including studies published from 1965 to 2001 (99). The key finding from this review is that cumulative incidence of diabetes ranged from 2.6% to more than 70% in studies that examined women six weeks postpartum to 28 years postpartum. Incidence was reported to increase fastest during the first five years after pregnancy. These findings have been used to support development of T2D risk-reduction interventions and screening regimes in the postpartum period. It is therefore appropriate to update these estimates in light of more recently published studies with longer follow-up and changing protocols for GD and T2D diagnosis and management. Furthermore, they did not formally combine incidence estimates. Since registering and starting my review, Vounzoulaki *et al.* have compared progression rates to T2D in women with GD and healthy controls between 2000 and 2019 (registered on PROSPERO in January 2019) (121). Twenty studies were included in the meta-analysis, and the authors concluded that they did not have sufficient power to identify associations between co-variables and T2D progression.

Bellamy *et al.* 2009 and Song *et al.* 2018 (which specifically aims to update Bellamy *et al.* with data from the subsequent ten years) are large systematic reviews that investigate relative risk by many study level subgroups (98,122). They report that women who have had GD are nearly eight-times more likely to develop T2D than women who have not had affected pregnancies, whereas Vounzoulaki *et al.* reported a nearly ten times higher risk (121).

4.2 Aim

In this study, I aimed to synthesise all available data from published observational and experimental studies concerning the percentage of women developing T2D after GD and the relative risk of T2D in women with and without GD, to describe the heterogeneity of estimates of progression, and to explore study-level characteristics associated with heterogeneity.

4.3 Methods

The full methods for the literature review are described in Chapter 3.1, and the protocol was registered on PROSPERO in November 2017 (record ID CRD42017080299). The roles of the other researchers involved in the review are described below.

4.3.1 Search strategy

A literature search was conducted in September 2017 by Rebecca Ward. The search strategy in Table 3.1 was used to identify studies reporting diagnoses of T2D in women with a history of GD. I updated this search in October 2019 to identify studies published in the last two years. Additionally, I screened the reference lists of previous similar literature reviews and tested the studies they included against our inclusion criteria.

4.3.2 Inclusion criteria and study selection

I, along with five medical students at the University of Cambridge under my supervision (Eileen Chen, George Farmer, Madeline Green, Deeya Kotecha and Chloe Legard), screened the titles and abstracts and then the full texts according to our inclusion criteria. We independently screened an overlapping 10% to ensure consistency in the decision making, and discussed any discrepancies with Simon Griffin. We included studies:

- That quantified development of diabetes after GD,
- That indicated time after pregnancy of T2D assessment,
- That followed up the total or a random sample of a population with GD,
- Where diabetes diagnosis was assessed at an average six months or longer after GD-affected pregnancy,

- That reported diagnostic method and/or criteria for both GD and T2D, and
- With a sample size of 50 or more participants with GD followed up.

4.3.3 Quality assessment

Two authors independently assessed the quality of the included studies using a checklist of six questions assessing recruitment, exposure and outcome ascertainment, and follow-up (Table 3.2).

4.3.4 Statistical analysis

Two authors independently extracted key data into an Excel spreadsheet. Definitions of the study-level characteristics of the studies and participants analysed are explained in Table 4.1.

The analysis was performed using STATA 15.1. I used random-effects meta-analyses to summarise the percentage of women developing T2D overall and according to the subgroups. I then used meta-regression to quantify the extent to which a diagnosis of T2D was associated with the values of one or more study level characteristic. I also calculated the relative risk of diabetes in studies that had a comparator population and combined these across studies using random-effects meta-analysis, overall and stratified by study and maternal characteristics.

Table 4.1: Definitions of the study-level variables used in the meta-analysis of the incidence of type 2 diabetes after gestational diabetes.

Variable	Description	Categorical variable	Continuous variable
Study characteristics			
Region	Geographical region to represent the ethnic makeup of each region and, additionally, facilitate distribution of data where possible	Australasia, Europe, Western Pacific, North America, Middle East and South Asia, Africa, Central and South America, or Multiple	NA
Follow-up duration	Mean, median or planned interval between delivery and assessment of T2D; if only the range or upper limit was reported, I estimated the mid-point (estimated follow-up was only used as a categorical variable)	<3.0, 3.0–5.9, 6.0–8.9, 9.0–11.9, or ≥12.0 years	Average years of follow-up
Method to identify GD	Whether glycaemic tests were performed within the study to identify GD (e.g. OGTT), or whether other sources such as medical records from hospitals, insurance data or self-report were used	Medical records or self-report, or glycaemic test	NA

Sensitivity of GD diagnosis	GD diagnostic criteria classified as low sensitivity (FPG ≥5.8 mmol/l), high sensitivity (FPG <5.8 mmol/l), or a clinical diagnosis based on author consensus. If criteria changed during the study, the one used for the greatest proportion of time informed sensitivity	Clinical, low, or high	NA
Method to classify T2D	Whether glycaemic tests were performed within the study to classify T2D (e.g. OGTT or HbA_{1c} test), or whether other sources such as medical records from hospitals, insurance data or self-report were used	Medical records or self-report, or glycaemic test	NA
Sensitivity of T2D diagnosis	T2D diagnostic criteria classified as low sensitivity (FPG ≥7.8 mmol/l), high sensitivity (FPG <7.8 mmol/l), or a clinical diagnosis based on author consensus. If criteria changed during the study, the one used for the greatest proportion of time informed sensitivity	Clinical, low, or high	NA
Year of pregnancy	Midpoint of the year of GD diagnosis or delivery eligible (the year 2003 was the median across the studies, so the year 2000 was used for the binary variable)	Before 2000, or during/after 2000	Median year of pregnancy
Quality assessment score	Quality assessment based on a score out of 6	Low quality (score 0–2/6), medium quality (score 3–4/6), or high quality (score 5–6/6)	NA
Maternal demographics			
Ethnicity	Percentage of the study population that was White European, Caucasian, non-Hispanic White (or similar); if participants' ethnicity was not reported, it was inferred based on census data for the study setting (used in the binary variable only)	Estimated majority White European, or estimated majority not White European	Percentage of the study population reported to be White European
Age at delivery	Average age at delivery; this was estimated using age at another timepoint if not reported (31.8 years was the mean age at delivery across the studies, so 32 years was used for the binary variable)	<32 years, or ≥32 years	Average age at delivery
Age at follow-up	Average age at T2D assessment; this was estimated using age at another timepoint if not reported (37.7 years was the mean age at follow-up across the studies, so 38 years was used for the binary variable)	<38 years, or ≥38 years	Average age at follow-up
Pre-pregnancy BMI	Average BMI before pregnancy (25.9 kg/m^2 was the mean BMI before pregnancy across the studies, and 25 kg/m^2 was used to define average or overweight)	<25 kg/m^2, or ≥25 kg/m^2	Average pre-pregnancy BMI
BMI at follow-up	Average BMI at T2D assessment (27.8 kg/m^2 was the mean BMI at follow-up across the studies, and 25 kg/m^2 was used to define average or overweight)	<25 kg/m^2, or ≥25 kg/m^2	Average BMI at follow-up

Percentage nulliparous at index pregnancy	Average percentage for which the index pregnancy was their first pregnancy or delivery (37.6% was the mean percentage across the studies, so 35% was used for the binary variable)	<35%, or ≥35%	Average percentage who were nulliparous at index pregnancy
Family history of diabetes	Average percentage reporting diabetes in their family history (53.4% was the mean percentage across the studies, so 50% was used for the binary variable)	<50%, or ≥50%	Average percentage with family history of diabetes

FPG: fasting plasma glucose; NA: not appropriate; OGTT: oral glucose tolerance test.

4.4 Results

4.4.1 Literature review

The literature search identified 25,789 studies after removal of duplicates. We reviewed 518 full texts and included 129 citations from the literature search and reference lists (Figure 4.1). Seventy seven studies were excluded because they reported data from the same population as an included study. The percentage developing T2D was reported in 310,214 women with a history of GD, plus 4,155,247 parous women without GD. Appendix 5 reports details of the 129 included studies.

4.4.2 Study-level characteristics

4.4.2.1 Characteristics of the included studies

Study-level characteristics are summarised in Table 4.2. Sixty one studies (47%) were based in Europe and 61 studies (47%) followed up more than 200 participants with GD. The date of pregnancy ranged from 1979 to 2018, and 45 studies (35%) included a non-GD comparator group. Thirteen studies involved interventions, mostly during pregnancy. The median duration of follow-up was 5.0 years (range 0.6 to 29.9 years). Most studies fell into the less than 3.0 years or 3.0 to 5.9 years follow-up categories (n=38 [29%] and n=44 [34%], respectively).

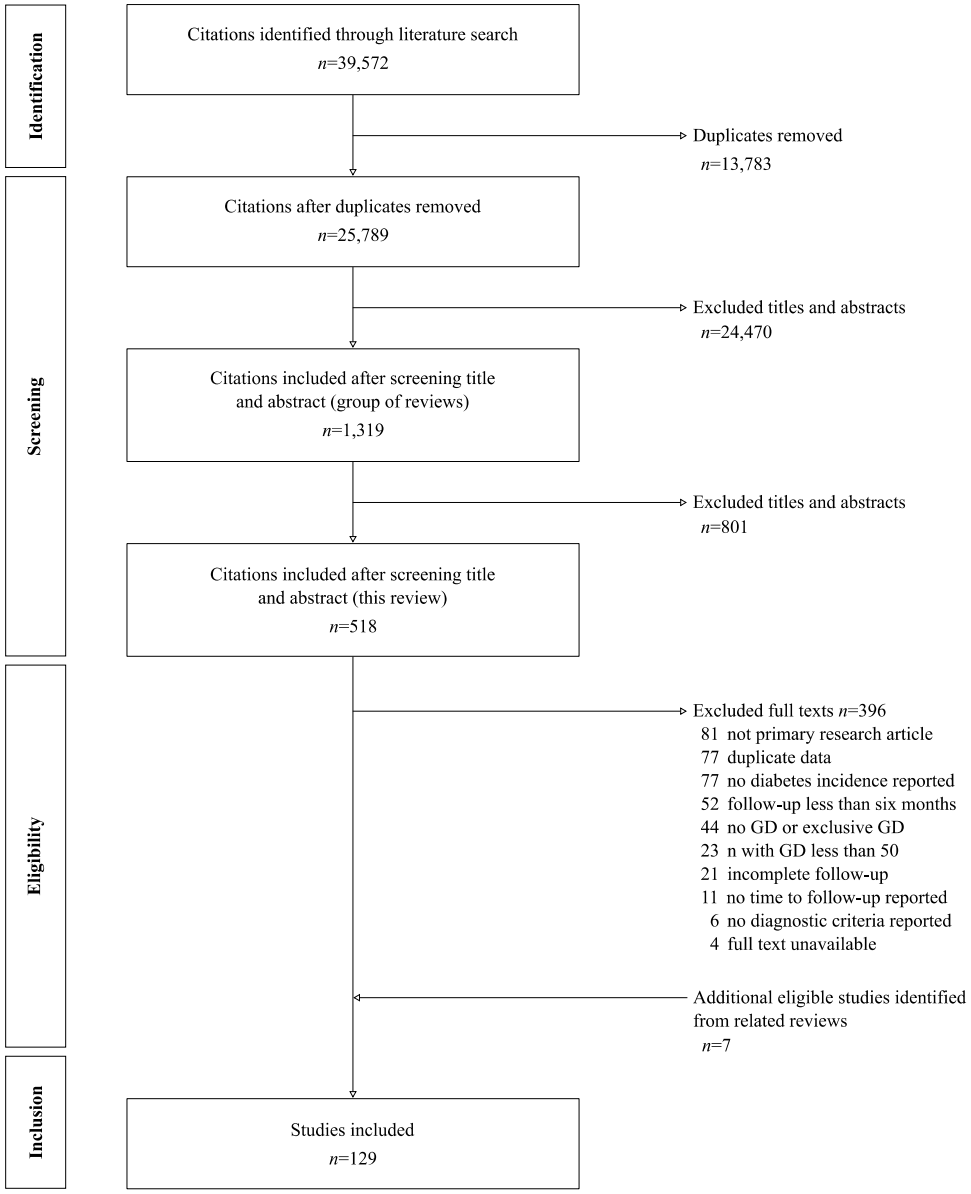


Figure 4.1: PRISMA diagram for the incidence of type 2 diabetes screening after gestational diabetes systematic review.

Table 4.2: Summary of study-level characteristics of studies included in the meta-analysis.

	N studies	% or median [IQR]
Sample size with GD (followed up)	129	195 [110–489]
Sample size without GD (followed up)	45	388 [71–6,359]
Region		
Africa	1	0.8
South Africa	1	0.8
Australasia	8	6.2
Australia	8	6.2
Central and South America	3	2.3
Brazil	1	0.8
Mexico	1	0.8
Trinidad	1	0.8
Europe	61	47.3
Austria	1	0.8
Belgium	1	0.8
Croatia	2	1.6
Czech Republic	1	0.8
Denmark	3	2.3
Finland	6	4.7
France	2	1.6
Germany	5	3.9
Greece	1	0.8
Ireland	1	0.8
Italy	6	4.7
Netherlands	2	1.6
Norway	1	0.8
Poland	7	5.4
Portugal	1	0.8
Spain	6	4.7
Sweden	6	4.7
Turkey	3	2.3
UK	6	4.7
Middle East and South Asia	13	10.1
India	4	3.1
Iran	4	3.1
Israel	1	0.8
Saudi Arabia	2	1.6
Sri Lanka	2	1.6
North America	29	22.5
Canada	10	7.8
US	19	14.7
Western Pacific	13	10.1
China	1	0.8
Hong Kong	1	0.8
Japan	2	1.6
Malaysia	1	0.8
South Korea	5	3.9
Taiwan	2	1.6
Thailand	1	0.8
Multiple	1	0.8
Multiple	1	0.8
Average duration of follow-up (years)	108	5.0 [2.1–7.4]

Method to identify GD		
Medical records or self-report	93	72.1
Glycaemic test	36	27.9
Sensitivity of GD diagnosis		
Clinical	32	24.8
Low	34	26.4
High	63	48.8
Method to classify T2D		
Medical records or self-report	50	38.8
Glycaemic test	79	61.2
Sensitivity of T2D diagnosis		
Clinical	26	20.2
Low	16	12.4
High	87	67.4
Median year of pregnancy	119	2003 [1996–2008]
Study quality		
Low quality (score 0–2/6)	13	10.1
Medium quality (score 3–4/6)	91	70.5
High quality (score 5–6/6)	25	19.4

IQR: interquartile range.

Most cases of GD were identified by OGTTs performed during the study (n=36 [28%]) or recorded in medical records (n=86 [67%]). However, many different diagnostic criteria were used (varying by timing, dose of glucose administered, and glycaemic cut-offs); Carpenter and Coustan (23), Australasian Diabetes in Pregnancy Society (216), ADA (217–220), and WHO (199,221–223) (various years) criteria were frequently reported alongside local protocols. According to the definitions described in Table 4.1, 34 studies (26%) used low sensitivity and 63 (49%) used high sensitivity tests, and the remainder were grouped as clinical diagnoses.

To assess T2D status, glycaemic tests such as 75g OGTT or HbA_{1c} alongside multiple different criteria were used frequently (n=79 [61%]); high sensitivity tests were most common (n=87 [67%]). Clinical diagnoses included review of medical records, diabetes registers, or reimbursement for diabetes medication records.

Ninety one (71%) studies were medium quality and 25 (19%) were high quality. Median score in the quality assessment was 4/6. The most common reasons for reduced quality were high loss to follow-up (n=63 [49%]) and no assessment of pre-existing T2D (n=61 [47%]; Figure 4.2).

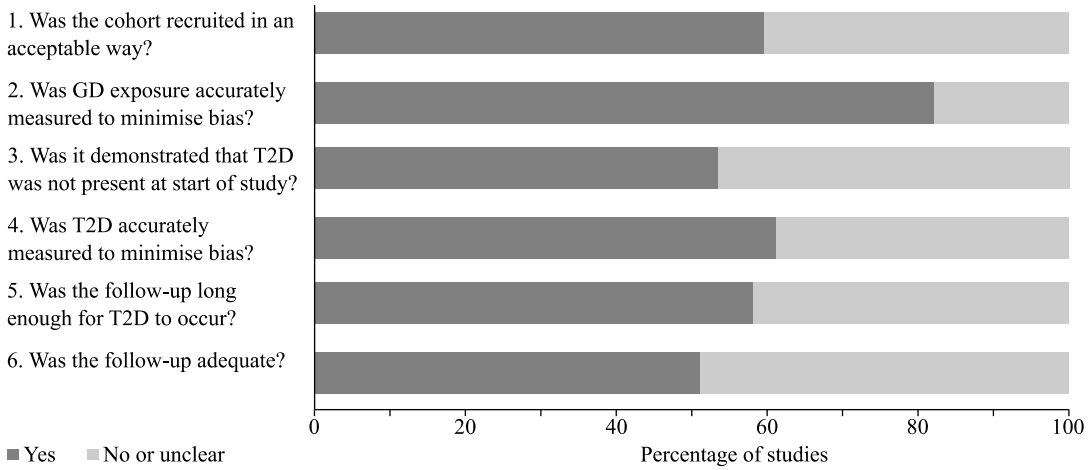


Figure 4.2: Summarised results of the quality assessment for the incidence of type 2 diabetes screening after gestational diabetes systematic review.

Table 3.2 shows for full definitions and scoring of quality assessment criteria.

4.4.2.2 Characteristics of the included participants

Study-level maternal characteristics are summarised in Table 4.3. Among women with GD, average age was 31.8 years at delivery (range 18.7 to 38.5 years; data available in n=103 studies) and 37.7 years at follow-up (30.2 to 52.2 years; n=96). In studies clearly reporting participants' ethnicity, 44.9% were White European (0 to 100%; n=78). I estimated that 57% of studies (n=74) included populations in which the majority of women were White European. Participants were often overweight: average BMI before pregnancy was 25.9 kg/m^2 (range 21.0 to 32.4 kg/m^2; n=41) while the average at follow-up was 27.8 kg/m^2 (range 22.7 to 35.0 kg/m^2; n=46). At the index pregnancy, 37.6% of participants were nulliparous (range 9.7 to 100.0%; n=37). Fifty three percent of participants reported a family history of diabetes (range 7.2 to 100%; n=60).

Table 4.3: Summary of study-level characteristics of participants included in the meta-analysis.

	N studies	% or mean [range]
Ethnicity		
Average percentage White European	78	44.9 [0.0–100.0]
Estimated majority White European	74	57.4
Average age at delivery (years)	103	31.8 [18.7–38.5]
Average age at follow-up (years)	96	37.7 [30.2–52.2]
Average pre-pregnancy BMI (kg/m^2)	41	25.9 [21.0–32.4]
Average BMI at follow-up (kg/m^2)	46	27.8 [22.7–35.0]
Average percentage who were nulliparous at index pregnancy	37	37.6 [9.7–100.0]
Average percentage with family history of diabetes	60	53.4 [7.2–100.0]

BMI: body mass index.

4.4.3 Absolute incidence of type 2 diabetes after gestational diabetes

Overall, 17.0% (95% CI 15.1 to 19.0%; I^2 99.3%) of women across the studies developed T2D after GD. In the remainder of this section, I describe how this estimate varied according to study-level variables. It ranged from 0.0% in a study with an average 1.5 years follow-up (n=68 followed up) (224) to 93.4% at 29.9 years follow-up in a high-risk population (n=332) (225).

Percentage developing T2D increased in a near-linear way as study-level duration of follow-up increased (Figure 4.3). A third of women developed T2D within 15 years of pregnancy.

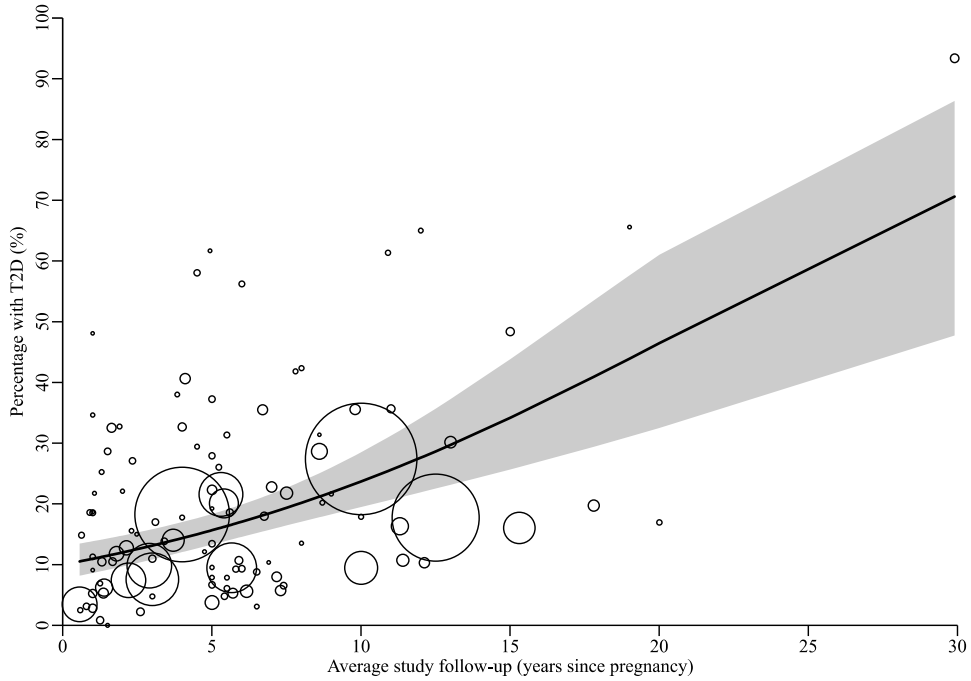


Figure 4.3: Scatter plot showing the percentage of women developing type 2 diabetes after gestational diabetes by average study follow-up duration.

Size of circle indicates weight given to each study (based on number of women followed up); line of best fit and 95% confidence region (grey shaded area) estimated from meta-regression. N=108 studies and 226,497 women.

Studies in Central and South America and Africa had the highest percentage diagnosed with T2D (47.7% [95% CI 31.9 to 63.8%]; I^2 84.0%, and 31.3% [95% CI 24.4 to 39.2%]; I^2 100.0%, respectively) while those in Europe and Australasia had the lowest (12.8% [95% CI 9.7 to 16.8%]; I^2 99.1%, and 12.7% [95% CI 7.5 to 20.8]; I^2 96.7%, respectively; Figure 4.4 and Figure 4.5).

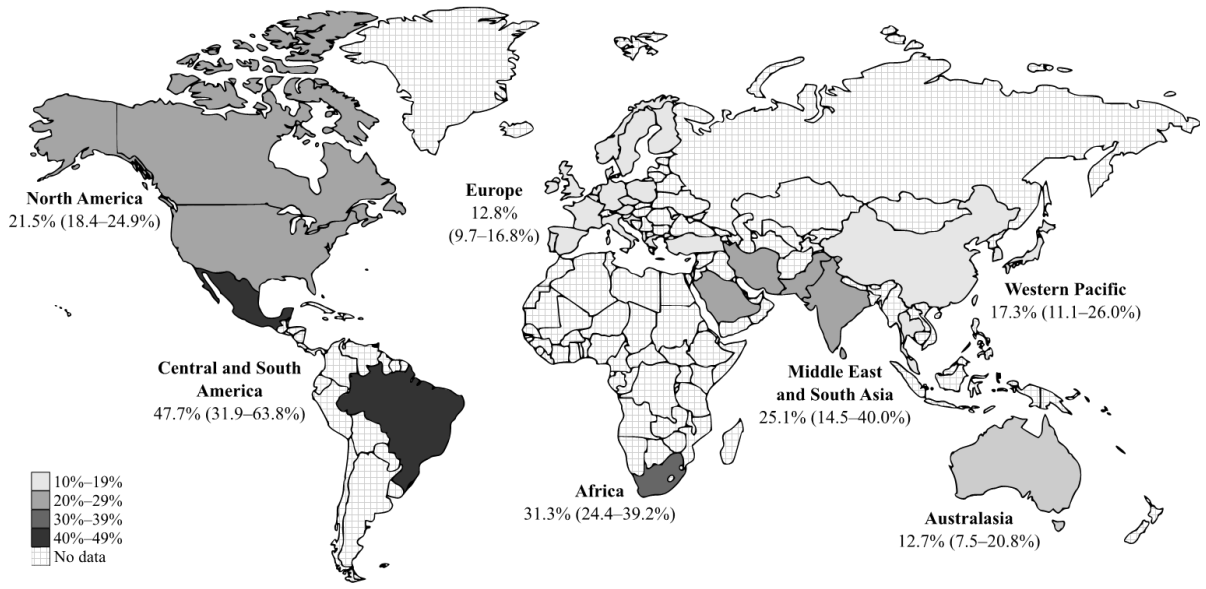


Figure 4.4: Map showing the crude percentage and 95% confidence intervals of women with type 2 diabetes after gestational diabetes by region, estimated using random-effects meta-analysis.

Australasia: 8 studies, 7,081 women; Europe: 61 studies, 96,773 women; Western Pacific: 13 studies, 8,416 women; North America: 29 studies, 183,533 women; Middle East and South Asia: 13 studies, 13,327 women; Africa: 1 study, 150 women; Central and South America: 3 studies, 271 women.

Figure 4.5 and the corresponding univariable analysis in Table 4.4 show that progression to T2D did not clearly vary with GD or T2D diagnostic method or sensitivity, or study quality (see Section 4.4.3.1). However, there was a tendency for studies that relied on a clinical or low sensitivity diagnosis to report higher percentages with T2D than highly sensitive GD diagnoses. Studies in which women were pregnant, on average, before the year 2000 reported higher percentages with T2D as shown in Figure 4.6A (22.0% [95% CI 18.9 to 25.5%]; I^2 98.6, and 13.3% [95% CI 11.0 to 15.9%]; I^2 99.5, respectively).

Figure 4.7 and the corresponding univariable analysis in Table 4.4 show the percentage developing T2D after GD according to study-level maternal demographics. Diagnosis of T2D was higher in studies considering women who were not White European, older at follow-up (reflecting longer duration of follow-up), less frequently nulliparous, and had a higher BMI at follow-up. Scatter plots showing the percentage of women developing T2D after GD by these variables are shown in Figure 4.6B–E. Age at delivery, pre-pregnancy BMI, and the proportion of women with a family history of diabetes did not appear to influence the estimates.

Subgroup	N studies	N participants	Percent (95% CI)	I^2
Region				
Australasia	8	7,081	12.7 (7.5–20.8)	96.7
Europe	61	96,773	12.8 (9.7–16.8)	99.1
Western Pacific	13	8,416	17.3 (11.1–26.0)	98.0
North America	29	183,533	21.5 (18.4–24.9)	99.5
Middle East and South Asia	13	13,327	25.1 (14.5–40.0)	98.7
Africa	1	150	31.3 (24.4–39.2)	100.0
Central and South America	3	271	47.7 (31.9–63.8)	84.0
Multiple	1	663	10.7 (8.6–13.3)	100.0
Average follow-up duration				
<3.0 years	38	28,734	12.9 (10.0–16.5)	97.3
3.0–5.9 years	44	152,531	14.9 (11.6–18.9)	99.5
6.0–8.9 years	22	7,706	18.3 (14.1–23.3)	95.9
9.0–11.9 years	13	67,167	21.8 (16.0–29.2)	98.9
≥12.0 years	12	54,076	33.9 (26.1–42.7)	99.5
Method to identify GD				
Medical records or self report	93	303,047	17.8 (15.6–20.2)	99.5
Glycaemic test	36	7,167	14.5 (10.9–19.2)	95.7
Sensitivity of GD diagnosis				
Clinical	32	248,111	20.5 (16.3–25.4)	99.8
Low	34	15,190	19.3 (14.4–25.3)	97.9
High	63	46,913	14.2 (12.1–16.6)	97.4
Method to classify T2D				
Medical records or self report	50	290,678	14.9 (12.3–17.8)	99.7
Glycaemic test	79	19,536	18.3 (15.2–21.8)	96.7
Sensitivity of T2D diagnosis				
Clinical	26	253,865	14.5 (11.3–18.5)	99.8
Low	16	3,715	21.0 (15.0–28.7)	95.5
High	87	52,634	17.0 (14.4–20.0)	97.9
Median year of pregnany				
Before 2000	50	71,967	22.0 (18.9–25.5)	98.6
During/after 2000	69	236,109	13.3 (11.0–15.9)	99.5
NR	10	2,138	21.8 (14.8–30.9)	94.6
Quality assessment score				
Low quality (score 0–2/6)	13	42,826	12.1 (8.2–17.5)	94.4
Medium quality (score 3–4/6)	91	184,308	17.8 (15.7–20.1)	99.1
High quality (score 5–6/6)	25	83,080	16.8 (10.5–25.8)	99.6

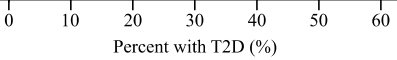


Figure 4.5: Summary random-effects meta-analyses of the percentage of women with gestational diabetes developing type 2 diabetes by study-level study characteristics.

Diamonds indicate summary percentage with T2D and the 95% confidence interval (CI). NA: not appropriate; NR: not reported.

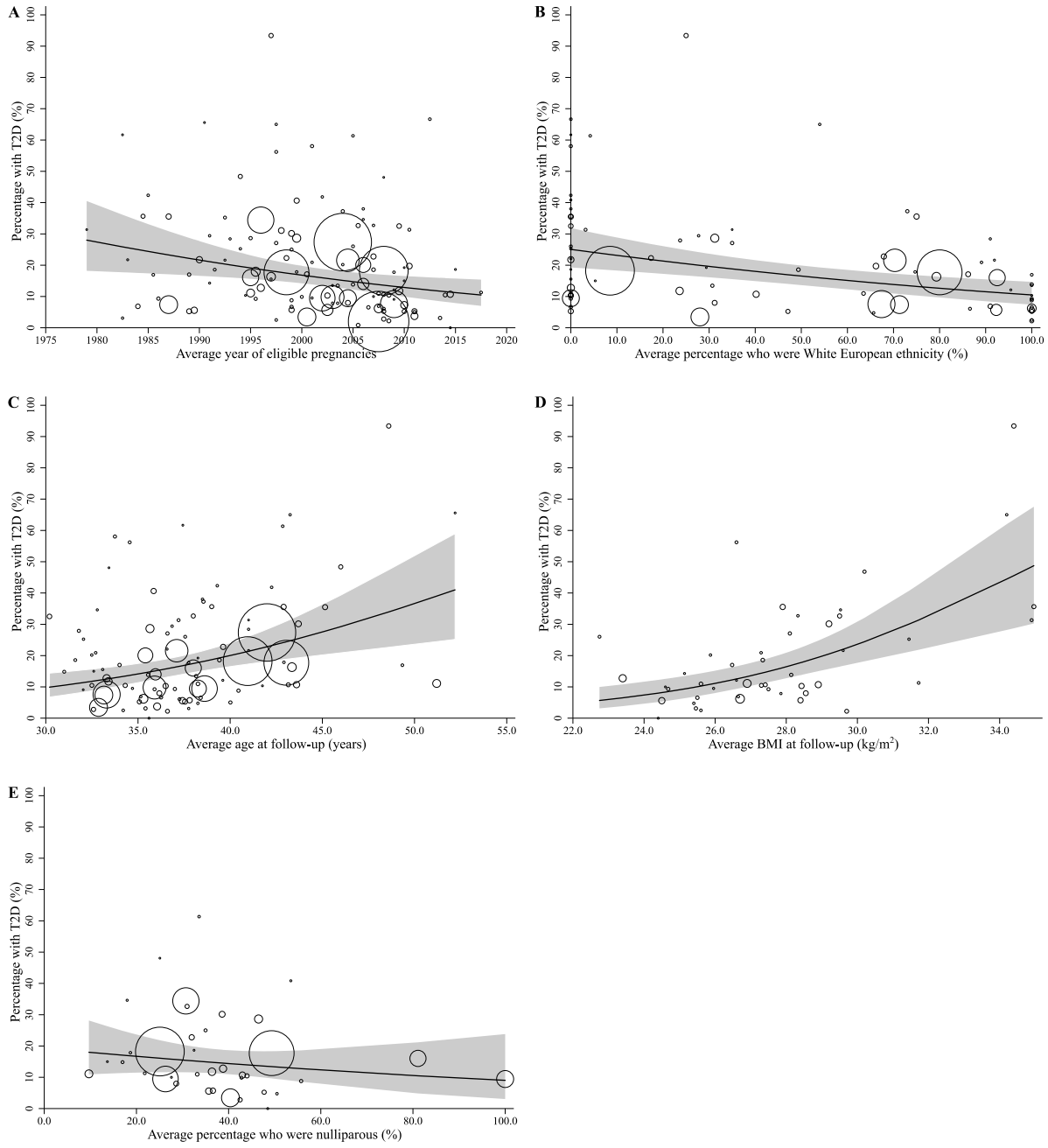


Figure 4.6: Scatter plots showing the percentage of women developing type 2 diabetes after gestational diabetes by average study-level (A) year of eligible pregnancies, (B) percentage who were White European ethnicity, (C) age at follow-up, (D) BMI at follow-up, and (E) percentage who were nulliparous.

Size of circle indicates weight given to each study (based on number of women followed up); line of best fit and 95% confidence region (grey shaded area) estimated from meta-regression.

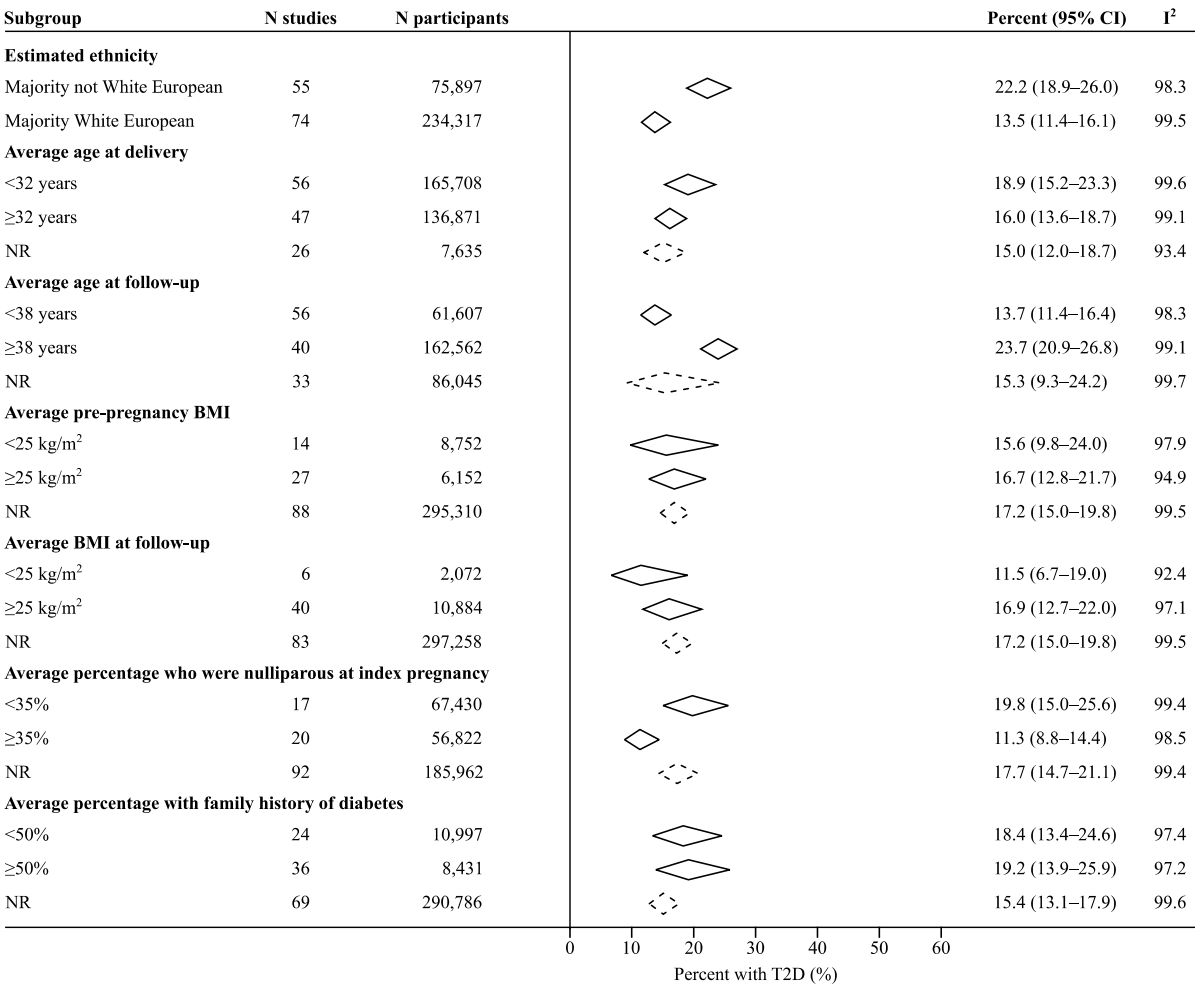


Figure 4.7: Summary random-effects meta-analyses of the percentage of women with gestational diabetes developing type 2 diabetes by study-level maternal demographic characteristics.

Diamonds indicate summary percentage with T2D and the 95% confidence interval (CI). BMI: body mass index; NR: not reported.

As indicated by the I^2 values in Figure 4.5 and Figure 4.7, heterogeneity was high in subgroup analyses, with I^2 ≥84.0% for study characteristics and ≥92.4% for maternal demographics. After adjusting for follow-up duration and ethnicity in the meta-regression, the associations with diabetes development from univariable analysis were slightly attenuated for most characteristics (Table 4.4). Overall, ethnicity, follow-up duration and BMI at follow-up had greatest influence on estimates of T2D development, although residual heterogeneity remained high in these models. Adjusting for follow-up duration, White European populations had 57% lower percentage developing T2D compared to non-White European populations. Adjusting for ethnicity, percentage developing T2D was 12% higher for each additional year of follow-up after pregnancy. For each unit higher BMI at follow-up the adjusted percentage developing

T2D was 18% higher (compared to 10% higher for each unit of BMI before pregnancy, which was not statistically significant).

Table 4.4: Associations of categorical and/or continuous study and maternal characteristics with the incidence of type 2 diabetes after gestational diabetes.

			Univariable		Multivariable	
	N studies	N women	Odds ratio [95% CI]	p value	Odds ratio [95% CI]	p value
Study characteristics						
Region						
Australasia	8	7,081	0.51 [0.22–1.18]	0.114	0.78 [0.35–1.73]	0.541
Europe	61	96,773	0.54 [0.34–0.86]	0.010	0.95 [0.57–1.57]	0.837
Western Pacific	13	8,416	0.77 [0.39–1.52]	0.444	0.80 [0.41–1.55]	0.503
North America	29	183,533	Ref		Ref	
Middle East and South Asia	13	13,327	1.24 [0.62–2.46]	0.539	1.28 [0.65–2.51]	0.467
Africa	1	150	1.67 [0.21–13.28]	0.624	1.66 [0.25–11.23]	0.600
Central and South America	3	271	3.39 [0.97–11.83]	0.055	3.51 [1.10–11.23]	0.035
Multiple	1	663	0.44 [0.056–3.44]	0.430	0.22 [0.03–1.54]	0.125
Average duration of follow-up (per year)*	108	226,497	1.11 [1.07–1.15]	<0.001	1.12 [1.08–1.16]	<0.001
<3.0 years	38	28,734	Ref		Ref	
3.0–5.9 years	44	152,531	1.19 [0.75–1.89]	0.458	1.39 [0.91–2.15]	0.129
6.0–8.9 years	22	7,706	1.49 [0.85–2.60]	0.158	1.75 [1.04–2.93]	0.035
9.0–11.9 years	13	67,167	1.91 [0.99–3.70]	0.053	2.44 [1.32–4.52]	0.005
≥12.0 years	12	54,076	3.58 [1.81–7.05]	<0.001	5.15 [2.71–9.80]	<0.001
Method to identify GD						
Medical records or self-report	93	303,047	Ref		Ref	
Glycaemic test	36	7,167	0.79 [0.51–1.21]	0.275	0.89 [0.61–1.31]	0.561
Sensitivity of GD diagnosis						
Clinical	32	248,111	Ref		Ref	
Low	34	15,190	0.93 [0.55–1.57]	0.787	0.81 [0.50–1.33]	0.410
High	63	46,913	0.63 [0.40–1.00]	0.050	0.76 [0.50–1.17]	0.212
Method to classify T2D						
Medical records or self-report	50	290,678	Ref		Ref	
Glycaemic test	79	19,536	1.29 [0.87–1.90]	0.202	1.24 [0.87–1.75]	0.232
Sensitivity of T2D diagnosis						
Clinical	26	253,865	Ref		Ref	
Low	16	3,715	1.58 [0.79–3.13]	0.191	1.37 [0.72–2.61]	0.332
High	87	52,634	1.22 [0.76–1.97]	0.410	1.08 [0.69–1.71]	0.719
Median year of pregnancy (per year)	119	308,085	0.97 [0.95–0.99]	0.011	0.98 [0.96–1.00]	0.064
Before 2000	50	71,967	Ref		Ref	
During/after 2000	69	236,109	0.55 [0.37–0.81]	0.003	0.68 [0.46–1.00]	0.047
Quality assessment score						
Low quality (score 0–2/6)	13	42,826	Ref		Ref	
Medium quality (score 3–4/6)	91	184,308	1.69 [0.88–3.24]	0.116	1.03 [0.56–1.90]	0.920
High quality (score 5–6/6)	25	83,080	1.60 [0.76–3.38]	0.217	1.18 [0.59–2.35]	0.645

Maternal demographics						
Ethnicity (per 10% White European)	78	139,398	0.90 [0.85–0.95]	<0.001	0.87 [0.83–0.92]	<0.001
Estimated majority not White European	55	75,897	Ref		Ref	
Estimated majority White European	74	234,317	0.54 [0.37–0.79]	0.001	0.43 [0.30–0.61]	<0.001
Average age at delivery (per year)	103	302,579	0.91 [0.84–0.99]	0.022	0.97 [0.89–1.05]	0.425
<32 years	56	165,708	Ref		Ref	
≥32 years	47	136,871	0.79 [0.50–1.25]	0.314	0.94 [0.62–1.43]	0.788
Average age at follow-up (per year)	96	224,169	1.09 [1.04–1.14]	0.001	1.04 [0.90–1.20]	0.592
<38 years	56	61,607	Ref		Ref	
≥38 years	40	162,562	1.94 [1.25–3.00]	0.003	1.20 [0.70–2.05]	0.508
Average pre-pregnancy BMI (per kg/m^2)	41	14,904	1.04 [0.91–1.18]	0.593	1.10 [0.93–1.31]	0.566
<25 kg/m^2	14	8,752			Ref	
≥25 kg/m^2	27	6,152	1.08 [0.56–2.07]	0.811	1.32 [0.62–2.80]	0.462
Average BMI at follow-up (per kg/m^2)	46	12,956	1.25 [1.13–1.39]	<0.001	1.18 [1.05–1.34]	0.008
<25 kg/m^2	6	2,072	Ref		Ref	
≥25 kg/m^2	40	10,884	1.57 [0.51–4.83]	0.424	1.50 [0.50–4.56]	0.462
Average percentage who were nulliparous at index pregnancy	37	124,252	0.99 [0.97–1.01]	0.318	0.98 [0.96–1.00]	0.061
<35%	17	67,430	Ref		Ref	
≥35%	20	56,822	0.51 [0.29–0.91]	0.024	0.44 [0.24–0.81]	0.010
Average percentage with family history of diabetes	60	19,428	1.01 [0.99–1.03]	0.222	1.01 [0.99–1.02]	0.313
<50%	24	10,997	Ref		Ref	
≥50%	36	8,431	1.06 [0.58–1.95]	0.848	1.18 [0.68–2.04]	0.547

Data were transformed to the logit scale for analyses. Multivariable meta-regression adjusted for whether the majority of the study population is White European ethnicity and duration of follow-up (<3.0, 3.0–5.9, 6.0–8.9, 9.0–11.9, or ≥12.0 years). I^2 remained high (87.9–99.4% in the univariable model; 95.8–99.2% in the multivariable model).

** Only adjusted for whether the majority of the study population is White European.*

BMI: body mass index; CI: confidence interval; ref: reference.

4.4.3.1 Sensitivity analyses

I conducted two sensitivity analyses: the first to understand the influence of one study with long follow-up, and the second to determine whether the overall estimate varied according to studies meeting each quality assessment question.

Only one study had more than 20 years follow-up: Carr *et al.* 2006 reported a high incidence of 93.4% diagnosed with T2D by 29.9 years after GD pregnancy (n=332) (225). I therefore investigated how influential this study was by comparing the original analyses to those when it was excluded.

In the adjusted meta-regression, when Carr *et al.* 2006 was excluded, the odds ratio for percentage developing T2D for each additional year of follow-up after pregnancy was 1.10 (95% CI 1.05 to 1.15, p<0.001, I^2 98.5%) versus 1.12 (95% CI 1.08 to 1.16, p<0.001, I^2 98.6%) in the original analysis. The odds ratio for percentage developing T2D for White European populations compared to non-White European populations was 0.47 (95% CI 0.33 to 0.66, p<0.001, I^2 99.0%) versus 0.43 (95% CI 0.30 to 0.61, p<0.001, I^2 99.0%) in the original analysis. The odds ratio for percentage developing T2D for each unit higher BMI at follow-up was 1.15 (95% CI 1.03 to 1.29, p=0.016, I^2 95.6%) versus 1.18 (95% CI 1.05 to 1.34, p=0.008, I^2 96.2%) in the original analysis.

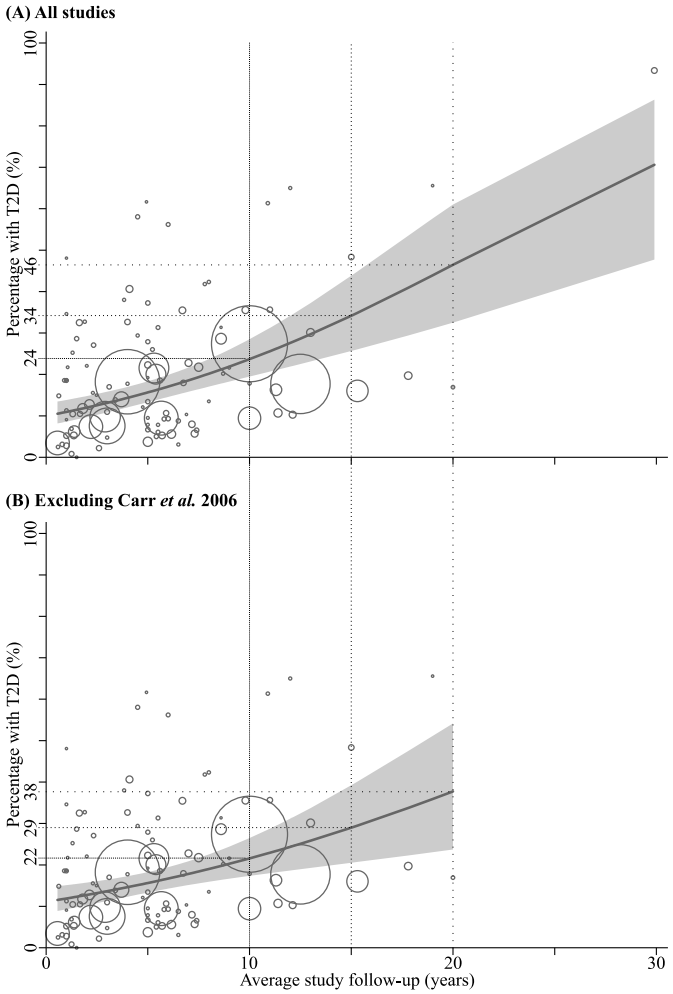


Figure 4.8: Scatter plots showing the percentage of women developing type 2 diabetes after gestational diabetes by average study follow-up duration (A) with and (B) without Carr *et al.* 2006.

Additionally, I compared the scatter plots showing the percentage of women developing T2D after GD by average study follow-up duration with and without Carr *et al.* 2006 (Figure 4.8). Below 15 years follow-up, minimal influence of this study can be seen. At 15 years, the graph including Carr *et al.* has approximately 5% higher percentage with T2D. At 20 years postpartum, this difference is approximately 8%.

I therefore concluded that Carr *et al.* had a small influence on this analysis, particularly after 15 years postpartum.

Furthermore, although I found that most studies were medium quality in the quality assessment, I sought to investigate whether quality in each domain assessed affected the effect estimates.

Table 4.5 shows the effect of each question for the overall estimate and the adjusted meta-regression. As can be seen by the overlapping confidence intervals, there was not a significant difference between the subgroups (with an exception in the exposure assessment) and estimates of risk only changed slightly in the sensitivity analyses compared to the original analysis, which increases our confidence in the findings.

Table 4.5: Sensitivity analysis of overall crude percentage of women with gestational diabetes developing type 2 diabetes according to each quality assessment domain.

	N studies	Overall percentage with T2D [95% CI]	N studies	Odds ratio for incidence per year follow-up* [95% CI]
All studies	*129*	*16.96 [15.10–19.00]*	*108*	*1.12 [1.08–1.16]*
1. Was the cohort recruited in an acceptable way?				
Yes	77	16.85 [14.28–19.78]	61	1.10 [1.04–1.17]
No	52	16.98 [13.92–20.54]	46	1.13 [1.07–1.19]
2. Was GD exposure accurately measured to minimise bias?				
Yes	105	15.83 [13.39–18.64]	87	1.11 [1.06–1.17]
No	24	22.86 [19.28–26.87]	20	1.13 [1.04–1.22]
3. Was it demonstrated that T2D was not present at start of study?				
Yes	68	16.72 [13.99–19.86]	55	1.12 [1.06–1.17]
No	61	17.41 [14.98–20.14]	52	1.13 [1.05–1.21]
4. Was T2D accurately measured to minimise bias?				
Yes	78	17.59 [14.46–21.23]	69	1.14 [1.09–1.20]
No	51	15.78 [13.17–18.79]	38	1.06 [0.99–1.14]
5. Was the follow-up long enough for T2D to occur?				
Yes	75	18.87 [16.09–22.00]	62	1.14 [1.08–1.20]
No	54	14.47 [12.10–17.22]	45	1.36 [1.08–1.71]
6. Was the follow-up adequate?				
Yes	66	16.62 [14.18–19.40]	52	1.10 [1.05–1.16]
No	63	17.17 [14.06–20.80]	55	1.14 [1.07–1.22]

Table 3.2 shows for full definitions and scoring of quality assessment criteria.

** Adjusted for ethnicity.*

95% CI: 95% confidence interval.

4.4.4 Relative incidence of type 2 diabetes after gestational diabetes

Women who had GD were 8.3 (95% CI 6.5 to 10.6) times more likely to develop T2D than women with normoglycaemic pregnancies, as shown in Figure 4.9 (unadjusted relative risk).

The relative risk by subgroups are shown in Table 4.6. Relative risk was particularly high in studies in Europe (16.1 [95% CI 12.4 to 21.0]) compared to studies in other regions, and in mainly White European populations (11.2 [95% CI 9.0 to 13.9]) compared to non-White

European populations. Relative risk was highest before six years postpartum (15.8 [95% CI 12.6 to 19.9]), and in studies using clinical diagnosis of T2D (16.5 [95% CI 12.9 to 21.2]).

Relative risk tended not to vary with other study-level maternal characteristics (measured in women with GD), except by BMI before pregnancy. In studies in which the average pre-pregnancy BMI was less than 25 kg/m^2, the relative risk was comparatively low (2.1 [95% CI 1.4 to 3.4]).

When three low-quality studies reporting very high relative risks were excluded, the overall relative risk remained at 8.1 (95% CI 6.3 to 10.3).

Thirteen studies reported adjusted relative analyses (odds ratios, relative risks, hazard ratios or incidence rate ratios). A history of GD statistically significantly increased T2D risk in all cases, but the magnitude of increase was highly variable. In five studies, the pooled adjusted odds ratio was 8.1 (95% CI 3.0 to 22.1), and ranged from 2.2 (95% CI 1.5 to 3.1; adjusted for age, BMI and family history of diabetes) (226) to 52.5 (95% CI 26.5 to 103.9; adjusted for age at delivery) (227). Engeland *et al.* 2011 reported an adjusted relative risk of 41 (95% CI 35 to 47; adjusted for maternal age and parity in women with GD but not preeclampsia) (228) and Sreelakshmi *et al.* 2015 reported an adjusted relative risk of 13.2 (95% CI 1.5 to 116.0; variables adjusted for unclear) (229). Five studies reported adjusted hazard ratios but two did not report the confidence intervals so could not be pooled. In the remaining three studies, the pooled adjusted hazard ratio was 14.2 (95% CI 6.6 to 30.4), and ranged from 5.36 in Canadian First Nation women (variables adjusted for unclear) (230) to 40.1 in overweight women (95% CI 34.4 to 46.6; adjusted for adjusting for maternal age, preeclampsia, parity, smoking status during pregnancy, ethnicity, socioeconomic status and GD in a subsequent pregnancy) (231). Daly *et al.* 2018 reported an adjusted incidence rate ratio of 22.0 (95% CI 18.3 to 26.3; adjusted for age, Townsend quintile, BMI and smoking status) (153).

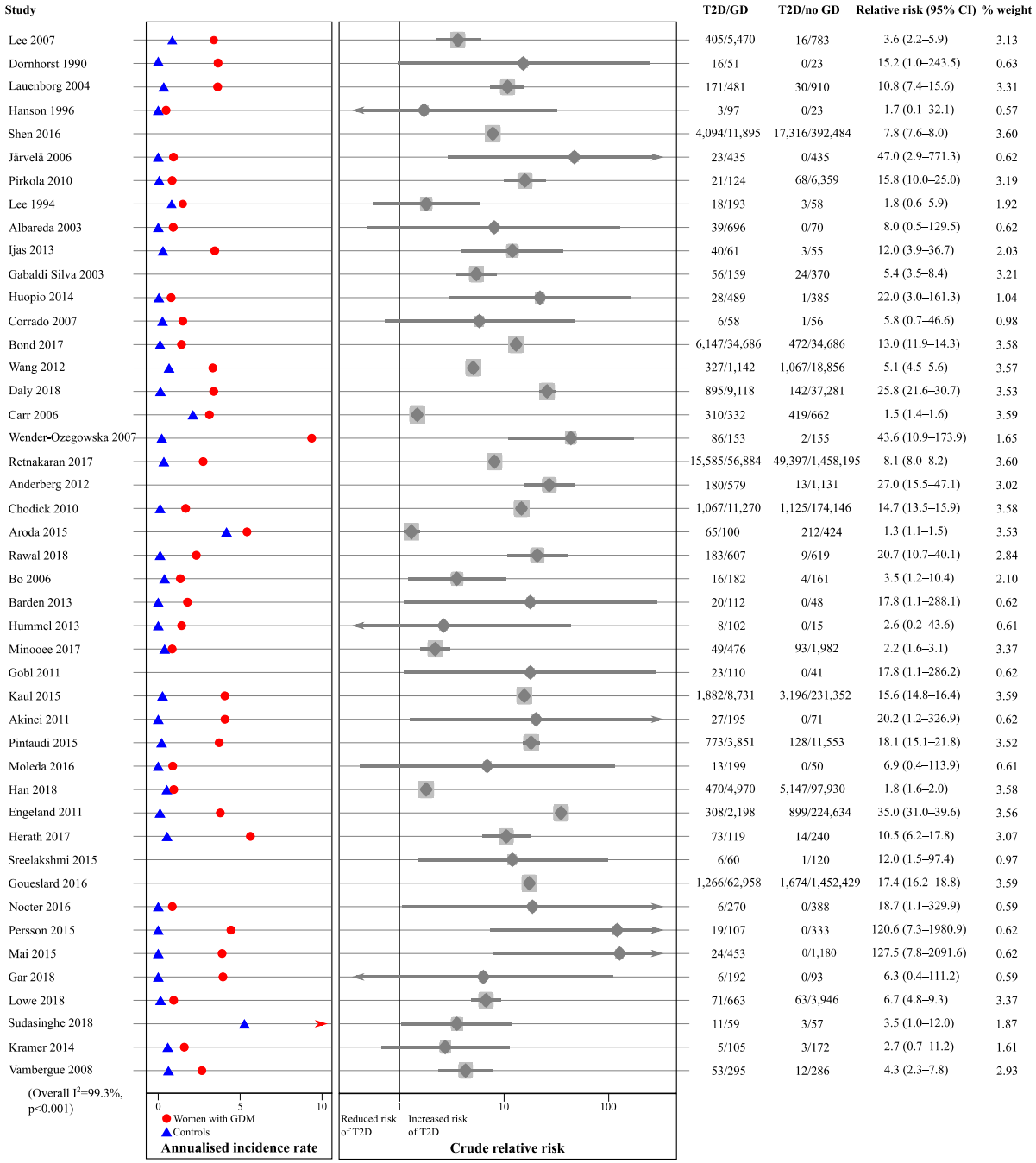


Figure 4.9: The crude relative risk of type 2 diabetes after gestational diabetes compared to pregnancies not affected by gestational diabetes.

Annualised incidence rates are not presented for studies that did not report an average follow-up duration. Grey diamonds represent the crude relative risk for each study; horizontal lines indicate 95% confidence intervals (CIs). Pale grey squares indicate the weight given to each study. Studies are ordered by date of pregnancy.

Table 4.6: Relative risk of type 2 diabetes after gestational diabetes by study-level study and maternal characteristics.

	N studies	N women with GD	N women without GD	Relative risk [95% CI]	Weight	I^2
Study characteristics						
Region						
Australasia	2	5,582	831	4.4 [1.6–12.4]	3.8	19.6%
Europe	25	83,608	1,737,556	16.1 [12.4–21.0]	44.0	85.6%
North America	8	113,875	2,136,831	5.2 [3.4–7.8]	26.7	99.8%
Western Pacific	3	5,616	99,168	3.7 [0.9–15.9]	6.1	78.8%
Middle East and South Asia	5	11,984	176,545	6.6 [2.2–19.5]	12.9	96.9%
Central and South America	1	159	370	5.4 [3.5–8.4]	3.2	NA
Multiple	1	663	3,946	6.7 [4.8–9.3]	3.4	NA
Duration of follow-up						
<3.0 years	7	15,622	39,902	11.0 [3.4–35.1]	11.3	90.9%
3.0–5.9 years	11	90,062	2,095,181	18.2 [14.4–23.1]	22.6	94.1%
6.0–8.9 years	12	3,714	20,493	5.4 [3.8–7.7]	19.9	42.4%
9.0–11.9 years	7	63,808	1,562,400	8.4 [3.8–18.5]	20.6	99.5%
≥12.0 years	8	48,281	437,271	5.8 [2.6–12.8]	25.7	99.8%
Method to identify GD						
Medical records or self-report	33	218,569	4,143,693	8.6 [6.6–11.3]	82.8	99.5%
Glycaemic test	12	2,918	11,554	7.0 [4.4–11.2]	17.2	47.8%
Sensitivity of GD diagnosis						
Clinical	15	184,364	3,700,025	8.6 [5.8–12.8]	39.4	99.7%
Low	11	3,042	11,372	6.8 [3.7–12.5]	25.8	90.1%
High	19	34,081	443,850	9.0 [6.4–12.8]	34.8	95.8%
Method to classify T2D						
Medical records or self-report	18	214,597	4,142,947	11.8 [9.2–15.1]	53.9	99.5%
Glycaemic test	27	6,890	12,300	6.3 [3.6–11.0]	46.1	96.6%
Sensitivity of T2D diagnosis						
Clinical	13	191,626	3,850,992	16.5 [12.9–21.2]	37.0	99.3%
Low	3	341	104	2.6 [0.8–9.0]	3.1	15.1%
High	29	29,520	304,151	6.3 [3.9–10.2]	59.9	98.9%
Median year of pregnancy						
Before 2000	22	58,102	458,753	7.5 [4.6–12.3]	49.4	99.4%
During/after 2000	20	162,509	3,694,054	12.1 [8.2–17.6]	42.7	99.4%
NR	3	876	2,440	2.8 [1.7–4.7]	7.9	47.1%
Quality assessment score						
Low quality (score 0–2/6)	3	437	841	24.9 [5.9–105.9]	2.2	0.0%
Medium quality (score 3–4/6)	31	143,193	2,432,843	7.8 [5.9–10.4]	73.0	99.4%
High quality (score 5–6/6)	11	77,857	1,721,563	8.9 [5.0–15.7]	24.9	99.1%
Maternal demographics						
Ethnicity (estimated)						
Majority not White European	13	19,947	299,570	5.1 [2.6–9.9]	33.4	99.5%
Majority White European	32	201,540	3,855,677	11.2 [9.0–13.9]	66.7	98.7%
Average age at delivery						
<32 years	22	137,766	2,252,083	7.0 [4.5–10.7]	57.7	99.6%
≥32 years	15	81,904	1,899,964	12.3 [7.7–19.6]	28.5	98.4%
NR	8	1,817	3,200	8.9 [3.9–20.5]	13.9	80.5%
Average age at follow-up						
<38 years	18	33,923	528,493	11.0 [6.9–17.7]	33.8	97.9%
≥38 years	18	111,004	1,778,682	6.6 [4.0–10.8]	45.8	99.6%
NR	9	76,560	1,848,072	9.4 [5.8–15.2]	20.4	98.2%

Average pre-pregnancy BMI						
<25 kg/m^2	4	6,047	98,211	2.1 [1.4–3.4]	6.9	15.4%
≥25 kg/m^2	9	1,891	8,730	14.1 [9.1–21.8]	16.9	47.2%
NR	32	213,549	4,048,306	8.1 [6.2–10.6]	76.2	99.4%
Average BMI at follow-up						
<25 kg/m^2	3	949	248	4.0 [1.1–15.0]	3.5	32.5%
≥25 kg/m^2	14	4,372	9,898	6.7 [3.2–14.0]	27.4	97.9%
NR	28	216,166	4,145,101	10.2 [8.2–12.8]	69.1	99.2%
Average percentage who were nulliparous at index pregnancy						
<35%	6	23,515	567,095	9.7 [6.0–15.6]	13.7	97.6%
≥35%	9	43,540	156,825	6.4 [2.9–14.4]	22.3	99.3%
NR	30	154,432	3,431,327	9.2 [6.3–13.5]	64.0	99.4%
Average percentage with family history of diabetes						
<50%	10	7,325	4,388	7.9 [3.7–16.9]	18.3	86.1%
≥50%	8	2,777	5,712	6.7 [2.1–21.3]	12.1	95.3%
NR	27	211,385	4,145,147	9.5 [7.5–12.1]	69.6	99.3%

NA: not appropriate; NR: not reported.

4.5 Discussion

These findings show that progression to T2D after GD is both common and highly variable, and while the relative risk is highest soon after pregnancy, the number of women diagnosed with T2D continues to increase in a near-linear and clinically important way over time. Women with GD therefore have a comparable or higher overall relative risk of T2D when compared to women who did not have GD in pregnancy than people with IGT or IFG when compared to the normoglycaemic population (232). Although having lower relative risk, non-White European women have high rates of progression, as do women who are older and overweight at follow-up. Nonetheless, many of the differences between populations and studies remain unexplained.

I report considerable heterogeneity in the meta-analysis, which I investigated through stratified analyses and study-level meta-regression. The heterogeneity, measured using the I^2 statistic, did not improve in the multivariable meta-regression, indicating that many of the differences between populations and studies were not accounted for. This may be due to variation in study design or exposure/outcome assessment that I did not adjust for, or due to diversity within the GD population. A proportion of the heterogeneity may be explained by variables that were measured in just a few studies, and some may remain unmeasured or unknown. Buchanan and Xiang describe different GD phenotypes (autoimmune, monogenic and chronic insulin

resistance) that are not currently assessed in GD diagnosis (9). It is possible that these phenotypes have different associations with development of diabetes postpartum.

Nonetheless, my findings support sustained T2D screening after GD; I did not identify a time after GD for which screening might become less clinically useful. However, low long-term attendance is often reported in routine practice (146,148), including in the UK (153–155). Non-White European and overweight women developed T2D at higher rates therefore shorter screening intervals for these populations may be considered appropriate. Further research should be done to improve precision of risk stratification and determine the clinical benefit, cost-effectiveness and acceptability of different stratified screening strategies.

Moreover, consistent with T2D risk factors in the general population, women with high BMI at follow-up had higher-than-average progression to and relative risk of T2D. The authors of the DPP suggested that participants with GD did not reduce their risk because they lost less weight than comparable high-risk women (who had had normoglycaemic pregnancies) (163). Other evidence suggests that dietary and physical activity guidelines are not adhered to after GD (233), therefore development of effective strategies to help women to manage weight in order to reduce T2D risk is important.

4.5.1 Comparison to existing literature

Following publication of the protocol for my review, Vounzoulaki *et al.* reported the incidence of T2D after GD in 20 studies (published from 2000 to 2019) (121). This study found that cumulative T2D incidence was higher, but not statistically significantly higher, in mixed ethnicity and non-White populations than in White populations (up to 16.5% [95% CI 16.2 to 16.8%]), and was higher in longer study follow-up categories. However, of note, they found that effect size was not significantly associated with mean study age, BMI, publication year or length of follow-up in the univariable meta-regression analyses and suggested this was due to a lack of power. My larger study meant that I was able to examine potential associations between these variables and others, concluding that ethnicity, time since pregnancy and BMI at follow-up were associated with diabetes risk in a multivariable analysis.

Prior to Vounzoulaki *et al.* (121), Kim *et al.* conducted an influential literature review of the cumulative incidence of T2D after GD in 2002 using similar inclusion criteria to mine (99). Adjusting for retention, they reported that cumulative incidence increased most quickly during

the first five years postpartum, plateauing after ten years. Just one study with more than 11 years follow-up was included. This is inconsistent with the findings of individual studies, such as Lee *et al.* and Albareda *et al.* (234,235) as well as Vounzoulaki *et al.* (121). I have reported a more constant increase in the crude proportion developing T2D over time, including 12 studies with more than 11 years follow-up in the meta-regression, which supports sustained follow-up efforts. They discuss how different exclusion criteria, particularly including women with symptomatic diabetes in the GD cohorts, might increase T2D diagnoses soon after pregnancy, whereas I included more studies after the immediate postpartum period. They also reported that women with GD progressed to T2D at similar rates independent of ethnicity. In contrast, I found that White European women were less likely to progress than women from other ethnic groups.

My relative risk estimate of 8.3 (95% CI 6.5 to 10.6) is based on more studies and participants (45 studies and 4,376,734 women in total) than previous recent reviews, hence is more precise but highly comparable. Bellamy *et al.* reported a relative risk of 7.4 (95% CI 4.8 to 11.5) in 20 studies published up to 2009 including 675,455 women (98); Song *et al.* reported a relative risk of 7.8 (95% CI 5.1 to 11.8) in 30 studies published up to 2017 including 2,626,905 women, alongside an adjusted odd ratio of 17.9 (95% CI 17.0 to 19.0) (122); Vounzoulaki *et al.* reported a relative risk of 9.5 (95% CI 7.1 to 12.7) in 20 studies published between 2000 and 2019 including 1,332,373 women (121). These data suggest that relative risk may be increasing over time, although again this may be explained by other factors such as changes in diagnostic thresholds. I observed similar trends across subgroups. Unlike these previous reviews, I also considered parity and family history of diabetes but they did not convincingly affect relative risk.

4.5.2 Strengths and limitations

This meta-analysis is larger than previous ones, in part, because I did not restrict study methods, language or publication year, which enabled me to report a percentage estimate of T2D risk in a large number of women with GD. This increased the analysis power and consequently the opportunity for stratified and multivariable analyses to explore heterogeneity. Furthermore, I report longer follow-up than previous reviews by including new studies and updates of studies already published. Most of the studies I included had a medium overall risk of bias in relation

to T2D outcomes (13/129 [10%] were low quality) and overall estimates of risk only changed slightly in the sensitivity analyses, which increases my confidence in the findings.

There are differing views on the relative merits of 'lumping' and 'splitting' heterogeneous studies in a systematic review. Previous studies have reported T2D risk after GD through a narrative synthesis (e.g. Zhu and Zhang 2016 (36)) as well as a meta-analysis (e.g. Vounzoulaki *et al.* (121). I judged that by identifying, synthesising and then pooling all the evidence, I could explore heterogeneity and improve understanding of the topic more than would be possible through a narrative review. Using meta-regression, I quantified the extent to which a diagnosis of T2D was associated with the values of one or more explanatory variables. It was not possible to adjust for all study characteristics therefore I adjusted for ethnicity and follow-up duration in the meta-regression. When interpreting the findings, I did not report one overall estimate without describing the range of estimates. Random-effect analyses were used to allow for differences in the effect estimate between studies (236).

One source of heterogeneity can be attributed to the inclusion of any type of study design, and prospective and retrospective studies. I included all study designs because all of the studies assessed GD exposure at baseline (i.e. diagnosed during pregnancy or after pregnancy based on blood samples that were collected during pregnancy). Follow-up then began at the time of delivery and the duration of follow-up was defined from that date of delivery to assessment of T2D status, therefore cohorts are represented in this sense. Some studies were described as cross-sectional studies but in these studies the cohorts were still defined retrospectively. Retrospective and prospective designs have different strengths and weaknesses, and subgroups were based on these attributes rather than the design. A retrospective study including all women with GD and re-measuring the majority will be less biased in some ways than a prospective study with high loss to follow-up. In the quality assessment, retrospective studies scored highly on question 6 (completeness of follow-up) but not on questions 2 and 4 (assessment of GD or T2D status) if they used medical records or self-report. Conversely, prospective studies scored a point for question 6 (completeness of follow-up) less frequently. Incidence estimates did not clearly vary by study quality according to the quality domains assessed in this study and previous reviews have not reported significant differences in risk by prospective/retrospective study design (98,121).

Across all of the studies, there may be a difference in outcomes between those that recruited women with GD during pregnancy and those that recruited postpartum. This remains an unexplored source of heterogeneity. Excluding women who progressed early (such as before eight or 13 weeks postpartum) or never remitted from the baseline cohort and therefore probably had diabetes in pregnancy rather than GD) would enable a more accurate estimate of the true incidence of T2D after GD, whereas identifying T2D diagnoses after any pregnancy during which the mother is diagnosed with GD is perhaps more relevant to clinical practice. I have taken this second approach in the main analysis. However, excluding studies that did not attempt to exclude pre-existing/previously undiagnosed T2D from the GD cohort did not significantly affect the overall incidence estimate.

I only used study-level data. Individual patient data meta-analysis might have improved confidence in the findings, but the significant additional work in obtaining individual data from 129 studies is unlikely to be feasible or to add sufficient value and policy impact to be justifiable. The use of crude subgroups reduced accuracy. For example, diagnostic sensitivity was grouped as clinical, low or high rather than by specific criteria because numerous different criteria were used. Although I investigated incidence by 15 characteristics, some characteristics that may have explained heterogeneity were not available or not reported in a usable way for all studies. For example, few studies reported data on socioeconomic status or other T2D risk factors (e.g. gestational age at onset of GD, or breastfeeding). Breastfeeding may help to prevent T2D after GD, although Rayanagoudar *et al.* did not find a significant association (126,213). In the relative risk analyses, subgroups were developed according to characteristics of women with GD only and adjusted analyses were limited.

Studies also varied by quality, as noted above, which may have influenced the analyses. In particular, a frequently observed weakness was poor percentage of the study population followed up. Previous studies report that women with fewer diabetes risk factors are more likely to receive follow-up than women with more risk factors (148), therefore I may have underestimated the percentage developing T2D because those at highest risk were not tested and T2D remained undiagnosed. However, I did not observe large differences in the estimates when only high quality studies were included according to each criteria examined in the *post hoc* sensitivity analysis (Table 4.5). Also, the relative risk of T2D was much higher in studies of women with clinical, as opposed to biochemical, T2D diagnoses. Clinical diagnoses are

made as part of routine medical care where women presenting with suspected hyperglycaemia are tested. This leads to a higher proportion diagnosed with T2D compared to when a whole cohort is recalled for a biochemical assessment.

Most of the included studies had short follow-up therefore many of the women may have been yet to develop T2D at the time of assessment. In part because I included the timepoint of studies with the most person-years follow-up, Carr *et al.* was the only study where I reported the outcome at more than 20 years follow-up (225). This study was not representative of the general GD population because all of the participants had diabetes in first-degree relatives, and inflated the estimate after 15 years postpartum. Furthermore, different factors may have confounded associations with T2D risk. For example, older studies tend to use lower sensitivity diagnostic criteria and include women with higher glucose levels than would be the case with current criteria, therefore more of the cohort are likely to develop T2D. These studies also tend to have longer follow-up, also increasing risk of developing T2D. The association between follow-up duration and development of T2D may also reflect, in part, the change in diagnostic criteria with time. Studies with longer and complete follow-up are needed in order to accurately describe progression to T2D.

Risk of diabetes may also be influenced by whether studies distinguished between diabetes in pregnancy and GD, for example by recruiting women whose immediate postpartum tests were normal. However, excluding studies that did not attempt to exclude pre-existing/previously undiagnosed T2D from the GD cohort did not significantly affect the overall incidence estimate (Table 4.5). Furthermore, excluding the three studies that were part of a postpartum intervention (152,164,237) did not influence the findings.

4.6 Summary

In this review, I have described and explored development of T2D after GD. The findings strengthen the evidence for T2D risk to remain on the agenda of affected women and the clinicians who care for them (akin to glucose intolerance disorders). Unlike previous research that suggested risk plateaued over time since pregnancy, the results show that the number of women diagnosed with T2D increases each year and underline the need for continued blood glucose monitoring over time. This is in line with current guidelines but is not implemented

systematically, thus should be promoted as discussed in the following chapters. Also, the association I reported between BMI and T2D, which has not previously been highlighted, emphasised the need for effective weight management strategies that are appropriate to the needs of women with a history of GD. I describe challenges to healthy changes such as these, and approaches to overcome them, in Chapters 7 and 8.

Chapter 5 Factors associated with postpartum diabetes screening after gestational diabetes

In order to understand attendance at postpartum screening in a local setting, I conducted an analysis of testing uptake among women diagnosed with GD at the Rosie Hospital, Cambridge University Hospitals NHS Foundation Trust. In this chapter, I describe the frequency of glucose testing attendance up to one year postpartum, as well as personal and general practice-related factors associated with attendance. Understanding current trends in attendance will be useful for targeting interventions and informing changes to care protocols to improve uptake.

5.1 Background

National and international guidelines recommend that women with GD are screened for glucose abnormalities at six to 13 weeks postpartum (1,2). According to the result of the test, women not diagnosed with T2D should be offered support for behaviour change or drug therapies to reduce their risk while in those women in whom T2D is diagnosed, it can be managed in a timely way to reduce exposure to hyperglycaemia.

Despite small increases in attendance over time, uptake of postpartum screening has remained suboptimal, often at less than 50% (145–148). Attendance in the UK is poorly reported, particularly using hospital records where early screening often takes place. Women who are at higher diabetes risk tend to be less likely to attend, for example, those with higher parity and lower socioeconomic status. However, older age, Asian ethnicity and use of insulin during pregnancy have all been associated with higher attendance rates (148). Inconsistent associations between predictors of attendance in multiple different healthcare settings have been reported (148). In particular, associations between general practice factors and attendance at postpartum screening had not been investigated in the UK.

A better understanding of the factors that influence attendance for postpartum testing could inform the adjustment of procedures to increase uptake, and therefore potentially improve women's long-term outcomes.

5.2 Aim

I aimed to describe the frequency of and factors associated with postpartum testing in women with GD. In addition to personal and pregnancy characteristics, I assessed whether features of their general practice, where women are seen at six weeks for postpartum checks, were associated with likelihood of testing.

5.3 Methods

The complete methods for this analysis are described in detail in Chapter 3.2. The data were provided by Catherine Aiken. Catherine Aiken and Claire Meek provided information about GD management at the Rosie Hospital. Juliet Usher-Smith and Matthew Barclay provided statistical advice.

5.3.1 Cohort

I examined postpartum diabetes screening up to one year after pregnancy at Cambridge University Hospitals NHS Foundation Trust between October 2014 and March 2017. This was a secondary analysis of data that had been extracted from electronic medical records. I used an OGTT or HbA_{1c} test result as a proxy for attendance at testing.

5.3.2 Statistical analysis

I used STATA 15.1 to run univariable and multivariable two-level mixed-effects logistic regression analyses to identify factors associated with the odds of diabetes screening. The multivariable analyses were adjusted for variables that were statistically significant in the univariable analysis or I had strong *a priori* rationale to include, as reported in Table 5.1.

Table 5.1: Explanation of the variables included in the multivariable logistic regression analysis of attendance at diabetes screening after gestational diabetes.

Variable	Justification
Maternal age	A key potential confounder, although not significant in the univariable analysis.
Maternal deprivation (IMD decile)	A key potential confounder, although not significant in the univariable analysis.
Parity	Significant in the univariable analysis and has previously been found to be associated with T2D risk.
Pre-pregnancy BMI	Significant in the univariable analysis and has been found to be associated with T2D risk (I did not also adjust for weight, which was significant but BMI is a better measure of overweight).
Birthweight z-score	Used as an indirect measure of a difficult delivery (women with more medicalised deliveries would take longer to physically recover and might struggle to attend these sorts of non-urgent appointments), although not significant in the univariable analysis.
Medication (insulin and/or metformin) at 36 weeks gestation	Insulin use has previously been found to be associated with attendance, plus is a measure of disease severity and medicalisation of pregnancy), although not significant in the univariable analysis.
First OGTT before 22 weeks gestation	May be considered a proxy for previous GD because these patients will be offered an OGTT soon after booking at 12 to 14 weeks gestation, whereas high-risk and symptomatic women were offered testing at 24 weeks gestation (22 weeks gestation was selected as the cut-off because this was the lowest point between two peaks, suggestive of the above groups, when a histogram of time to first OGTT was plotted).
FPG at diagnosis	Significant in the univariable analysis.
Percentage recommending their practice	Significant in the univariable analysis (a measure of patient satisfaction with their GP practice).
Percentage with a foot examination	Significant in the univariable analysis (a measure of the comprehensiveness of diabetes management in their GP practice).

BMI: body mass index; FPG: fasting plasma glucose; GP: general practice; IMD: index of multiple deprivation; OGTT: oral glucose tolerance test.

5.4 Results

5.4.1 Participants and general practices

We identified 556 women with GD, defined according to the modified IADPSG criteria (17) used at the hospital during the study period. Characteristics of the included women and their general practices are summarised in Table 5.2. Average (median [interquartile range, IQR]) maternal age at delivery was 34.0 (30.2 to 37.8) years and deprivation was lower than the average for the UK. On average, the patients were overweight before pregnancy. Forty one percent had a caesarean delivery. By 36 weeks gestation, half of the participants controlled GD using medication: 156 participants used insulin only, 69 participants used metformin only, and 68 participants used both insulin and metformin.

Table 5.2: Characteristics of women with a history of gestational diabetes and their general practices.

	N	Median [IQR] or n (%)
Personal and pregnancy characteristics		
Maternal age (years)	553	34.0 [30.2–37.8]
IMD decile[1] (1, most deprived, to 10)	532	7 [6–9]
Parity	553	1 [0–1]
Pre-pregnancy weight (kg)	430	73.0 [62.0–90.0]
Pre-pregnancy BMI (kg/m^2)	429	27.4 [23.7–33.3]
Preterm birth (less than 37 weeks)	482	40 (8.3)
Gestational weight gain (kg)	366	9.1 [5.2–13.5]
Caesarean delivery	489	199 (40.7)
Baby weight (g)		
Boy	262	3,262.5 [2,969.9–3,640.1]
Girl	229	3,229.9 [2,939.8–3,504.9]
Median birthweight z-score	481	0.3 [-0.3–1.0]
GD diagnosis		
First OGTT before 22 weeks gestation	555	54 (9.7)
FPG at diagnosis (mmol/l)	554	4.8 [4.3–5.3]
120 min plasma glucose at diagnosis (mmol/l)	555	7.3 [6.3–8.6]
HbA_{1c} at diagnosis (mmol/mol)	497	35 [33–39]
GD treatment by or at 36 weeks gestation	556	293 (52.7)
Insulin	556	224 (40.3)
Metformin	556	137 (24.6)
Postnatal glucose testing		
Postnatal OGTT or HbA_{1c} (any test)	556	415 (74.6)
Postnatal OGTT (±HbA_{1c})	415	372 (89.6)
Postnatal HbA_{1c} (±OGTT)	415	150 (36.1)
Time of postnatal OGTT (weeks)	370	6.4 [6.0–7.3]
Practice characteristics and performance in the preceding 12 to 15 months[2]		
Number of registered patients	93	10,593 [7,607–14,333]
Practice IMD score[1] (range 3 to 66, most deprived)	93	10.8 [8.7–15.1]
Total QOF score	93	98.1 [96.9–99.8]
Percentage recommending practice	93	81.9 [76.1–86.5]
Percentage with HbA_{1c} blood test[3]	86	96.7 [95.5–97.1]
Percentage with foot examination[3]	93	86.0 [81.1–89.0]
Percentage with HbA_{1c} <59 mmol/mol (7.5%)[3]	93	61.6 [58.7–64.6]
Percentage referred to education programme[3]	93	75 [60.5–83.3]

Median and IQR presented for continuous variables; n and percentage presented for categorical variables.

[1] IMD is weighted and considers income, employment, education, skills and training, health and disability, and living environment deprivation, crime, and barriers to housing and services. [2] See Table 3.4 and https://fingertips.phe.org.uk/profile/general-practice for full definitions. [3] Percentage of diabetic patients with measure.

IMD: Index of Multiple Deprivation; IQR: interquartile range; N/n: number of participants; QOF: Quality and Outcomes Framework.

The women with GD were registered at 93 different general practices, with an average total QOF score of 98.1 (96.9 to 99.8) out of 100, indicating high performance. Practice deprivation score was lower than the average for the UK (the UK average was 21.8 (200)). Eighty two

percent of all patients registered across the 93 practices would recommend their practice. In terms of diabetes care, 97% of diabetic patients across the practices had had an HbA_{1c} blood test and 62% had HbA_{1c} controlled at less than 59 mmol/mol (7.5%).

5.4.2 Uptake of postpartum testing

Four hundred and fifteen participants (74.6%) had undergone a postpartum test: 265 (63.9%) were tested by OGTT alone, 43 (10.4%) by HbA_{1c} alone and 107 (25.8%) had both tests within one year of delivery (Figure 5.1). None of the participants had a single FPG test documented in the medical record.

OGTTs were performed at 6.4 (6.0 to 7.3) weeks after delivery (range 0.5 to 26.4 weeks), and the time of HbA_{1c} tests was not reported separately. Two hundred and ninety four OGTTs were recorded within the recommended six to 13 weeks postpartum window: 70.8% of all of the postpartum tests performed and 53.2% of all eligible pregnancies.

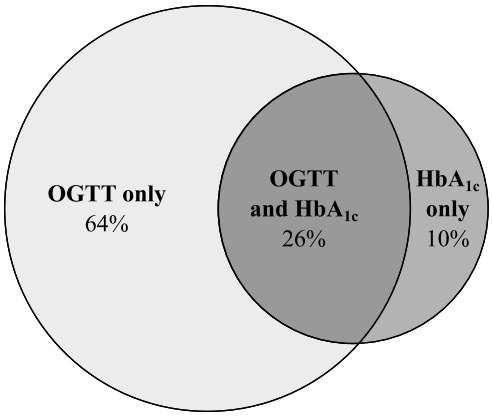


Figure 5.1: Type of test used for diabetes screening after gestational diabetes in this cohort.

Six patients (1.4%) were diagnosed with T2D and a further nine (2.2%) met the criteria for IGT at the postpartum test.

5.4.3 Characteristics associated with attendance

The associations between personal or practice characteristics and odds of completing a diabetes screening test are shown in Table 5.3. Appendix 6 shows these associations for OGTTs and HbA_{1c} tests separately.

In the univariable analyses, higher parity, pre-pregnancy weight, pre-pregnancy BMI, and FPG at GD diagnosis were associated with lower odds of testing at each practice. The percentage of the total population registered at the practice who would recommend the practice (patient satisfaction) and the percentage of those with diabetes receiving a foot examination were positively associated with higher odds of testing.

In the multivariable analysis, greater parity was associated with a third lower odds of testing (odds ratio 0.68, 95% CI 0.53 to 0.87). Compared to women whose GD was not treated with medication, women who received insulin and/or metformin treatment were more than twice as likely to undergo testing (odds ratio 2.35, 95% CI 1.22 to 4.55). Some variables associated with higher risk of diabetes, such as higher pre-pregnancy BMI and FPG, were also associated with lower odds of testing but not statistically significantly. Higher patient satisfaction was associated with higher odds of testing (odds ratio 1.04, 95% CI 1.01 to 1.07 per percentage of patients recommending the practice).

Similar associations were seen when testing by OGTT was considered alone (Appendix 6), although no practice-related variables were independently associated with testing and higher pre-pregnancy BMI was additionally associated with lower odds of an OGTT in the multivariable analysis (odds ratio 0.93, 95% CI 0.89 to 0.96 per kg/m^2). In contrast, practice-related characteristics were more frequently associated with HbA_{1c} testing. In the univariable analysis, four practice-related variables had significant odds ratios (percentage who would recommend the practice, and percentage of patients with diabetes who had had a blood test, foot examination and HbA_{1c} less than 59 mmol/mol [7.5%]). A higher patient satisfaction was the only predictor of HbA_{1c} testing in the multivariable model (odds ratio 1.05, 95% CI 1.02 to 1.09 per percentage) when the variables listed in in Table 5.1 were included.

Table 5.3: The association between pregnancy and practice-related factors and postpartum diabetes screening (by any test) in women with a history of gestational diabetes

	Univariable			Multivariable		
	N	**OR [95% CI]**	**p**	**N**	**OR [95% CI]**	**p**
Personal and pregnancy characteristics						
Maternal age (years)	553	1.03 [0.99– 1.06]	0.158	362	1.01 [0.95–1.06]	0.822
IMD decile[1] (1, most deprived, to 10)	532	1.05 [0.95–1.15]	0.33	362	0.94 [0.82–1.07]	0.345
Parity	553	0.76 [0.65–0.90]	0.002	362	0.68 [0.53–0.87]	0.002*
Pre-pregnancy weight (kg)	430	0.98 [0.97–0.99]	<0.001*			
Pre-pregnancy BMI (kg/m^2)	429	0.95 [0.92–0.98]	0.002	362	0.97 [0.93–1.01]	0.104
Premature birth (<37 weeks)	482	0.65 [0.30–1.40]	0.272			
Gestational weight gain (kg)	366	1.00 [0.96–1.05]	0.905			
Caesarean	489	0.79 [0.50–1.27]	0.333			
Birthweight z-score	481	0.90 [0.72–1.13]	0.379	362	0.98 [0.74–1.30]	0.914
Baby's gender (girl)	493	0.86 [0.55–1.37]	0.532			
GD diagnosis						
First OGTT before 22 weeks gestation	555	0.64 [0.35–1.17]	0.145	362	1.01 [0.37–2.80]	0.979
FPG at diagnosis (mmol/l)	554	0.73 [0.57–0.93]	0.012	362	0.80 [0.52–1.23]	0.312
120 min plasma glucose at diagnosis (mmol/l)	555	1.00 [0.89–1.12]	0.969			
HbA_{1c} at diagnosis (mmol/mol)	497	0.97 [0.93–1.01]	0.143			
GD treatment by or at 36 weeks gestation	556	1.13 [0.77– 1.67]	0.52	362	2.35 [1.22– 4.55]	0.011*
Insulin	556	1.07 [0.72–1.59]	0.735			
Metformin	556	1.09 [0.70–1.72]	0.694			
Practice characteristics and performance in the preceding 12 to 15 months[2]						
Number of registered patients (per 1000)	555	0.98 [0.94–1.03]	0.378			
Practice IMD score[1] (range 3 to 66, most deprived)	555	0.97 [0.94–1.01]	0.172			
Total QOF score	555	1.02 [0.95–1.09]	0.553			
Percentage recommending practice	555	1.02 [1.00–1.04]	0.027	362	1.04 [1.01–1.07]	0.013*
Percentage with blood test[3]	522	1.08 [0.98–1.20]	0.105			
Percentage with foot examination[3]	555	1.03 [1.01–1.06]	0.012	362	1.00 [0.96–1.04]	0.855
Percentage with HbA_{1c} <59 mmol/mol (7.5%)[3]	555	1.03 [0.99–1.07]	0.104			
Percentage referred for education[3]	555	1.00 [0.99–1.01]	0.687			

All regressions are adjusted for clustering by practice. The multivariable regression considered all variables that are reported.
[1] IMD is weighted and considers income, employment, education, skills and training, health and disability, and living environment deprivation, crime, and barriers to housing and services. [2] See Table 3.4 and https://fingertips.phe.org.uk/profile/general-practice for full definitions. [3] Percentage of diabetic patients with measure.
95% CI: 95% Confidence Interval; IMD: Index of Multiple Deprivation, N: number of participants, OGTT: Oral Glucose Tolerance Test, QOF: Quality and Outcomes Framework, OR: Odds Ratio.

5.5 Discussion

In this population, three-quarters of women had a diabetes test up to six months after a GD-affected pregnancy, of which 90% included an OGTT. Half of the total population had an OGTT within six to 13 weeks postpartum, in accordance with the timing recommended by NICE (2).

Attendance was more strongly associated with patient satisfaction and individual characteristics, particularly parity and use of medication during GD, than other practice factors. Practice-related factors were more frequently associated with testing by HbA_{1c} than OGTT, which is recommended after 13 weeks postpartum therefore is more likely to take place in general practice. Overall, women at highest diabetes risk (125,126) and registered at lower-rated practices were more likely to be those not attending testing and should be prioritised.

5.5.1 Strengths and limitations

In this analysis, I assessed associations with routinely-available general practice data in addition to personal factors that other studies have considered, adding to the sparse UK literature on this topic. These included practice demographics (such as size and area deprivation) and both diabetes outcome and process measures (such as percentage of the diabetic population with good glycaemic control and referred to education programmes, respectively). Two-level mixed-effects analyses retained the distinction between general practices rather than removing any effects through adjustment.

However, some variables that other studies have reported associations for (147,148) were not available due to the use of a routine dataset that was created for another purpose. These include ethnicity, individual socioeconomic status and previous history of GD (therefore I used the time of the OGTT to indicate this). Whether women were invited for testing was also missing, as was the time that postpartum HbA_{1c} tests were performed. HbA_{1c} tests are recommended after 13 weeks postpartum (2), therefore it is unclear from this analysis whether these were performed appropriately.

In addition to missing variables, there were missing data. BMI and birthweight were the variables that were most frequently missing. This could have led to bias in the associations with testing attendance if missing was not at random, such as if weight was less likely to be

recorded in the medical record of those who were overweight. However, the complete case cohort was representative of the original cohort with regards to the characteristics included so missing data were not imputed.

In 2015, NICE recommended not to routinely offer postpartum OGTTs but to use the FPG test (2). Although I did not access delivery date in order to protect patient confidentiality, OGTTs were available to all postpartum women both before and after the change in guidelines at this hospital between 2014 and 2017. This reduces the generalisability of the findings to the rest of the UK. Not accessing the date of delivery also meant that I could not use practice variables specific to the year of delivery.

I assessed uptake of screening up to one year after a GD pregnancy as recorded in hospital medical records. The first postpartum test tends to occur in secondary care, although mothers are anticipated to be seen for a general health check with their baby at six weeks postpartum by their GP (the six week mother-and-baby check (238)), providing an opportunity for the GP to ensure they have had the diabetes screening test. Some women will have a postpartum test in the community, which is anticipated to be included in the hospital record, although it is unclear whether this occurs in every case. As a result, more women could have undergone testing than recorded here.

5.5.2 Comparison to existing literature

5.5.2.1 Uptake of screening and diabetes diagnoses

I observed similar rates of testing and slightly lower incidence of T2D and IGT after GD than comparable studies in the UK have reported. The small differences in diagnoses of glucose intolerance disorders may reflect the differences in demographics between settings. Table 5.4 shows a comparison of attendance at the first postpartum diabetes screening test after GD based on hospital records in the UK.

Since 2000, uptake has ranged from 51% to 80%. However this comparison is based on five similar studies and small numbers of participants (2,449 records in total). Comparisons across hospital cohorts are challenging due to heterogeneous designs including different local protocols for GD diagnosis (e.g. Cambridge University Hospitals NHS Foundation Trust used modified glycaemic cut-offs based on the IADPSG criteria whereas Oxford University

Hospitals NHS Foundation Trust used the original IADPSG criteria (156), neither of which are recommended by NICE (2)), methods for informing or inviting women to attend testing (e.g. there were pre-arranged six week follow-up appointments booked for women in Sheffield (157)), and different postpartum testing protocols that may include OGTTs, FPG tests and/or HbA_{1c} tests. Nevertheless, these differences reflect attendance rates in routine practice therefore are of value.

Table 5.4: Comparison of attendance at the first postpartum diabetes screening test after gestational diabetes based on hospital records in the UK.

Study	Source	Years	N	Screened for diabetes (n [%])	Timing of screening	Diagnosed with T2D (n [%])
This study	Cambridge University Hospitals NHS Foundation Trust	2014 to 2017	556	415 (74.6%)	Up to 27 weeks	6 (1.4%)
Walsh 2019 (239)	Shrewsbury and Telford Hospital NHS Trust	2015 to 2016	229	160 (69.9%)	Up to 24 weeks	5 (3.1%)
Walsh 2019 (239)	Shrewsbury and Telford Hospital NHS Trust	2012 to 2015	306	185 (60.5%)	Up to 24 weeks	5 (2.6%)
Castling 2019 (157)	Maternity database, Royal Hallamshire Hospital, Sheffield	2008 to 2012	1,052	794 (75.5%)	6 weeks postpartum test	23 (2.9%)
Walker 2020 (156)	Oxford University Hospitals NHS Foundation Trust	2010	154	78 (50.6%)	Up to 13 weeks	NR
Holt 2003 (240)	Princess Anne Hospital, Southampton	2000 to 2002	152	122 (80.3%)	6 weeks postpartum test	3 (2.4%)

NR: not reported.

Screening attendance recorded in hospital records tend to be higher than that recorded in primary care records. In 2018, one study reported 58% attendance up to one year postpartum across approximately 675 general practices (9,118 records in 1990 to 2016 [62% attendance since 2010]) (153). In contrast, uptake of testing was reported to be 19% up to six months postpartum, with most attending at approximately three months, in a previous general practice audit in England (788 records in 2006 to 2009) (154). Wide regional variation was reported, although this was not sufficient to explain the differences observed between community and hospital records. Reasons for the stark differences in attendance remain unclear, although some may be explained by the poor transfer of information between maternity and primary care.

5.5.2.2 Factors associated with screening attendance

Previous reviews, not including UK-based studies, report variable and inconsistent associations between specific characteristics and non-attendance at testing, including some factors that increase diabetes risk (147,148). Like this study, a multi-centre US study found that obesity and higher parity were associated with lower screening completion by postpartum OGTT (152). According to the above study of a Sheffield hospital, the following categorised variables were associated with lower attendance: higher deprivation, smoking, unemployment, under 25 years of age, high parity and not breastfeeding (157). In comparison, I reported associations with parity, pre-pregnancy weight and BMI, and FPG at GD diagnosis using continuous variables. I also found that use of GD medication predicted follow-up in the multivariable analysis, like Walsh 2019 (239) and the Black, Asian and minority ethnic subgroup in Castling and Farrell 2019's analysis (157). Conversely, no statistically significant associations between test attendance and the personal characteristics assessed were reported in the study in Southampton (use of GD medication was not examined) (240), nor did uptake of HbA_{1c} testing vary by personal factors in one UK centre, although details of the methods were unavailable (241).

As noted above, explanations for the differences in associations are challenging due to important differences between clinical practice, the cohorts and study designs. For example, Castling and Farrell used a binary overweight cut-off of level II obesity (BMI greater or less than 35 kg/m^2 (242)) that may be too crude to observe differences according to BMI, and did not report when BMI was measured (157). Also, the population in Cambridgeshire may not have had enough diversity in IMD scores to identify differences in attendance according to deprivation. Overall, there is most consistent evidence that use of medication during GD is associated with higher postpartum screening attendance, which is logical since this is likely to be associated with a better understanding of the need for follow-up through more clinical contact and a more pronounced experience of diabetes.

No previous studies have examined associations with the mothers' general practice. My findings are consistent with the broader literature that suggests that patients' experience of their general practice is associated with health outcomes, albeit with often weak associations (243). For example, patients who felt that they had enough support from local services to manage their long-term conditions tended to have better managed T2D (244) whereas overall experience was not associated with emergency hospital admissions (both recorded in the

national General Practitioner Patient Survey) (245). Overall experience is most strongly associated with interpersonal quality of care provided by the GP, rather than factors like ease of booking appointments and opening hours, which might be expected to be more strongly associated with attendance at screening after GD (246).

5.5.3 Implications

In addition to the novel finding that patients' satisfaction with the practice was related to uptake of postpartum diabetes screening in this region, the results of this analysis contributes to describing diabetes screening after GD in the UK.

Because I found that women with higher parity and higher BMI (in the univariable analysis and for OGTT attendance), were less likely to attend screening and these are the women who are at highest risk of diabetes, interventions to improve attendance could be focused on these women. It might be particularly important to facilitate them to bring their older children to the appointment, for example. In addition, the importance of screening should be promoted in those who controlled GD symptoms by diet alone, and may perceive themselves to have a lower risk than women who needed medication.

In the longer term, future research should address reasons why women at high risk of diabetes were more likely to not attend testing. Some of the reasons given for missing testing, such as the unpleasant testing procedure (87), are universally applicable. Other possible explanations include not recognising risk or being afraid of positive diagnoses. Interventions focused on improving awareness and acceptability of diabetes screening postpartum, particularly in practices with lower patient satisfaction, could therefore potentially improve uptake of screening and women's long-term outcomes in turn.

5.6 Summary

Through an analysis of medical records from Cambridge University Hospitals NHS Foundation Trust between 2014 and 2017, I found that a quarter of eligible women missed out on diabetes screening in the first year after a GD pregnancy. Lower parity, use of medication and overall patient satisfaction (indicated by the percentage that would recommend their general practice) were associated with higher attendance. However, not all the variables that might explain

attendance were available for analysis, and this hospital used a GD follow-up protocol that is no longer recommended by NICE.

Further research is needed to understand why women with these characteristics are less likely to attend and how to improve attendance, and the role that their general practice plays in screening or promoting screening. In the next chapter, I report women's views towards diabetes screening through a synthesis of published literature, and examine approaches to improve uptake using qualitative interviews in Chapter 8.

Chapter 6 Women's views on screening for type 2 diabetes after gestational diabetes

A systematic review, qualitative synthesis and recommendations for increasing uptake.

In order to better understand the reasons for poor attendance at postpartum diabetes screening that have been reported in the literature and that I described at the Rosie Hospital in Chapter 5, I conducted a synthesis of qualitative studies of women's views concerning postpartum testing.

Previously published reviews examined postpartum care and health seeking in general. I attempted to distinguish between views towards attending appointments after pregnancy and the diabetes screening test itself. Views towards healthy diet and physical activity after GD pregnancy are considered in Chapter 7, although some studies are included in both reviews.

The findings from this review and the recommendations that I suggested for increasing uptake informed the study in Chapter 8.

The study described in this chapter was published in 2019 (208): Dennison RA, Fox RA, Ward RJ, Griffin SJ, Usher-Smith JA. Women's views on screening for type 2 diabetes after gestational diabetes: A systematic review, qualitative synthesis and recommendations for increasing uptake. Diabetic Medicine. 2020;37(1):29–43.

6.1 Background

As explained previously, national and international guidelines recommend that women are screened for glucose abnormalities at one to three months after GD to exclude persisting diabetes, followed by lifelong screening to monitor glycaemia and to identify those who have developed diabetes (1,2). Earlier detection of T2D and effective management of 'pre-diabetes'

decreases the duration of exposure to hyperglycaemia and hence reduces risk of longer-term complications (247).

There is currently variation between guidelines regarding which screening tests and schedules to use. For example, the ADA recommends using the 75g OGTT at the first postpartum test followed by either a FPG test, OGTT or HbA_{1c} test at least every three years (1). In 2015, NICE advised that women in the UK should be screened using FPG postpartum followed by annual HbA_{1c} testing, and should not be routinely offered an OGTT (2).

Frequency of postpartum screening varies by population but remains suboptimal; many studies report just 50% uptake (145–148). Attendance tends to be highest for the first postpartum test, and declines with time since pregnancy. In the UK, for example, analysis of medical records in The Health Improvement Network (THIN) database found that 58% of women attended diabetes screening in the first year postpartum (9,118 records; 1999 to 2016), and less than 40% attended in the second and third years (153). Two small, local studies suggest even lower annual rates of 16% and 20% thereafter (154,155). Younger women with other children and those of lower socioeconomic status attend less frequently, particularly if they received little perinatal care or their GD was managed by diet alone (148).

A previous systematic review of both qualitative studies and surveys found that healthcare seeking after GD can be constrained by the maternal role (meaning prioritising the needs of children and constraints associated with childcare), failures of the healthcare system, and women's perspectives towards testing (87). However, only studies published up to 2013 were included and general care, rather than glucose testing, was considered.

6.2 Aim

In light of recently-published studies about screening plus changing guidelines for GD and T2D diagnosis and management (1,2,19,119,248,249), I aimed to synthesise the literature regarding the views and experiences of women with a history of GD on follow-up glucose testing. I particularly focused on barriers and facilitators to attendance. Furthermore, I developed recommendations to adjust testing protocols and inform interventions for improving long-term follow-up based on the findings.

6.3 Methods

The complete methods for this systematic review and qualitative synthesis are described in detail in Chapter 3.1. I developed the protocol and registered it on PROSPERO in May 2018 (record ID CRD42018092386).

I was assisted in this work by Rachel Fox, a clinical medical student. Under my supervision, Rachel screened the full texts. She undertook the role of second reviewer in coding the findings, quality assessment and interpretation, and wrote the first draft of the theme 'Concern about diabetes' (Section 6.4.3.4) for the publication.

6.3.1 Search strategy

In brief, the search strategy shown in Table 3.1 was used to search five electronic databases. This was developed for a group of literature reviews concerning GD, including the studies in Chapters 4 and 7, and this chapter. We also screened reference lists of included studies for citations not identified by this search.

6.3.2 Inclusion criteria and study selection

We included peer-reviewed journal articles that examined women's experiences following GD in relation to postpartum glucose tolerance testing or diabetes screening, or experience of interventions to promote attendance at screening. All qualitative and mixed methods study designs were eligible. We excluded studies exclusively reporting views of healthcare providers and about postpartum lifestyle in order to focus on screening.

After removing duplicates, Rebecca Ward and I assessed the titles and abstracts against these selection criteria. I then acquired full text articles and reassessed them against these criteria with help from Rachel Fox. Both authors reviewed and discussed an overlapping 10% of citations to ensure consistency at both stages.

6.3.3 Quality assessment

Rachel Fox and I used the CASP checklist for qualitative research shown in Table 3.3 (196) to assess the quality of the qualitative research in each study, and discussed the findings. We awarded scores of 0, 0.5 and 1 for answering 'no', 'unclear' and 'yes' to each of the ten

questions, respectively. We did not exclude studies based on quality in order to make use of all available information.

6.3.4 Qualitative synthesis

We conducted a thematic synthesis as described by Thomas and Harden (187) with the aid of NVivo 11. This involved coding the data, developing descriptive themes, and developing analytical themes. This process is presented in Figure 6.1 using an example from this review.

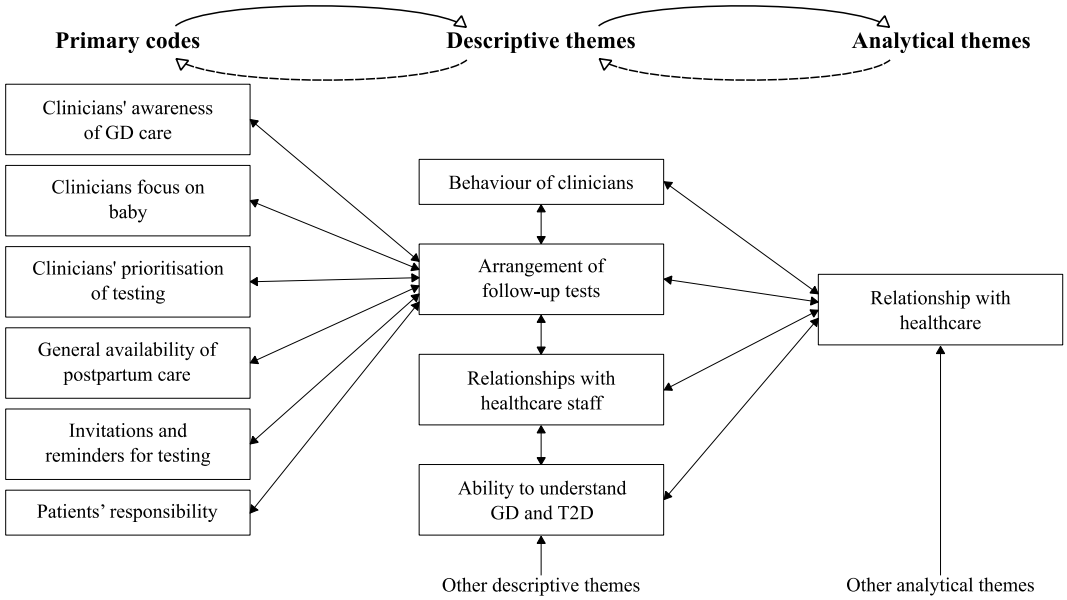


Figure 6.1: Example of the use of thematic synthesis in the qualitative synthesis of diabetes screening after gestational diabetes.

After familiarisation with the data through reading the studies and making notes and annotations, I formed a coding frame and used this to develop descriptive themes. Rachel Fox and I coded the data, including independently coding a subset of papers to check consistency. We developed descriptive themes to define the each concept in line with the primary studies. Next, we translated concepts from one study to another by making summaries and comparisons, and developed new concepts. I considered these independently, then with Rachel Fox and finally refined the analytical themes through discussion with the wider research team.

6.3.5 Recommendations for promoting screening

Based on the analytical findings and aided by Rachel Fox, I developed recommendations to promote uptake of screening that aimed to address the behaviours or beliefs that hindered

screening attendance and to make use of facilitators. I aligned each recommendation with standardised behaviour change technique taxonomy to enable greater consideration of the process by which the recommendations could be effective (190).

We used the GRADE-CERQual approach to evaluate our confidence in each of these recommendations by considering the relevance, coherence, adequacy and methodological limitations of the included data (197).

6.4 Results

6.4.1 Included studies

We included 16 qualitative papers after screening 23,160 citations and reviewing 129 full texts (Figure 6.2). Two papers published by Rafii *et al.* in 2017 reported data from the same set of interviews but used different analysis methods (250,251) therefore both were included in the analysis.

The median number of participants was 22 (IQR 12 to 31) and 746 postpartum women were represented overall. Appendix 7 shows the characteristics of these studies. Fifty three percent of participants attended testing (97/184, based on seven studies reporting attendance). All the studies except the one by Morrison *et al.* (252) used interviews to collect data, with most conducted face-to-face. Most of the studies were set in high-income countries and some recruited ethnic minority populations; where populations with mixed ethnicities were recruited, often over half of participants were White European. Average age was approximately 35 years (range 24 to 56 years). When reported, the majority of each population was married. Using insulin during pregnancy, family history of diabetes and being overweight were common (the majority of participants in most of the studies had these characteristics). Data were collected between six weeks and nine years after pregnancy and, correspondingly, views towards both the first postpartum test and general testing were considered.

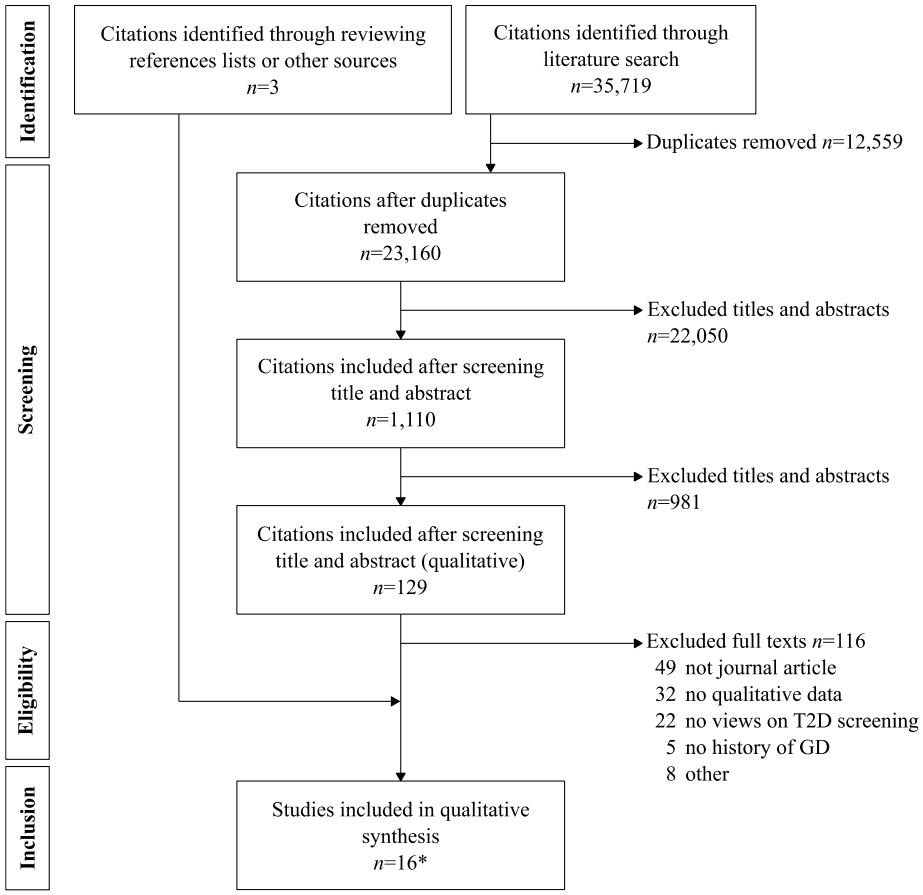


Figure 6.2: PRISMA diagram for the qualitative synthesis of diabetes screening after gestational diabetes.

**Two of these publications report the same set of interviews using different approaches to the analysis.*

6.4.2 Quality assessment

Most of the studies were considered to be good quality (mean CASP score 7.6/10), as detailed in Figure 6.3. Two studies scored below 6/10 because they did not report use of rigorous qualitative methods (253,254). The value of some studies to this review (CASP question 10) was unclear or low because they presented mixed results from both mothers and healthcare providers and some only had a small section about testing. The relationship between the researcher and participants (CASP question 6) and ethical issues (CASP question 7) were poorly considered in general.

A

Study	1. Clear statement of aims?	2. Qualitative methodology?	3. Appropriate research design?	4. Appropriate recruitment strategy?	5. Suitable data collection?	6. Researcher-participant relationship considered?	7. Ethical issues considered?	8. Rigorous data analysis?	9. Clear findings?	10. Valuable to us?	Score (/10)
Soares 2006 (253)	◐	●	◐	◐	◐	○	◐	○	○	○	3.5
Bennet 2011 (255)	●	●	●	●	●	○	◐	●	●	●	8.5
Sterne 2011 (254)	●	●	◐	●	○	○	◐	○	●	◐	5.5
Lie 2013 (256)	●	●	●	●	●	○	◐	●	●	◐	8.0
Abraham 2014 (257)	●	●	●	◐	●	○	◐	●	●	○	7.0
Morrison 2014 (252)	●	◐	◐	●	◐	○	●	●	◐	◐	6.5
Paez 2014 (258)	●	●	●	●	●	○	◐	●	◐	●	8.0
Kilgour 2015 (259)	●	●	●	●	●	◐	●	◐	●	●	9.0
Nielsen 2015 (260)	●	●	●	●	●	●	●	●	●	●	10.0
Bernstein 2016 (261)	●	●	●	◐	◐	○	◐	◐	●	◐	6.5
Campbell 2017 (262)	●	●	●	◐	●	●	●	●	●	◐	9.0
Pennington 2017 (263)	●	●	●	●	●	○	◐	●	●	◐	8.0
Rafii 2017a (251)	●	●	●	●	●	○	◐	◐	●	◐	7.5
Rafii 2017b (250)	●	●	●	●	●	◐	●	●	●	●	9.5
Svensson 2017 (264)	●	●	●	◐	●	○	●	●	●	○	7.5
Zulfiqar 2017 (265)	●	●	●	●	●	◐	◐	◐	●	○	7.5
Score frequency — Yes	15	15	13	11	12	2	6	10	13	5	
Score frequency — Unclear	1	1	3	5	3	3	10	4	2	7	
Score frequency — No	0	0	0	0	1	11	0	2	1	4	

B

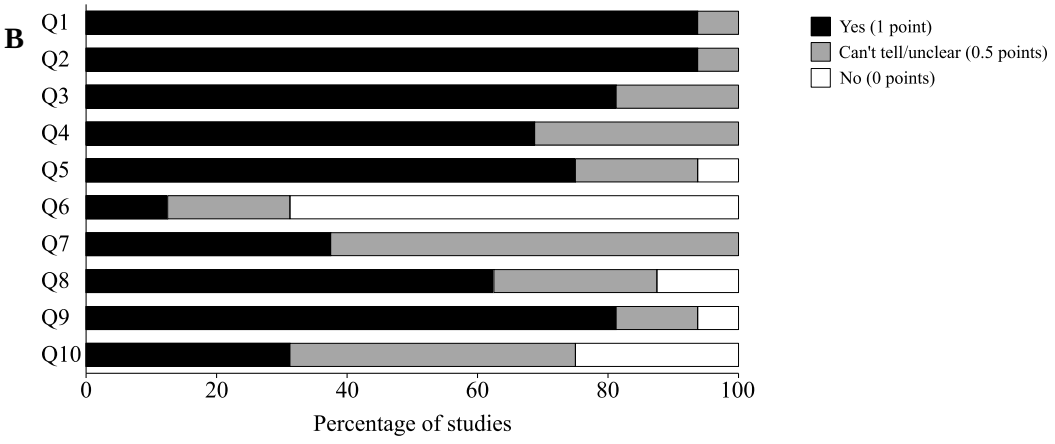


Figure 6.3: Findings from the Critical Skills Appraisal Programme (CASP) checklist for the qualitative synthesis of diabetes screening after gestational diabetes (A) according to each included study, and (B) overall.

6.4.3 Findings of the qualitative synthesis

Barriers and facilitators to attending screening after GD were translated into four themes and 13 subthemes that are described below. Although not discrete categories, I organised the themes into quadrants according to the degree to which they related to the healthcare system or were personal factors, and the degree to which they supported attendance (permissive factors) or influenced attitudes towards testing (motivational factors). This is summarised in Figure 6.4. Influences were reported from the perspective of GD-affected participants but not all participants were influenced by each factor.

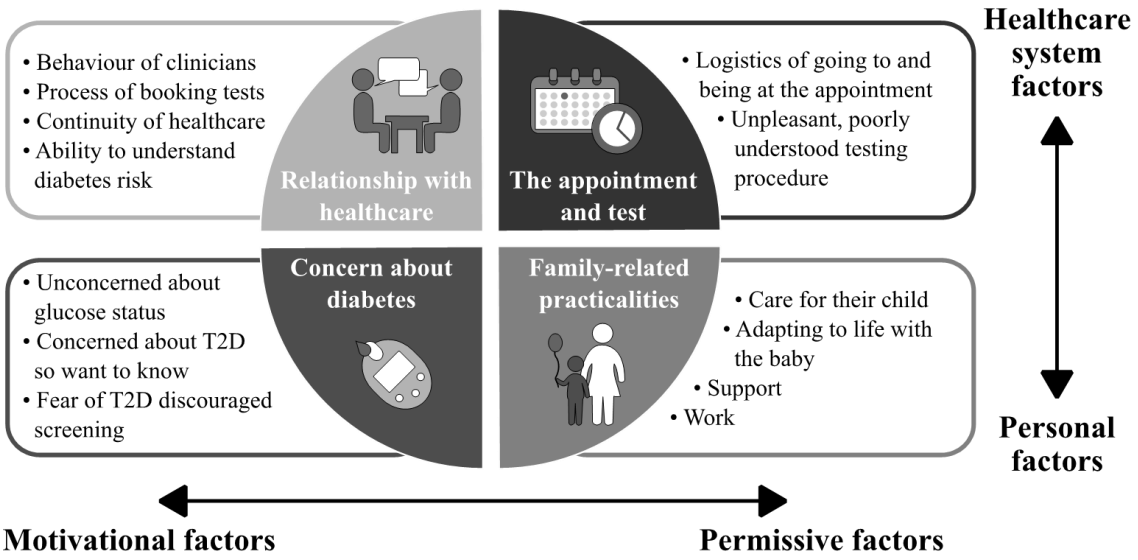


Figure 6.4: Summary of the themes and subthemes of influences on attendance at postpartum glucose testing after gestational diabetes.

The studies that contributed to each theme are shown in Table 6.1. All of the studies contributed to more than one theme, although sometimes this was just a small contribution such as listing that concept without explaining it in detail. The subtheme 'Unpleasant, poorly understood procedure' was the least well informed, with only one medium quality study reporting this as a barrier to attending testing (263) in detail.

Table 6.1: Studies that contributed to each theme and subtheme in the qualitative synthesis of diabetes screening after gestational diabetes.

Study	Relationship with healthcare				Appointment and test		Family-related practicalities				Concern about diabetes		
	Behaviour of clinicians	Process of booking tests	Continuity of healthcare	Ability to understand diabetes risk	Unpleasant, poorly understood procedure	Logistics of the appointment	Care for their child	Adapting to life with the baby	Work	Support	Unconcerned about glucose status	Concerned about T2D so want to know	Fear of T2D discouraged screening
Soares 2006 (253)		○				○		○					
Bennet 2011 (255)			●			◯	●	●	●	●	●	●	●
Sterne 2011 (254)	•	•		•	•	•	•	•		•	○	•	○
Lie 2013 (256)	●	●									◯	◯	◯
Abraham 2014 (257)	•		○	•							○	○	
Morrison 2014 (252)	•												
Paez 2014 (258)	●	●	◯		◯	●	◯	●	◯	●	●	●	●
Kilgour 2015 (259)	●	●	●	●		◯	◯	◯			◯	◯	
Nielsen 2015 (260)	●	●	●	●				●			●	●	
Bernstein 2016 (261)			•	○	•	•		•	•	•	○	•	
Campbell 2017 (262)			●	●		●	◯	●		◯	●	◯	
Pennington 2017 (263)		●	●	◯	●	◯		●			◯		
Rafii 2017a (251)		◯		●	◯	●	●			◯	●	◯	●
Rafii 2017b (250)		●		●				◯			●	●	◯
Svensson 2017 (264)	◯	●	◯	●									
Zulfiqar 2017 (265)	◯	◯									●	●	

Large dot: CASP score ≥8.5, medium dot: 7.5–8.0 (median=7.75), small dot: ≤7.0.

Open dots indicate where a study briefly contributes to the theme, or lists the theme.

In the text below, quotations from the primary studies are presented in italics. Participants' quotations are reported in double quotation marks ("/") and the authors' descriptions or explanations are reported in single quotation marks ('/'). Additionally, I report whether the participant attended the screening test if this was reported in the primary study.

6.4.3.1 Relationship with healthcare

Participants' interaction with the healthcare system influenced their intentions towards screening.

Behaviour of clinicians

The behaviour of clinicians could conflict with or reinforce prioritisation of screening. Pregnancy and postpartum care could imply that GD and the associated diabetes risk were not important after delivery therefore there was no need for further testing. For example, the message that GD would resolve after delivery could appear inconsistent with messages about postpartum screening: "*…my diabetes midwife said it normally goes away after the pregnancy so I didn't get anything afterwards*" (256). Glucose monitoring and dietary restrictions stopped immediately after delivery, reinforcing that they no longer had diabetes: "*I sat there in the hospital eating a big huge piece of chocolate cake…*" (257). Furthermore, some clinicians had "*no time*" for glucose testing (260) but focused on the baby or non-diabetes-related maternal care at postpartum appointments. On the other hand, clinicians '*promoting*' follow-up (263) helped women to understand its importance, for example, "*I think that [postnatal follow-up] was explained to me both pre and post that that needed to happen. It was explained by both the hospital and the GP*" [screened] (259).

Process of booking tests

Participants additionally commented on the process of booking tests. Many were surprised to discover that this was their responsibility rather than doctors', and that missed appointments were not chased. They often needed to act on generic information, such as "*…[the leaflet] said it was something I was supposed to take care of myself…*" [screened] (260). Although many did arrange the test, some considered that invitations and reminders should be sent from their general practice: "*Well, it would be a lot easier if I got a letter that said, now it's time – like they do for that cervix cancer screening*" [screened] (260). Positively, proactive clinicians encouraged attendance: "*…[my doctor] even wrote it down in my insurance booklet*" [screened] (250). Participants would be reassured to know that GPs were involved in this part of their care because "*…You tend to forget… so much occurs after the childbirth*" (265). At an extreme, some women perceived that their GP did not know about routine follow-up care after GD ("*Even for blood test I had to tell him I have to do a blood test for diabetes*" [screened] (259)), or explicitly gave incorrect advice. One participant concluded that "*[GPs] don't really understand it, GD, at all*" [screened] (259).

Continuity of healthcare

In addition, continuity of healthcare was frequently discussed. Some women were distressed by lack of continuity: "*…You see all different [doctors] and then they didn't have my record and… everybody just seems so confused here, like they don't know what's going on with their patient*" [attended visit] (255). Conversely, consistency in relationships meant that they knew and trusted their clinicians, and could feel safe with predictable appointments: "*It meant a lot to me that I didn't have to see a new person every time I was there. That would definitely have made me feel all confused – it wouldn't have been fun at all…*" (260). Fragmented care was particularly obvious between pregnancy and returning to the GP postpartum, where Bernstein *et al.* referred to a '*chasm between specialities*' and '*professional silos*' (261). Consequently, women needed to take on the role of '*information broker*' (259) and communicate their pregnancy history with their GP; electronic medical records were not sufficient (259,261). Additionally, Bennett *et al.* reported that relationships built with administrative staff facilitated follow-up: "*…when I called to reschedule [the clerk]'s like, 'Oh, I was hoping you'd bring the baby so I could see him.' So I told her I'd bring him*" [screened] (255).

Ability to understand diabetes risk

Finally, clinicians played an important role in women's understanding of diabetes risk. A lack of patient-focus prevented participants from asking questions about GD because there was only time for clinicians' agenda in consultations ("*She [GP] basically said don't eat any carbs, any sugar, don't eat any fruit… I was sort of like a bit overwhelmed. I came home and I just cried because there is nothing I can eat now…*" [not screened] (259)), or because it was explained using medical terminology that they could not understand (259). Some clinicians were too keen to refer them to websites and/or leaflets (260). Inability to learn about GD could leave women anxious and uninformed about their risk of diabetes or the need for screening. Several identified the need for "*good education antenatally as well as once you've had the baby [and] your brain's working again…*" (263).

6.4.3.2 The appointment and test

Practical aspects of both the appointment and the glucose test itself affected opportunity to attend.

Logistics of the appointment

Logistics of going to and being at the appointment could create several barriers to attendance. These included the appointment time, needing to travel long distances or needing to use public transport, which one participant experienced all of: "*It was a long and tiring day and I was exhausted when I got back home*" (262). Some factors were inherent to OGTT procedures such as the long appointment: "*because it took two hours of my time I kept putting it off*" (254). Furthermore, lack of health insurance or the ability to pay for testing prevented attendance: "*I don't really need [testing]… only because of how much it costs, since we are in a terrible financial position*" [not screened] (251).

Unpleasant, poorly understood procedure

Women found the testing procedure unpleasant or did not understand its purpose therefore wanted to avoid having to go through it. In particular, many in one study reported that fasting then drinking a glucose solution made them feel ill, and some disliked needles (261). Some respondents indicated that they did not understand how the test worked, meaning one participant had eaten breakfast so had to come back another time (255), and another questioned the procedure saying, "*…How can you give somebody sugar to drink and then you're going to have to test it? They're definitely going to find the sugar*" (261). Several suggested using more pleasant tests (254).

6.4.3.3 Family-related practicalities

Respondents reported various personal challenges to attending screening tests. As illustrated by the response "*…everything is about your baby…*" (260), these tended to relate to children. Bernstein *et al.* said that '*most women opt to plan activities around the needs of the newborn, not around the needs of the medical care system*' (261) therefore if the two were not compatible, they did not attend.

Care for their child

Mothers said that needing to care for their child prevented screening attendance: "*I don't think there was anything that made me hesitate other than, you know, life with a newborn and two other children…*" (258). Several mentioned their schedules: some reported that a new baby led to a lack of a schedule ("*…[getting things] done happens in the window of opportunity on the spur of the moment*" (263)) whereas others struggled around feeding and sleep routines. Importantly, the clinic was not seen to be a suitable place to wait with children or to breastfeed.

Few women in one study brought their children to the test (255); when others spoke about the need to find childcare, it appeared that bringing them was not considered an option (due to the anticipated challenges of the waiting room and during the procedure). '*A "separate room to facilitate breast feeding, toys for kids, nappy changing facilities" at the testing centres may also facilitate screening attendance*' (254). This theme was more important in unusual or unexpected circumstances: "*I guess [I didn't come be]cause [I was] seeing the baby [at the hospital] every day… It's the only thing I did…*" [not screened] (255).

Adapting to life with the baby

Unsurprisingly, adapting to life with the baby was difficult and women described feeling "*just tired… because I'm burnt out, frustrated*" [not screened] (255) and that "*life is stressful. With a new baby, mum gets no sleep and has no energy and… may be feeling overwhelmed*" (262). In the context of "*trying to get showers in and get food in is an issue right now*" [screened] (255), mothers' own health and arranging testing were forgotten or simply too much, although many intended to go at a later date or when things were more under control ("*I had no time to go… Always I tell I do it tomorrow… But I do not gone again, because I have to do another duty…*" [not screened] (251)).

Support

The support that women received at home affected their ability to take time away from childcare and attend testing: several mentioned that their husbands or parents had looked after the children whereas others did not have this option. One participant explained that "*Because of my children, I cannot go out much… There is no one to keep an eye on them while I'm gone*" [not screened] (251).

Work

Finally, the need to work presented a further barrier to attendance because women were not able to take time away for the test: "*I couldn't leave work because they could take it away and I knew the situation I was in, I needed to work*" (261), and it presented another demand on their time: "*…I've been running around trying to get stuff done before I go back to work*" [screened] (255).

6.4.3.4 Concern about diabetes

Lastly, participants' level of concern regarding diagnosis of diabetes was a key factor affecting motivation to attend screening.

Unconcerned about glucose status

Some participants were unconcerned about discovering their glucose status so were not motivated to attend screening. This represented apathy ("*could not be bothered*" and "*having a slack attack*" (262)) or a lack of urgency (259). Others were untroubled by the possibility of a diabetes diagnosis because they did not deem themselves to be at risk. One participant denied her GD diagnosis, which was outlined in her medical record, saying "*My glucose level was not too high. It wasn't GD…*" [not screened] (250). Some had concluded that they did not have diabetes due to reassuring results of self-monitoring that they continued postpartum ("*everything is normal*" [not screened] (255)) and because they felt healthy or were "*very careful and compliant*" with lifestyle recommendations [not screened] (250). Other women were unconcerned but were nevertheless tested as screening coincided with other postpartum appointments or marked '*closure with their care*' (255).

Concerned about T2D so want to know

Concern regarding a diabetes diagnosis and understanding the need for management most often encouraged screening. In particular, understanding the significance of diabetes was a motivator to attend ("*…so I am afraid of diabetes… That's why I'm screening*" [screened] (250)). This could be reinforced through knowing friends and family with diabetes, or their own experience: one participant considered the implications of a diagnosis very seriously: "*…I would have to ask for counselling or something to help me cope with that…*" (261). Additionally, plans for future pregnancies motivated some to be tested '*…to avoid any complications that might jeopardize her ability to do this successfully*' (258). Abnormal results of self-monitoring increased concern about diabetes risk and stimulated formal screening.

Fear of T2D discouraged screening

Occasionally, women's fear of diagnosis of diabetes discouraged screening as they tried to hide from it: "*It's, like, oh my gosh, I don't want to have it. And so, I guess, in my mind, it's been, if I don't get checked, maybe I won't develop it*" (258).

6.4.4 Recommendations for promoting postpartum testing

In light of the findings, I developed ten recommendations for approaches to support attendance at glucose testing, both at six weeks postpartum and beyond (Table 6.2). These aim to promote ideas that the participants of the included studies explained helped them to attend, or thought would help them to attend, and suggest ways of overcoming barriers.

To illustrate, the first recommendation is to educate clinicians to, and how to, promote screening throughout GD and postpartum care. This was made because I found that clinicians who endorsed testing during pregnancy and postpartum encouraged women with GD to attend because the mothers understood its importance. On the other hand, emphasising that the symptoms of GD would cease after delivery with no mention of T2D risk could be misleading. Therefore I anticipated that promoting the effective behaviour and changing the ineffective behaviour would be likely to promote attendance.

These recommendations reference behaviour change techniques and are directed at both women with GD (for example, '9. Educate women about the purpose of screening and how the procedure works' using technique '5.1 Information about health consequences') and clinicians or the healthcare system (for example, '5. Make clinics more child and nursing-friendly, and encourage mothers to bring children to appointments' using technique '12.1 Restructuring the physical environment') (190).

I had high confidence in three, moderate confidence in six and low confidence in one recommendation(s) in accordance with the GRADE-CERQual assessment; this is summarised in Table 6.2 and fully explained in Appendix 8. I had highest confidence in the recommendations if there were lots of data and the concept was addressed both positively (as a facilitator) and negatively (as a barrier).

Table 6.2: Ten recommendations for promoting postpartum glucose testing after gestational diabetes, and our confidence in each recommendation made using the GRADE-CERQual approach.

Recommendation	Behaviour change techniques relating to recommendation (190)	Confidence in evidence and explanation
Relationship with healthcare		
1. Educate clinicians to, and how to, promote screening throughout GD and subsequent care	1.1 Goal setting (behaviour), 4.1 Instruction on how to perform the behaviour, 9.1 Credible source	**High:** Lack of information (during pregnancy and postpartum) and seemingly conflicting advice about postpartum screening from clinicians were clearly reported, while the opposite encouraged screening

2. Implement recall systems for postpartum testing from general practice or obstetric care, and send reminders to non-responders/for missed appointments	1.4 Action planning, 1.6 Discrepancy between current behaviour and goal, 2.2 Feedback on behaviour	**High:** Benefits or anticipated benefits of invitations and reminders were reported in many studies
3. Establish standard protocols for communicating gestational diabetes history within the healthcare system	12.5 Adding objects to the environment *[for clinicians only]*	**Moderate:** There was a clear need to ensure sharing of patient history within the healthcare system, which would improve follow-up care; one benefit may be improved screening uptake
4. Promote patient-centred approaches to care in order to facilitate building relationships and opportunities to ask questions	4.1 Instruction on how to perform the behaviour *[for clinicians only]*, 9.1 Credible source	**Moderate:** Improving experience of care would make it more pleasant and may improve screening attendance (directly or indirectly)
The appointment and test		
5. Make clinics more child and nursing-friendly, and encourage mothers to bring children to appointments	1.4 Action planning, 12.1 Restructuring the physical environment, 12.5 Adding objects to the environment	**Moderate:** It is clear that clinics/long appointments are not considered suitable places to bring children but how to improve this was rarely discussed in the studies
6. Seek innovative, personalised options to make it easier for hard-to-reach women to attend testing (e.g. drop-ins, alternative locations)	12.1 Restructuring the physical environment	**Moderate:** Too inconvenient appointments discouraged testing but the studies did not clearly suggest alternatives
7. Utilise more pleasant, less time-consuming testing procedures and protocols	None	**Moderate:** OGTTs discourage screening; a shorter test without fasting or a glucose drink is desired and may increase uptake
Personal and family-related practicalities		
8. Schedule postpartum glucose testing to coincide with other postpartum check-ups (both mothers' and children's appointments)	10.5. Social incentive, 10.7. Self-incentive	**Low:** Glucose tests were difficult to attend; it is assumed that combing them with appointments that women are more motivated to attend would facilitate attendance
Concern about diabetes		
9. Educate women about the purpose of screening and how the procedure works	4.1 Instruction on how to perform a behaviour, 5.1 Information about health consequences	**High:** Often knowledge of the purpose of screening increased attendance; apathy and fear of diagnosis were barriers but could be reduced through education
10. Educate women that postpartum self-testing, behaviour compliance or one negative test result is not sufficient to rule out T2D in the long term	5.1 Information about health consequences	**Moderate:** Many studies explored how postpartum self-testing influenced concern about diabetes; education that this is not sufficient to rule out diabetes could increase screening attendance

6.5 Discussion

Through a synthesis of qualitative studies, I have explained how multiple healthcare and personal factors influence attendance at postpartum glucose testing after GD. Although barriers were dominant in the studies I included, the factors can operate as both barriers and facilitators. Some influenced practical aspects whereas others affected desire or motivation to attend screening. I focussed on postpartum testing yet several influences were clearly being established during pregnancy.

This sheds light on the low uptake of diabetes screening that is often observed: only women with high intention for testing may be able to overcome certain logistical barriers and attend, whereas these same barriers may stop less motivated women. Furthermore, motivation may decrease over time, corresponding to a decline in attendance at annual testing. Postpartum, the contact that most women have with clinicians is focused on the baby, rather than their own health, and their concern about T2D may be replaced by other worries or busyness. Accordingly, I have identified and assessed my confidence in the effectiveness of multiple strategies to increase attendance by reducing logistical barriers and increasing motivation, most with high or moderate confidence.

6.5.1 Strengths and limitations

I completed a rigorous literature search and qualitative synthesis as the lead member of a small multidisciplinary team for this review. In order to minimise personal bias, I discussed the analysis with other researchers, and used CASP and GRADE-CERQual checklists when evaluating the quality of studies that contributed to the synthesis and my confidence in the resulting recommendations. I utilised the behaviour change technique taxonomy to describe strategies to promote screening in this population. Additionally, I have included perspectives from different populations and healthcare systems and found influences that could be relevant across multiple settings. For example, the cost of testing in the included studies related to paying for the test, yet in settings with free healthcare, costs associated with travel (e.g. parking charges) may be a barrier.

Some of the 16 papers that I included were poor quality and/or only contributed a small amount to the review findings. There was inevitable selection bias whereby people with stronger views

were more likely to participate than those who did not. However, participants included both women who had attended screening and those that had not. Interpretation was also limited by the data that were reported: I sought to focus on attendance at screening rather than postpartum care seeking more generally, but I was not always able to distinguish between the two. Similarly, use of OGTT, FPG or HbA_{1c} tests was not reported, although descriptions from participants suggest that most were offered an OGTT. Fewer studies specifically discussed how to increase screening attendance therefore the recommendations were primarily suggestions of how to overcome barriers.

In addition, it was difficult to identify patterns in influences on screening attendance. For example, although some will be similar, it is likely that influences will vary between the first test at approximately six weeks postpartum and diabetes screening several years after pregnancy, yet it was often unclear how long after pregnancy participants referred to. I was also not able to consider individual-level interactions such as whether first-time mothers were more influenced by certain factors than experienced mothers. Although participants criticised or identified gaps in their care, or conversely praised the system, the extent to which this contributed to their decision to attend screening or not was not clear. In practice, it is likely that the influence of the factors I describe varied according to the individual situation. For example, whether there was someone available to take care of the children while the mother went to the test, or it would be simple to arrange this. It is likely that this is socially patterned, where mothers who face childcare barriers are more likely to also experience financial barriers. I anticipated that mothers with higher motivation for testing, such as those with high concern about their risk of T2D, will be more determined to overcome logistical barriers than those with less incentive. However, the primary studies did not state this explicitly.

6.5.2 Comparison to other literature

6.5.2.1 Theory

Although I analysed the data using thematic synthesis rather than a framework-based approach, the influences I identified operate in a way similar to those described in the COM-B model of behaviour (266). In this model, capability, opportunity and motivation interact to influence, and are influenced by, performance of the behaviour of interest.

On one side of Figure 6.4, I identified motivational influences: emotions such as worry about diabetes and relationships with healthcare. On the other side, the permissive themes could be described as opportunity and capability to attend, where I consider external factors that prompt or inhibit screening such as employment, and psychological and physical potential such as degree to which they are overwhelmed in caring for their baby.

6.5.2.2 Related literature reviews and quantitative studies

These findings echo many of those identified by Van Ryswyk *et al.*'s review of qualitative and quantitative studies (87). However, while they covered the wider context of healthcare seeking after GD, I was able to develop a more detailed understanding that was specifically related to postpartum testing, as well as attending appointments. Although Van Ryswyk *et al.* identified '*a need for clinicians to take a more pro-active approach to postpartum care*' (page 114), they did not describe that failure to so could confuse the participants or be understood to mean that screening was not important. In addition, I was able to explain their finding that '*The oral glucose tolerance test was a barrier for some women, with a more convenient, pleasant test being desired*' (page 114–115) and how it related to postpartum testing: I described how the OGTT was a barrier to testing because it took a long time (particularly when travelling time was also considered), made the participants feel unwell, and that some did not understand how the test worked or what it measured. This meant that the discomfort and inconvenience that most had already experienced at least once during pregnancy did not seem to be worthwhile, therefore they wanted to avoid having the test again postpartum.

Additionally, a lack of time was the most frequently reported reason for non-attendance in a survey of 36 postpartum women, followed by losing the invitation (267). Similarly, Sterne *et al.* also quantified their findings, and inconvenience (such as the test takes too long) and lack of awareness of the need for testing were the two most common barriers to attendance (254).

6.5.2.3 Other populations

I found that attendance was closely associated with experience of the healthcare system and put forward strategies to adjust care. The views of clinicians about how to treat and support women with GD postpartum are therefore important, and help to further understand some of the experiences described. Several of the influences that I identified were also recognised by healthcare providers, as reported in a literature review assessing clinicians' views towards

postpartum testing (268), in a subsequent qualitative synthesis completed by a medical student under my supervision (269), and by three of the studies analysed in this chapter (261–263).

In Lithgow *et al.*, we described three challenges identified by GPs, midwives and obstetricians to postpartum follow-up that closely match to the theme 'relationship with healthcare' (Section 6.4.3.1) (269). As identified by mothers, individual clinicians found it hard to communicate the long-term risk of T2D after GD to mothers because they did not want to scare or overwhelm the mothers, and wanted to prioritise the pregnancy or baby. In addition, the postpartum test is recommended at the time when mothers transition from hospital care back into the community, and current protocols lack guidance about whether hospital or community is responsible for ordering tests so mothers fall into the gap. Adding to this, it is challenging to communicate the GD pregnancy history back to the GP, in part due to inability to share electronic medical records between systems. As described above, women reported that they needed to communicate their pregnancy history to their GP and identified challenges with medical records (259,261).

Van Ryswyk *et al.* 2014 add that clinicians considered that mothers should take more responsibility for their diabetes risk, and they were hindered by incomplete knowledge of their patients' pregnancy history (268). While there is agreement that long-term follow-up should take place in primary care, they also identified inconsistency and lack of clarity regarding responsibility for short-term follow-up (158,268).

6.5.3 Implications

A key component of this study was to develop a set of recommendations to increase attendance at screening. An important aspect of many of these recommendations is developing women's understanding of both the necessity and procedure of screening therefore increasing capability and motivation. Positively, many report awareness of the risk of developing T2D (256,258–261,265) but this did not always sufficiently impact on screening knowledge or attendance. While information and intention are rarely sufficient for behaviour change, they are nonetheless necessary and may be more effective in promoting attendance at infrequent screening appointments than influencing habitual behaviours. I therefore suggest reinforcing the following key messages to address different perspectives and promote screening, without false assurance or exaggerated concern:

1. Having had GD means you are at a higher risk of developing of T2D, which is a serious condition (addressing apathy);
2. We want to diagnose diabetes early (apathy) but, typically, it is initially asymptomatic so formal testing is needed. This differs from the glucose monitoring in pregnancy (self-testing reassurance);
3. We can manage T2D effectively through medication and changes to lifestyle. Early diagnosis improves long-term outcomes (fear) and knowing your diagnosis enables proactive management of your health (using proactiveness);
4. Blood glucose control usually returns to normal after delivery but this needs to be checked postpartum as part of routine GD follow-up (informing risk perception);
5. Diabetes can affect subsequent pregnancies (tested for other reasons).

Sharing this information with women with a history of GD is already included in many guidelines. However, this study suggests that communication must be optimised to increase understanding. The key messages outlined above could be included in a guide through and beyond GD using specific wording developed by consultation with patients with GD. The guide could refer back to experiences from pregnancy in order to improve relatability and understandability (e.g. the postpartum FPG test could be described as the first part of the OGTT that they had during pregnancy, and they would not need to drink a glucose solution). This information could be available to women with GD and their clinicians in order to reduce fragmentation of care and confusion over who is responsible for testing.

Additionally, I suggest several changes to healthcare provision that may increase screening. Aside from improving clinicians' awareness of agreed protocols, steps could be taken to adapt usual practice to remove some barriers to screening. I had high confidence that inviting mothers to postpartum testing and following up missed appointments (recommendation number 2) would improve uptake, yet it was unclear from this study how this might work best in practice. Other systematic reviews have found that reminders and recall systems, such as phone calls or letters to both mothers and GPs, are associated with higher uptake of screening compared to usual care (145,146). However, a recent evaluation from the Australian National Gestational Diabetes Register in the states of Victoria and South Australia suggested that mail outs had negligible impact on postpartum and annual follow-up (161). While the reasons for this warrant investigation, the authors suggest that more personalised, local invitations might be more

effective than national recall. Furthermore, an evaluation of a trial of text message reminders for T2D screening after GD reported mothers' preference for electronic reminders, particularly text messages that were sent by the study team (270) (this study was not included in this review because it used quantitative methods). Clinicians also had positive views towards reminders (268) and some advise their patients to have a blood test in the month of their child's birthday [personal communication]. It should be considered whether combining glucose testing with other appointments, such as newborn check-ups child vaccination schedules or cervical cancer screening could be both manageable for general practice and offer benefits to women in the long-term.

This qualitative synthesis also supports the need for further consideration of more acceptable screening tests due to the length and inconvenience of the OGTT and the need to fast then sugar load. The HbA_{1c} test is an accurate measure of chronic glycaemia in the general population that requires one non-fasting blood sample (271) although it is not suitable for use shortly after pregnancy and in certain populations, and questions about its sensitivity remain (272,273). Similar to the change in the NICE guidelines in 2015 (2), recent guidelines in Australia and New Zealand have recommended HbA_{1c} testing after the postpartum period. Small-scale analyses suggest that HbA_{1c} testing can have a higher uptake than OGTTs, yet uptake remains suboptimal in the long-term (274,275). My findings provide additional evidence that HbA_{1c} testing could reduce some motivational barriers to screening and make it easier to complete alongside other tests or appointments. In addition, novel strategies such as very early postpartum testing (e.g. before leaving hospital) could be considered. Although less accurate than a test at six weeks, very high uptake can be achieved and therefore identify the highest-risk women for targeted follow-up (276). Further research over longer periods is needed to evaluate the benefits and harms of increased use of other tests.

6.6 Summary

After a pregnancy with GD, women are advised to have regular tests in order to identify glucose intolerance or diabetes. Most studies report suboptimal attendance. In this chapter, I sought to understand why some women do not attend and identify approaches to support attendance using a systematic review and qualitative synthesis. Higher uptake will enable earlier detection and management of diabetes and improve long-term outcomes.

I found that logistical difficulties associated with attending appointments and a need to focus on their family can affect women's ability to attend glucose testing postpartum and in the long-term. Concern about risk of developing diabetes and experiences of healthcare can increase or limit intentions towards testing. Alongside clearer education about GD and T2D, I have suggested ten amendments to healthcare provision during and after pregnancy that may decrease these practical barriers and improve motivation for testing.

These findings informed the interview study reported in Chapter 8, in which I asked women with a history of GD about their views on the suggestions and preferences for delivery of interventions or information. In the next chapter, I have used a similar approach to synthesise the views of this population towards having a healthy diet and exercising after GD.

Chapter 7 Women's views on lifestyle changes to reduce type 2 diabetes risk after gestational diabetes

A systematic review, qualitative synthesis and recommendations for practice.

This qualitative literature review was completed in order to synthesise the published literature about women's attitudes towards and experience of healthy diet and physical activity (described as lifestyle behaviours) after a pregnancy affected by GD. It was also based on the literature search described in Chapter 3.1. I used the same approach and methods as in the previous chapter. Again, I wanted to present the implications of the findings clearly, thus recommendations for practice is a significant element of this work.

The findings from this review and the recommendations that I suggested for promoting healthy diet and physical activity informed the DAiSIeS interview study (Chapter 8).

This study was published in 2019 (209): Dennison RA, Ward RJ, Griffin SJ and Usher-Smith JA. Women's views on lifestyle changes to reduce the risk of developing type 2 diabetes after gestational diabetes: A systematic review, qualitative synthesis and recommendations for practice. Diabetic Medicine. 2019;36(6):702–17.

7.1 Background

A healthy diet and physical activity after pregnancy are strongly associated with T2D risk, yet most women do not attempt or sustain behaviour change but maintain lifestyles that increase their T2D risk (172). Interventions to prevent T2D have potentially positive effects for women with GD: they can facilitate behaviour change that leads to lower T2D incidence. For example,

women with GD in the intensive lifestyle intervention group of the US DPP lost weight and increased their physical activity levels up to an average 1.5 hours per week more than at baseline, although these changes peaked within one year of starting the intervention (164). Progression to T2D was reduced by 50% over three years and 35% over ten years compared to placebo (164). However, the effectiveness of interventions can be limited by poor engagement outside of rigorous trial settings (166–168). In the DPP, the intensive lifestyle intervention involved 16 initial individual in-person meetings with a case manager, followed by meetings at least every two months for the remainder of the study and additional support for those who did not meet the goals within the specified time frame (165). This type of intervention is unlikely to be feasible on a large scale in most health systems including in UK primary care.

In the UK, women with GD are managed according to the guidelines for preventing T2D (170). These include referral to weight-loss or exercise programmes. These programmes have been developed for the general population, which tends to be older and not have young families, therefore presenting barriers to attendance for women who recently had GD. They are not currently eligible for the NHS Diabetes Prevention Programme unless they are diagnosed with hyperglycaemia.

Previous qualitative or mixed methods reviews have explored women's views on reducing diabetes risk postpartum as part of broader investigations into their experience of GD.

- Jones *et al.* 2009 found that many studies reported a gap between knowledge of the association between GD and T2D, and individuals' behaviour (particularly physical activity and fruit and vegetable intake) and perception of their own risk (174).
- Parsons *et al.* 2014 reported the experience of GD alongside women's perceptions of their future risk and prevention of diabetes, including varying views towards lifestyle changes, prioritisation of children and the family, and community/support-focussed interventions (77).
- Nielsen *et al.* 2014 investigated determinants of GD care from GD screening and diagnosis to postpartum follow-up. After pregnancy, they found that women who were well informed could have intention for a healthy lifestyle but adherence was challenging (147).
- Van Ryswyk *et al.* 2015 similarly reported barriers including cost, lack of time and lack of knowledge (87).

However, no comprehensive review has focused on postpartum lifestyle. This means that the understanding of exactly how these positive attitudes and barriers influence diet and physical activity after GD lacks the depth and detail required to develop effective interventions.

7.2 Aim

I aimed to systematically synthesise the literature reporting the views of women with a history of GD on reducing their risk of developing T2D, including women participating in interventions. This was with the view to identify gaps in the understanding of the acceptability, feasibility and practicality of intervening postpartum and to inform the development or tailoring of effective approaches for this high-risk population.

7.3 Methods

In summary, I used the approach described in Sections 3.1 and 6.3 to identify papers relevant to the review question, conduct a thematic synthesis and develop recommendations for interventions as a result of the findings. This is detailed below.

I registered the protocol on PROSPERO in January 2018 (record ID CRD42018082049).

7.3.1 Search strategy

I used the search strategy described in Chapter 3.1.3 for this review. I also screened the reference lists of the included studies for citations that were not identified by the literature search and considered further papers that were suggested by a journal reviewer when submitting the manuscript for publication.

7.3.2 Inclusion criteria and study selection

I focused on influences on lifestyle behaviours in this review, including studies that examined women's experiences of healthy eating and physical activity after GD, views on T2D risk management or experience of attending a T2D prevention programme. Healthy diet and physical activity needed to be the key behaviours that were promoted. All qualitative methods

were eligible, including mixed methods, in order to access as much data on the topic as possible. I only included full text studies published in peer-reviewed journals.

Studies exclusively reporting the views of healthcare providers were excluded in order to focus on the views of women with a history of GD. I also excluded studies that focused solely on experiences during pregnancy because this had been reported in detail by previous studies (77,78). Views towards postpartum T2D screening only were noted for consideration in the qualitative synthesis reported in Chapter 6.

Following deduplication, titles and abstracts of all citations were assessed against these criteria by Rebecca Ward or myself. We independently reviewed approximately 10% of the citations to ensure agreement and refine the selection criteria. I then acquired full text articles and rechecked them against the selection criteria. Juliet Usher-Smith reviewed all articles that were included and those excluded for reasons other than article type, and agreed with my classification.

7.3.3 Quality assessment

I assessed the quality of each study using the CASP checklist for qualitative research. 1 point was awarded to studies that met the criteria, 0.5 points where it was unclear and 0 points where they did not. Scores were agreed following discussion with Juliet Usher-Smith.

7.3.4 Qualitative synthesis

As described previously, I used thematic synthesis to analyse the qualitative findings (18). This involved three key steps: coding the findings, developing descriptive themes, then developing analytical themes.

Due to the large amount of data available for this review, I completed the primary coding in two steps: firstly, data were categorised into anticipated or experienced barriers and facilitators to healthy diet, physical activity and participating in an intervention programme. I then developed a coding scheme for each section based on its content. Juliet Usher-Smith independently coded a subset of papers at multiple stages to check consistency. To develop the descriptive and analytical codes, concepts were translated from one study and category to another in order to understand the statements made. I did this by making summaries,

comparisons and contrasts, and testing new concepts across the data. Themes were discussed with all authors throughout.

An example of this process is summarised in Figure 7.1.

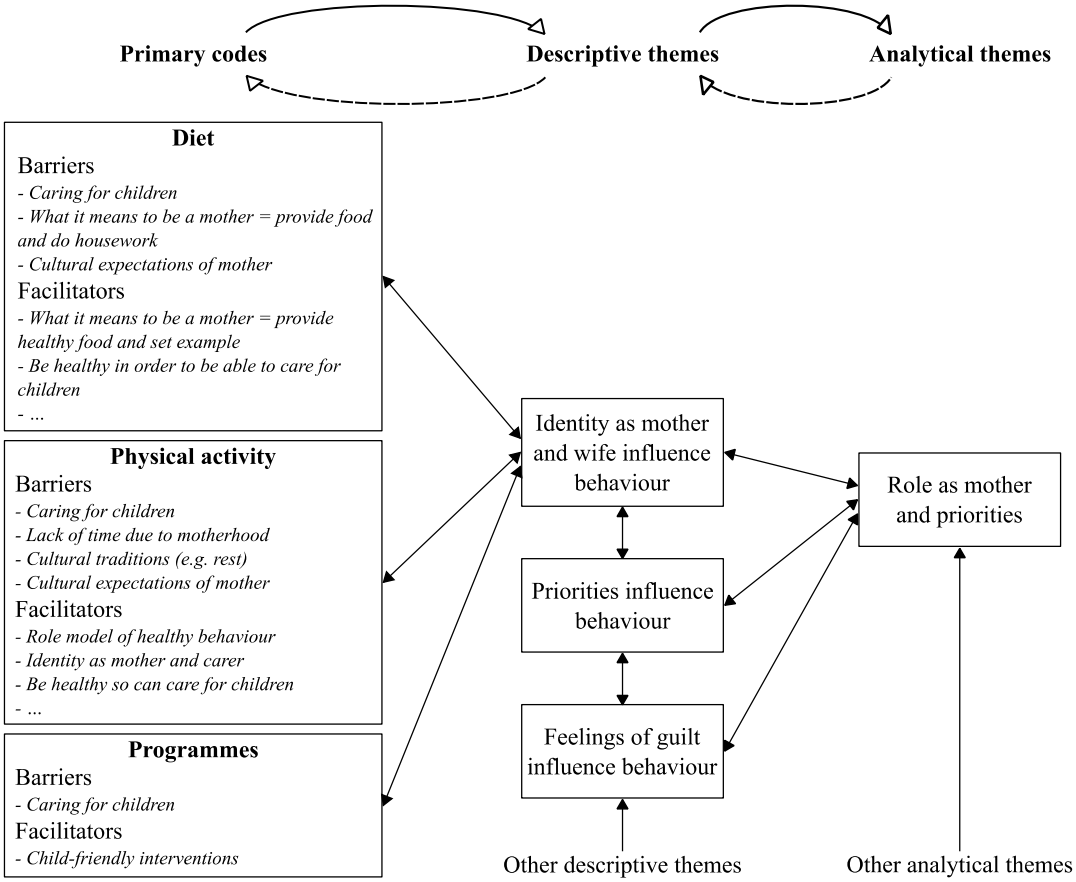


Figure 7.1: Example of the use of thematic synthesis in the qualitative synthesis of healthy lifestyle after gestational diabetes.

Actual and anticipated barriers and facilitators were combined in this diagram and not all codes are presented for simplicity.

7.3.5 Recommendations for promoting behaviour change

I developed 20 recommendations for promoting healthy postpartum lifestyle based on the findings of the qualitative synthesis. I considered which behaviour change techniques could be used to implement them in line with the behaviour change technique taxonomy (190). I assessed my confidence in each recommendation using the GRADE-CERQual approach (197) and discussed this with the other authors in order to inform the final interpretation.

7.4 Results

7.4.1 Included studies

Alongside the other authors, I screened 23,160 citations, reviewed 129 full texts and included 21 articles. Seventeen articles were identified in the literature search and four were added after reviewing the reference lists and reviewers' recommendations. The PRISMA diagram is presented in Figure 7.2.

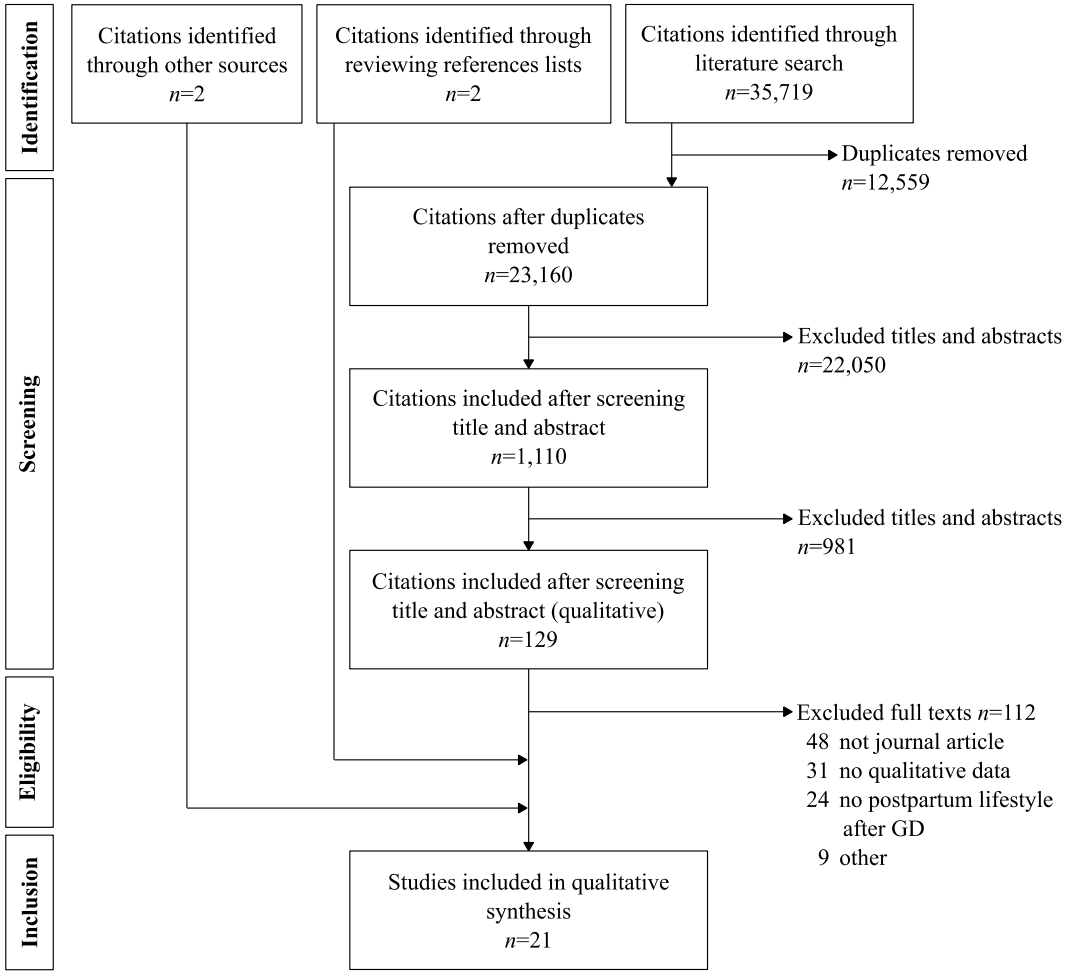


Figure 7.2: PRISMA diagram for the qualitative synthesis of healthy lifestyle after gestational diabetes.

Appendix 9 shows the characteristics of these studies and the 926 postpartum women represented. The median number of participants was 17 (IQR 11 to 26 per study). Most studies were set in high-income countries and involved face-to-face interviews. Of 17 studies specifying the timing of data collection, 12 were conducted one year or longer after the affected

pregnancy. The study populations had similar characteristics: women in their mid-30s who tended to be overweight and have more than one child. Where reported, more than half of the population in each study were employed, married and had gained a secondary education or higher.

7.4.2 Quality assessment

I found all of the studies to be medium or good quality (mean CASP score 8.0/10), shown in Figure 7.3. They were appropriate for qualitative methods with clear aims, results and implications. Generally, data collection was suitable, although sometimes important details were missing: authors rarely commented on their relationship with participants or implementation of ethical procedures, even though approval had been granted. Mixed methods studies scored lower because qualitative aspects were less well reported or supplementary to quantitative methods.

7.4.3 Findings of the qualitative synthesis

Actual and anticipated barriers and facilitators of healthy postpartum lifestyle codes were translated into six themes: role as mother and priorities, support from family and friends, demands of life, personal preferences and experiences, diabetes risk perception and information, and finances and resources, in addition to a seventh section on views on the practicalities of interventions. These are described below and summarised in Table 7.1.

I decided not to include a theme specifically relating to culture but discussed it in the context of the other themes.

The studies that contributed to each theme are shown in Table 7.2. Some studies made a small contribution to the findings (263,277,278) and seven studies contributed to six or seven of the seven themes (256,257,264,265,279–281). Each theme was based on at least eight studies and all but one study reported on diabetes risk perception and information.

A **Study**		**1. Clear statement of aims?**	**2. Qualitative methodology?**	**3. Appropriate research design?**	**4. Appropriate recruitment strategy?**	**5. Suitable data collection?**	**6. Researcher-participant relationship considered?**	**7. Ethical issues considered?**	**8. Rigorous data analysis?**	**9. Clear findings?**	**10. Valuable to us?**	**Score (/10)**
Graco 2009 (282)		●	●	●	●	●	○	◐	◐	●	●	8.0
Doran 2010 (277)		●	●	●	●	●	○	◐	○	◐	○	6.0
Evans 2010 (283)		●	●	●	●	●	○	◐	●	●	◐	8.0
Lindmark 2010 (284)		●	●	●	◐	●	○	●	●	●	◐	8.0
Razee 2010 (285)		●	●	●	●	●	○	◐	●	◐	●	8.0
Bandyopadhyay 2011 (278)		●	●	●	●	●	○	◐	◐	●	○	7.0
Nicklas 2011 (279)		●	●	●	●	●	◐	◐	◐	●	●	8.5
Gaudreau 2012 (280)		●	●	●	◐	●	◐	◐	●	●	●	8.5
Hjelm 2012 (286)		●	●	●	●	●	◐	●	●	●	◐	9.0
Jones 2012 (287)		●	●	●	●	●	○	◐	●	◐	◐	7.5
Dasgupta 2013 (281)		●	●	●	●	●	◐	◐	●	●	●	9.0
Lie 2013 (256)		●	●	●	●	●	○	◐	●	●	●	8.5
Abraham 2014 (257)		●	●	●	◐	●	○	◐	●	●	●	8.0
Morrison 2014 (252)		●	◐	◐	●	◐	○	●	●	◐	◐	6.5
Jones 2015 (288)		●	●	●	●	●	○	◐	●	●	●	8.5
O'Dea 2015 (289)		●	●	●	◐	●	○	◐	◐	●	●	7.5
Tang 2015 (290)		●	●	●	●	●	○	◐	●	●	●	8.5
Lim 2017 (291)		●	●	●	●	●	●	◐	●	◐	◐	8.0
Pennington 2017 (263)		●	●	●	●	●	○	◐	●	●	○	7.5
Svensson 2017 (264)		●	●	●	◐	●	○	●	●	●	◐	8.0
Zulfiqar 2017 (265)		●	●	●	●	●	◐	◐	◐	●	●	8.5
Score frequency	Yes	21	20	20	16	20	1	4	15	16	11	
	Unclear	0	1	1	5	1	5	17	5	5	7	
	No	0	0	0	0	0	15	0	1	0	3	

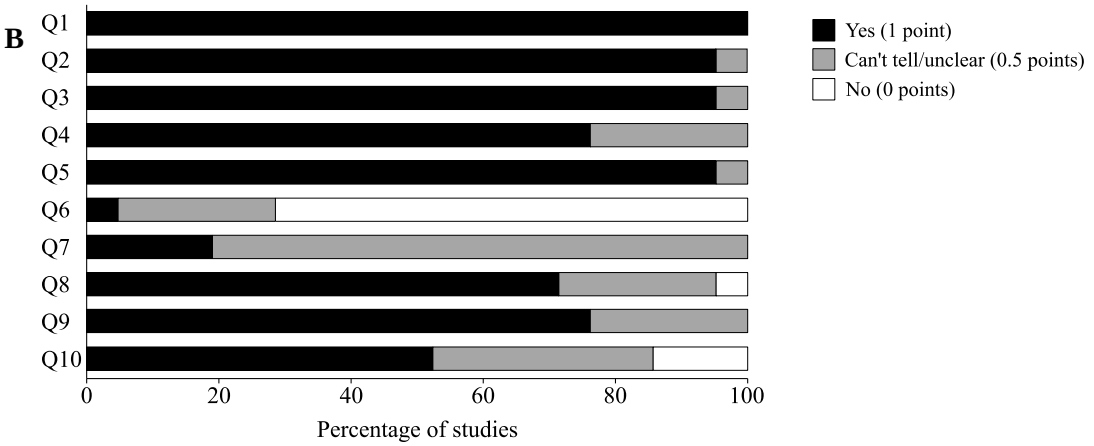


Figure 7.3: Findings from the Critical Skills Appraisal Programme (CASP) checklist for the qualitative synthesis of healthy lifestyle after gestational diabetes (A) according to each included study, and (B) overall.

Table 7.1: Summary of the themes and subthemes of barriers and facilitators of healthy lifestyle after gestational diabetes.

Theme	Description	Consequences for healthy lifestyle	Illustrative quotations
Role as mother and priorities	Women's identity was as a mother, requiring them to prioritise their family; most guilt was felt for not doing this	This was a barrier when giving families what they wanted and not having time for themselves, or a facilitator when health was recognised as important for their family	"[My child] already goes to occasional care on Friday mornings… but that's mainly so I can do the housework… the thought of putting him in care so I can do exercise, yeah, that's a big guilt on me" (282) "I don't [change my eating habits] so much for protecting me from getting diabetes; I do it so that my son, as he is learning to eat, he learns to eat healthier" (290)
Support from family and friends	Family could provide support by reducing burdens and, particularly affecting diet, providing information and being involved. Friends could offer encouragement for exercise and make it more pleasant. Societal/cultural norms influenced ability to have a healthy diet	Having support facilitated healthfulness; absence of support was identified as barrier	"Maybe [you need] help from your significant other because it's hard when they are eating cake and ice cream, all the stuff you can't have, and maybe just don't even have it in the house" (257) "If the other women can do it so can I. If others with three children can exercise, I with one can also change" (291)
Demands of life	Lack of time and energy, busyness and work influenced lifestyle choices, as did how convenient and easy to integrate into daily life it was	This was mainly a barrier to healthy lifestyle, although sometimes healthy options became part of daily life and saved time	"I was exhausted and already feeling so guilty for being away from my child while I was working, so I did not exercise" (279) Meal planning 'to reduce the number of trips per week to grocery stores' (281)
Personal preferences and experiences	Food played an important role in women's personal and social lives. Both diet and exercise affected emotions	Behaviour was determined by whether women had positive experiences or benefitted from healthy/unhealthy lifestyles	"Everything's back to normal so I've sort of been making up for lost time a little bit with all the chocolate I couldn't have" (256) "…If I'm not active then I find I don't cope as well with things" (282)
Diabetes risk perception and information	Women learned about diet during their GD-affected pregnancy; knowledge included risk of T2D, how to prevent it, repetition of messages and the need for culturally-relevant information	Relevant information facilitated healthfulness; absence of information was identified as a barrier	'The women felt neglected by healthcare providers and were left with unanswered questions about what to do next' (283) "…So the plan is to try and live healthy, get rid of the extra pregnancy kilos and return to my normal weight again, and then to be physically active" (264)
Finances and resources	Resources were needed to help women sustain a healthy lifestyle, and	Women thought that more resources would	"…[Healthy foods] are not the cheap items; they're a kind of more in the pricy end. It

	their lifestyle affected the family's <u>finances</u>	help them to be more healthy	could be a bit irritating to prioritize your money in that way…" (264) "I didn't eat out as often. It became less expensive to eat out because I cut down on my portions" (280)

Underlining highlights key components of the themes (subthemes).

Table 7.2: Studies that contributed to each theme and subtheme in the qualitative synthesis of barriers and facilitators of healthy lifestyle after gestational diabetes.

Study	Role as mother and priorities	Support from family and friends	Demands of life	Personal preferences and experiences	Diabetes risk perception and information	Finances and resources	Format of interventions
Graco 2009 (282)	●		●	●	●		●
Doran 2010 (277)					∘		∘
Evans 2010 (283)	○		○		●	○	
Lindmark 2010 (284)				●	●		
Razee 2010 (285)	●	●	●		●		
Bandyopadhyay 2011 (278)			∘		∘		
Nicklas 2011 (279)	●	●	●	●	●	●	●
Gaudreau 2012 (280)	●	●		●	●	●	○
Hjelm 2012 (286)	●				●	●	
Jones 2012 (287)	•			•	•		
Dasgupta 2013 (281)	●	●	●		●	●	●
Lie 2013 (256)	●	●	●	○	●		○
Abraham 2014 (257)		●	○	●	●	●	●
Morrison 2014 (252)	•		∘	•	•		
Jones 2015 (288)	●	●	○		●		●
O'Dea 2015 (289)	•	•	•	•			•
Tang 2015 (290)	●	●	●		●		
Lim 2017 (291)	●	●	●		●		●
Pennington 2017 (263)					•		
Svensson 2017 (264)	●	●	○	○	●	●	
Zulfiqar 2017 (265)	○	●	○	●	●	●	

Large dot: CASP score ≥8.5, medium dot: 8.0 (median), small dot: ≤7.5.

Open dots indicate where a study briefly contributes to the theme, or lists the theme.

As in Chapter 6, quotations from the primary studies are presented in italics in the text below. Participants' quotations are reported in double quotation marks ("/") and the authors' descriptions or explanations are reported in single quotation marks ('/').

In these studies, a healthier diet usually involved trying to consume more fruit and vegetables, and less sugar, fat and processed foods such as by making substitutions: for example, "*…I take light milk…we have changed…so it's low-fat…*" (286) and Algonquin women, a native North American people group, mentioned adapting or adding to their traditional diet (280).

Walking was the most frequently mentioned form of physical activity because it was seen as "*…the easiest exercise you can do – because you do it, to go to the bathroom, to clean the house*" (281), and several mentioned running. It was notable that no studies reported women being able to commit to regular gym sessions or classes, but activities that were flexible.

7.4.3.1 Role as mother and priorities

Prioritising their children and being what they perceived to be a good mother had one of the greatest influences on women's views of healthy postpartum behaviour; preventing T2D was rarely the primary motivation.

Identity as a mother

Many women's identity was as a mother and partner (the "*matriarch*" of the family (288)), which meant caring for their children (for example, cooking, transporting older children and nursing) and taking responsibility for providing food and doing housework. They wanted to do a 'good job' at this. However, carrying out these tasks acted as a barrier to healthy lifestyle by increasing their busyness, tiredness and shifting their priorities (explained in the sections below). Specifically, many women found it difficult to exercise while a child was present because the child demanded attention or the mother wanted to take care of them. Some got around this by exercising at home, for example, by '"*get[ting] creative" by holding her baby and doing squats*' (279). Some also thought that their lifestyle was less important after pregnancy because it was '*no longer seen as having a direct impact on the child*' (264).

On the other hand, other women considered that being a good mother meant being a role model of healthy behaviour, providing healthy food and maintaining their own health in order to care for their children: "*I don't [change my eating habits] so much for protecting me from getting diabetes; I do it so that my son, as he is learning to eat, he learns to eat healthier*" (290) and

'*to discourage "them from being obese"*' (285). Many wanted to include their families and children in healthier lifestyles or programmes.

Prioritising family

Similarly, women's priorities were influenced by motherhood, particularly prioritising their family's wants or finances. Some experienced objection when they gave their family, particularly the children, healthy foods or thought that it jeopardised their family's cultural identity not to eat their traditional foods: "*…What are the things that I can change without changing the culture of the food? What are the things that you can limit so your family doesn't feel like they can no longer eat what they like?*" (281).

When talking about participation in physical activity, this feeling was even stronger in some women: as part of putting themselves last or forgetting about themselves, some even thought that it was inappropriate to think about exercise while caring for a small child: "*All my time is devoted to them now, and yeah, I base myself around them, what their needs are and stuff you know. Forget about myself I guess sometimes*" (282) and "*Either I have to get up at five o'clock and do it before they wake up or it is taking time away that I could be spending with them*" (290). Mothers thought that they would be able to exercise more when their children were older because they would be less dependent or at school, or they would be able to exercise together.

Conversely, some women in Lim *et al.*'s programme evaluation did prioritise attendance at a diabetes prevention programme: "*Brought baby to session. I forced myself*" and "*I gave up working on Thursdays to come to the sessions*" (291).

Guilt

Probably resulting from their strong sense of identity, guilt was common across several themes. Women felt guilty if they did not prioritise caring for their family or were away from their children, such as to exercise or attend a diabetes prevention programme, and did not see this as a legitimate reason to use external childcare. For example, one participant said, "*[My child] already goes to occasional care on Friday mornings… but that's mainly so I can do the housework… the thought of putting him in care so I can do exercise, yeah, that's a big guilt on me*" (282). They also felt guilty towards their wider family for inconveniencing them with childcare when they believed they should do it, even if it was offered: "*…I feel I have really leaned on my mother a lot for sitting so I don't want to over-do it*" (290).

On the other hand, others felt guilty when they did not exercise when they thought they should.

7.4.3.2 Support from family and friends

In general, the presence of support acted as a facilitator to healthy behaviour whereas its absence was barrier, but the impact was also dependent on the support-giver's own knowledge and T2D risk perception.

Support from family

Support from family involved helping with childcare or housework to reduce busyness and tiredness, and to provide general support and encouragement for physical activity. A mother of two children said, "*[The partner needs to consider that] if I don't help with this then she might be too tired to actually get out for the run she actually would like to go for. I have to make sure she gets the one hour to do so – it's my responsibility too – …[the partners] need to think about how to organise everyday life around [healthy lifestyle]*" (264). Families supported healthy diet in a similar way, but were also a source of information, for example, "*[My sister] told me: 'That has too much sugar in it...' Because my sister is diabetic*" (280), and partners and children could join in eating healthily because it would be beneficial to them and "*…because I can't make two separate meals*" (279). In some cases, the whole family's diet became healthier to prioritise children's health. In addition, the benefits of (or need for) partners to be involved in behaviour change at home, or even attend part of the intervention was identified: "*…So I can explain to him really what's going on but if he would hear it from elsewhere, maybe, it'll be different*" (281).

Support from friends

Unlike support from family, support from friends acted in quite different ways for diet and physical activity. People outside of the family encouraged exercise: "*I like having a buddy system. I've never liked to do exercise on my own… I can't go there alone*" (281) and some thought, "*If the other women can do it so can I. If others with three children can exercise, I with one can also change*" (291). Furthermore, exercise became an opportunity for socialising. Women did not tend to mention that they were able to participate in exercise with their families. Conversely, friends did not so clearly support healthy eating: this tended to be discussed in terms of culture, as explained below.

Women frequently appreciated the social support received at programmes. Motivation and accountability were experienced with regards to healthcare providers or programme facilitators, and mutual encouragement and sharing experiences with fellow participants: "*Being accountable to someone – having someone to 'check in' with will help me*" (291). A couple of women mentioned continuing this relationship outside of the programme, showing how it can provide a contact for continued support (281). O'Dea *et al.* reported that the need to look after children or lacking childcare was the biggest barrier to attending the lifestyle interventions, that women without a partner could not attend, and "*I couldn't have done it if my husband hadn't been supportive of it*" (289). Consequently, women reported that interventions should either include the children or provide childcare.

Societal and cultural norms

Lack of support, particularly in migrant populations, could result in isolation, depression and abandonment because women avoided eating in company or dropped their diets in certain situations (265). Razee *et al.* explained that Arabic-speaking women '*felt duty bound to eat whatever was offered to them when they visited their family or friends. Such cultural expectations "created more problems" even when the family or friends' intention was to be helpful*' (285).

7.4.3.3 Demands of life

Lack of time and energy, and busyness

Women frequently reported lack of time and energy as key barriers to healthy behaviour – specifically lack of time to think about, prepare for and do physical activity and to plan and cook healthy meals. This resulted from caring for children and doing housework, potentially without support: "*You're so busy and so tired and the last thing you want to be bothered thinking about is whether you're eating properly and exercising enough*" (256). This may have been exaggerated when considering physical activity because it was frequently viewed as distinct from the other demands of being a mother: for many it required them to '*set aside time*' (278) and '*taking time out for themselves*' (282) away from children and doing housework (their priorities). Similar views were held when considering attending a programme, particularly if they needed to travel or the time was inconvenient (289); one women explained, "*Time constraint is a big one. Like with people with kids, I know I can't with a drop of a dime just take off and go somewhere*" (281).

On the other hand, some reported physical activity becoming easier and more maintainable when it became a '*daily habit*' (289) that was integrated into daily life. For example, one participant '*always walked upstairs to change her baby's diaper and one always used the stairs at work*' (279).

Women also felt that they needed to prioritise their energy, not use it on exercise. This was in contrast to diet because the role of a mother involved providing family meals, although many also noted struggles with shopping with their children: "*Confusing nutrition labels in store and with kids pulling on you, there is no time to read labels*" (279). On the other hand, some reported the added bonus of saving time through meal planning, such as '*to reduce the number of trips per week to grocery stores*' (281). Others wanted to know how to integrate physical activity into their daily lives, and also how to save time through healthy diet such as cooking quick, healthy meals.

Work

For similar reasons, work was only reported as a barrier to healthy lifestyle, specifically by increasing busyness. It also increased opportunities for unhealthy eating, such as snacking because "*meetings have danishes and muffins, cheese plate*" (279) and in work canteens. Work also took women away from their children, exaggerating the feelings of guilt and the desire not to access childcare, as explained above. One informant said, "*I was exhausted and already feeling so guilty for being away from my child while I was working, so I did not exercise*" (279).

Convenience

Finally, a healthier lifestyle was thought to be hard due to the convenience of and possibility to save time through unhealthy options. For example, the convenience of having a car verses having to walk and unhealthy food that was quick and readily available: "*For me, [the pedometer] does not change anything because I am always in a car. I walk very little so I will feel even guilty for not having walked*" (281).

7.4.3.4 Personal preferences and experiences

Role of food

Food was considered as an important part of life. Acting as a barrier to healthy eating, it was a key aspect of many social gatherings and celebrations: "*Everything revolves around food, and*

a lot of native peoples, that's their highlight of any kind of social gathering is that you've got to have food to celebrate" (287).

Furthermore, some women viewed unhealthy food as a pleasure, reward or comfort (e.g. home cooking helped a South Asian woman living in Australia to "*...feel closer to your home and that you still have this power and that you're still free to choose…*" (265)). Some considered their right to eat what they wanted, perhaps as a response to the controlled pregnancy diet; for example, the women in their early twenties in another study said they were too young to be on a restricted diet (278). While they were breastfeeding, additional hunger was experienced therefore women ate more. Some had cravings, such as for chocolate.

Other women felt pleasure from having a healthy diet; for example, "*The diet plan that I used with GD has benefited me now as I still follow it. I felt very healthy when I was pregnant due to the good foods that I had to eat for the wellbeing of both my baby and myself*" (252).

Emotional effects

Some women reported positive experiences of exercise, which helped them to maintain it. Exercise helped them relax or feel less stressed, energised them and helped them to eat a healthy diet. For example, "*...if I'm not active then I find I don't cope as well with things. If I get out there and get active, feel fitter, then little things don't seem to bother me as much*" (282). On the other hand, others did not enjoy exercise ("*exercise is something I could think about more but I find it so boring*" (284)) or struggled to do it in winter and bad weather.

7.4.3.5 Diabetes risk perception and information

Lack of information was reported in most of the studies. After the intense monitoring of pregnancy, women felt "*abandoned*" (252,264,283), that "*...you're left high and dry*" (256), "*neglected by healthcare providers and were left with unanswered questions about what to do next*" (283). For some, there was a lack of repetition of health messages after delivery so that "*…it was so long ago, I don't remember clearly*" (265). Conversely, some noted that they heard the same health messages again, which could either be annoying or "*...even if it is old knowledge it is good to hear it once more*" (284).

Risk of T2D

Women in most studies reported awareness of the link between GD and T2D. However, some women in half of the studies also did not recognise their personal risk (256,263–

265,279,283,284,286,290). '*One woman described having GD as an interruption in her life and that life does get back to normal so that you can "put it behind you and just kind of go on"*' (283). This could be because they were distracted by caring for the baby so they put it out of their minds, but it was clear that others lacked understanding; for example, "*I am confident. Nobody in my family ever had it*" and "*it's going to be hard to get [T2D]*" (290), or were given incorrect or unclear information by healthcare professionals; for example, "*…before I was worried… but …he (the doctor) said it is gone now… that makes me feel calm*" (286).

On the other hand, many women felt worried, scared or helpless because they thought T2D was inevitable; for example, "*I've got this cloud hanging over us… there's not a great lot more I can do*" (256). Others thought they could "*postpone getting diabetes as long as possible*' through diet and physical activity (264). This often resulted in a desire but not ability to make lifestyle changes. "*The risk of getting T2D is in the back of your mind, you think about what to eat and to exercise, struggling to reduce weight. It is really that simple but also so hard*" (284).

Some women focused on their diet to prevent T2D because they thought that the benefits of physical activity were mediated through weight loss alone. Others discussed how to have a healthy diet, rather than whether it was a good idea. Unlike for physical activity, many women were able to use dietary knowledge from their GD pregnancy: some did this with confidence after being encouraged by their GD lifestyle, whereas others were uncertain and used their pregnancy knowledge in response to not knowing what else to do, asking "*do you follow strictly [the plan] like you were pregnant or do you deviate from it a little because your body's handling it differently… Am I going in the right direction?*" (281). Diabetes prevention programmes were useful for learning about T2D, exercise, diet and weight loss.

Culturally-relevant information

Women often lacked information that was specific to them and were not able to benefit from postpartum follow-up, such as how to plan and cook culturally-specific meals. It appears that women become torn between a healthier, alternative diet and maintaining their cultural identity. Others, illustrated by the Algonquin community, benefitted from being able to adapt their traditional diet to be healthier – for example, switching cooking oil or using alterative meats. Provision of the information was also delivered in a culturally-appropriate way because '*They adapted appointments to the Algonquin way of life: instead of making appointments for a fixed*

time and date, they intervened immediately, adapting to a culture-specific concept of time described by the general informants as "now or never"' (280).

7.4.3.6 Finances and resources

Lacking resources, and the need to prioritise financial ones, were frequently quoted as barriers to healthy behaviour. A healthy lifestyle was perceived to be more expensive than an unhealthy one: healthy food was more expensive than junk food and going to the gym was more expensive than not exercising (particularly when external childcare was needed). "*...[Healthy foods] are not the cheap items; they're a kind of more in the pricy end. It could be a bit irritating to prioritize your money in that way…*" (264). None mentioned that they were able to use gyms to exercise; if gyms were available, they were seen to take up women's time and away from their children and one woman said that she still did not have time to use the gym even though it was in her building (279).

They anticipated that access to cheaper or free healthy food and facilities would increase their healthiness. Resources such as recipes and home exercise equipment or DVDs would equip and motivate them to be healthier. Gaudreau *et al.* found that women were able to sustain a healthier diet because they found that it was cheaper: '*Some said they went to restaurants less often or ate differently when they did go out to eat: "I didn't eat out as often. It became less expensive to eat out because I cut down on my portions"*' (280).

7.4.3.7 Format of interventions

Finally, women discussed the format of diabetes prevention programmes or interventions in five studies, and briefly mentioned it in three others.

There was no consensus of the best mode of delivery: web-based interventions were thought to be flexible, which could address some of the time and childcare barriers explored above. They could be used to provide support and encouragement, however others were less interested because they wanted face-to-face contact or did not want to spend any more time on computers. Telephone interventions were not popular, despite women in Lim *et al.* finding that it was personal and flexible to their requirements (291). The greatest appeal of face-to-face group interventions was that they could provide social support, including accountability, motivation and fulfilling the social needs of women. Mental health could be a barrier to group settings however – one woman reported that it was awkward to discuss depression and another did not

attend a group because of her depression. One participant suggested "*have a peer group in-person to start, to get to know each other, then use chat rooms/email to access at all times of the night*" (279) to utilise the benefits of multiple approaches. Graco *et al.* reported that women could be flexible with a physical activity programme as long as it was "*family-friendly*" (282), highlighting their priorities.

Little was described about women's preferred timing for intervention. Dasgupta *et al.* reported that interventions should start during pregnancy or immediately postpartum (281), which was supported by my finding that women felt unsupported after pregnancy. Conversely, Lie *et al.* concluded that weaning provided a "*window of opportunity for intervention to promote more healthy eating habits*" (256).

Several considered that lifestyle coaches, trainers or counsellors could provide support while medical staff were seen as a trustable source of knowledge, but the studies did not discuss who should deliver a programme.

7.4.4 Recommendations for promoting behaviour change

I developed 20 recommendations for promoting healthier lifestyles after GD based on these findings (reported fully in Appendix 10 and summarised in Table 7.3). I mapped them onto the behaviour change technique taxonomy to suggest a range of behaviour change techniques that could be included in future interventions, if appropriate to the setting.

To illustrate, recommendation 7 ('provide guidance about how to buy and prepare healthy, tasty food efficiently') is a 'non-specific incentive' in itself by incentivising women to save time and money through dietary changes. The physical activities suggested in recommendation 17 could be implemented through 'goal setting (behaviour)' by helping women to create personal daily walking targets or playing with their children at the park four times a week rather than sitting and watching.

Table 7.3: Twenty recommendations for promoting healthier lifestyles after gestational diabetes, and our confidence in each recommendation made using the GRADE-CERQual approach.

Recommendation	Behaviour change techniques relevant to recommendation (190)	Confidence in evidence and explanation
Role as mother and priorities		
1. Highlight the benefits to the family of the mother being healthier and role modelling healthy lifestyle to children as the incentive for change, alongside preventing diabetes	5.1 Information about health consequences, 5.3 Information about social and environmental consequences, 10.5 Social incentive, 10.7 Self-incentive, 13.1 Identification of self as role model	**Moderate:** Women directly or indirectly reported that their children were their incentive for change; whether it is appropriate for all should be considered
2. Include the option of childcare in face-to-face interventions if children are not part of the sessions	12.2 Restructuring the social environment, 14.1 Behaviour cost	**Moderate:** Few studies contributed to this recommendation but some directly suggested it; it is supported by general concern about children/childcare
Support from family and friends		
3. Promote healthier lifestyles in the wider family (and friends)	7.3 Reduce prompts/cues, 12.2 Restructuring the social environment	**Moderate:** It is clear that women need support for a healthy diet but few studies clearly discussed family and friends exercising
4. Encourage the wider family (and friends) to promote healthy lifestyles in mothers and support them practically (such as relieving housework burdens)	3.2 Social support (practical), 3.3 Social support (emotional)	**High:** Many studies explained the benefits of or need for support for lifestyle change
5. Include the family in interventions (e.g. information or modules for partners and children)	3.2 Social support (practical), 3.3 Social support (emotional)	**Moderate:** Inadequate data reduced our confidence that this recommendation would be useful to postpartum women
6. Encourage and facilitate women to exercise with others/a buddy	3.3 Social support (emotional)	**Moderate:** This recommendation was developed from the general need for support, plus a few studies that specifically addressed it
Demands of life		
7. Provide guidance about how to buy and prepare healthy, tasty food efficiently	1.2 Problem solving, 4.1 Instruction on how to perform a behaviour, 10.6 Non-specific incentive	**High:** Many women reported the lack of and need for more guidance for having a healthy diet
8. Provide guidance about how to exercise around the house and as part of regular daily routines	4.1 Instruction on how to perform a behaviour, 8.3 Habit formation, 10.6 Non-specific incentive	**Moderate:** It is clear, and stated, that women need help to increase exercise; however, there is some contradictory suggestions about the best form(s) of exercise to promote and how

Personal preferences and experiences		
9. Support women to maintain healthy behaviour/diet in challenging situations – eg. social gatherings, breastfeeding, at work (particularly for vulnerable groups)	1.2 Problem solving, 1.4 Action planning, 4.2 Information about antecedents	**Low:** Certain situations affect women's ability to maintain healthy diets; the best way to address this is unclear
10. Highlight the wider benefits of healthier lifestyle (such as reducing stress and weight as well as diabetes risk)	9.2 Pros and cons, 9.3 Comparative imagining of future outcomes, 13.2 Framing/reframing	**High:** Women had identified many benefits of adopting healthier lifestyles that helped them to maintain them (perhaps after awareness of diabetes risk declined over time)
Diabetes risk perception and information		
11. Make information, resources and training easily accessible and make interventions available to start immediately after pregnancy (or during pregnancy)	4.1 Instruction on how to perform a behaviour, 5.1 Information about health consequences, 5.2 Salience of consequences	**High:** This recommendation resulted from many studies that were in agreement, with few exceptions
12. Ensure that interventions are culturally appropriate and recommendations allow maintenance of women's identity	13.2 Framing/reframing, 13.5 Identity associated with changed behaviour	**High:** It was clear that women wanted culturally-relevant interventions and that they were beneficial to those who received it
13. Ensure that care providers consider women's attitude towards diabetes and advise them on their risk appropriately	5.1 Information about health consequences, 5.2 Salience of consequences	**Low:** This recommendation is a step on from women's attitudes towards behaviour change and their clinician
14. Promote a long-term perspective about maintaining healthy lifestyle, with an 'every little helps' approach, rather than 'all or nothing', and include the importance of both diet and activity	5.1 Information about health consequences	**Moderate:** Paucity of data has reduced our confidence in this recommendation
Finances and resources		
15. Provide information about low-cost or money-saving healthy behaviours and resources; interventions should be free	4.1 Instruction on how to perform the behaviour	**High:** There was agreement across studies but this was not reported in detail
Format of intervention and other		
16. Recommend increasing fruit and vegetable intake, reducing sugar and substituting with healthier ingredients or methods to improve diet	1.1 Goal setting (behaviour), 1.4 Action planning	**Moderate:** Several studies briefly reported women being able to makes these changes
17. Recommend flexible exercise such as walking and those performed around the home or with the baby to increase physical activity (rather than attending gyms or classes)	1.1 Goal setting (behaviour), 1.4 Action planning	**High:** Women across several studies reported how and why they did these types of exercises

18. Ensure interventions have web-based components but encourage additional face-to-face contact (they should not depend on women attending sessions)	6.2 Social comparison	**Low:** There was no agreement across studies; this recommendation attempted to consider what women wanted but also what was most practical
19. Deliver and promote interventions from recognised/trusted sources (e.g. the healthcare provider or a dietitian)	9.1 Credible source	**Low:** Preferred source of the intervention was not discussed; however women reported benefits from their interactions with various professionals
20. Promote establishment of systems to monitor progress and accountability (through an intervention or ensure the participant establishes this themselves)	2.2 Feedback on behaviour, 2.3 Self-monitoring of behaviour, 2.4 Self-monitoring of outcome of behaviour, 3.2 Social support (practical)	**High:** Accountability facilitates behaviour change, but the best way to promote this remains uncertain

Recommendations frequently result from findings within multiple themes but have been presented under the primary contributing theme.

I had high confidence in eight, moderate confidence in eight and low confidence in four recommendations in the GRADE-CERQual evaluation. The recommendations were based on many good-quality, relevant studies; confidence was therefore largely influenced by coherence and agreement between studies and richness of the data. I tended to have higher confidence about information that women wanted and the need for support and accountability, but lower confidence in recommendations about equipping women in situations such as at work, the behaviour of friends and family (other than offering support) and interactions with professionals because continued contact is not common. I felt that it was important to adapt interventions to the target population and facilitate family-friendly changes because the mother's own diabetes risk was unlikely to motivate change without her perceiving benefits for her children. Some of the most beneficial aspects of groups (such as forming supportive relationships) mean that they are impractical for most to commit to in the long-term. Consequently, a combination of approaches could be most appropriate: for example, online information, target-setting and accountability plus options to arrange video calls with healthcare professionals such as dieticians, and connections with local mothers' groups.

7.5 Discussion

This review shows that adopting and maintaining a healthy lifestyle after a pregnancy affected by GD is complex. An identity as a mother who prioritised family above herself influenced many women's ability to care for their own health, in addition to the need for resources, time, energy, information and support. Taking into consideration the significant impact that having new children has, these barriers frequently appeared to outweigh the perceived benefits of behaviour change by those maintaining established unhealthy behaviours, particularly when a negative effect on family life was anticipated.

Influences on the two key behaviours were similar. One difference was that diet could be adapted because meal preparation and eating were already necessary, whereas exercise was an additional task. Some influences were both positivity and negatively reported: for example, lack of culturally-specific information inhibited healthy diet (information as a barrier) plus guidance about adapting traditional foods helped women to make changes (information as a facilitator). In contrast, some facilitators were only anticipated: for example, women suggested giving gym passes to increase exercise, but none reported regularly using the gym.

7.5.1 Strengths and limitations

This is the first comprehensive qualitative synthesis to focus on the views of women with a history of GD on having a healthy lifestyle and to make clear recommendations for implementing the findings. Alongside a multidisciplinary team, I conducted a comprehensive literature search and thematic synthesis to identify repeated themes across studies and recognise those that may have previously been overlooked. Concurrent comparison of positive and negative influences and different behaviours permitted a more representative understanding than if barriers and facilitators had been analysed separately. I observed diverse perspectives and variety between and within study populations (such as ethnicity, social norms, other children and family members). Congruence between high-quality studies increased my confidence in my recommendations, which I transparently evaluated using GRADE-CERQual and linked to standard behaviour change techniques.

There are also limitations. I was not able to specifically investigate how experience of pregnancy, such as struggling to manage blood glucose control through lifestyle modifications

or feeling guilty for having GD (78), influenced postpartum behaviour based on these studies. Furthermore, I did not distinguish between timepoints but collated studies that collected data from six weeks to ten years postpartum, therefore could not explore changes over time as reported by Hjelm *et al.* (286). Most data were from educated or employed women recruited from medical settings in developed countries, meaning that I probably missed some experiences of motherhood (although the populations were quite different, as discussed). Although it is possible that participants felt that mental health did not influence behaviour, it is also possible that they avoided this topic and that women experiencing mental health difficulties did not participate in these studies. I did not access the primary data therefore was reliant on how the primary studies' authors interpreted and reported their data, nor did I examine quantitative literature. Barriers made the greatest contribution to analytical themes, perhaps because they were emphasised by researchers or respondents. Fewer studies reported experiences of diabetes prevention programmes but they were consistent with other themes.

Although the studies were good quality, quality did affect the results of the synthesis and recommendations. Authors rarely adequately considered their role as researchers, which could have led to bias in the formation and evaluation of research questions and social desirability bias among respondents. Furthermore, although I did not influence the participants or original analyses, my analysis was inevitably affected by my own preconceptions. In recognition of this, I developed the coding frame from the study findings in order not to impose a framework from the review question, used structured CASP and GRADE-CERQual checklists, and all authors discussed the themes and findings.

7.5.2 Comparison to other literature

7.5.2.1 Related literature reviews and quantitative studies

Whilst my findings broadly agree with previous literature reviews, I have added more studies and data, described the phenomena in more detail and put forward recommendations resulting from the findings. In 2014, a meta-synthesis found that, in the context of preventing diabetes in the future, women prioritised children and families and listed barriers and facilitators (77). They noted that few studies contributed to this whereas I identified 11 studies published since their search. Two other reviews, which had a greater focus on healthcare seeking, commented that many women have knowledge regarding diabetes prevention that affects their desire to

live healthily (87,147). They also list numerous barriers, including some that I found less emphasis on such as poor body image and an unsuitable neighbourhood. There is a growing recognition of the important influence that the environment exerts on population diet and activity. It is likely that women with a history of GD are subject to this influence to some degree and that interventions are likely to be more effective in a more supportive environment. Consistent with my findings, a discussion of a recent symposium (where speakers presented their experiences in Denmark, Australia, Canada and Ireland) concluded that postpartum behaviour is affected by women's beliefs about their susceptibility to diabetes, is considered at the cost to their family, and that healthcare systems gave disjointed care so women lack information (292).

My recommendations are comparable to those identified in the development of the 'STAR MAMA' intervention (293). In that study, focus groups (including overweight women or those with GD), alongside experts, were used to adapt the DPP to Latina women through the behaviour change wheel framework. In the adapted programme, techniques such as modelling narratives and role-playing were used to help participants overcome barriers to behaviour change through automated weekly telephone calls and coaching. The initial evaluation of the intervention was positive, with participants engaging with the telephone calls and the health coaches giving individualised tips (294). Sharing information about GD follow-up and more general postpartum support was a key element of this intervention, which may be less effective in populations with higher health literacy.

7.5.2.2 Other populations

There are also similarities between the experiences and needs of women with GD and those with normoglycaemic pregnancies. Postpartum mothers in the general population also report barriers to physical activity including lack of energy, time for housework and the responsibility of childcare (295,296). In Graco *et al.*, women with GD did not want to be seen as a separate group but to attend classes with mothers who had had a normoglycaemic pregnancy (282). This raises the question of whether interventions should be specifically targeted at women with previous GD or mothers seeking healthy lifestyles in general.

In a letter to a journal, Lim *et al.* compared my publication to their own systematic review that looked at characteristics of weight management interventions in postpartum women without GD, with the view to inform implementation (297,298). They introduced the Consolidated

Framework for Implementation Research (CFIR) (299), in which interventions have core components (such as those identified in other populations or systematic reviews) and an adaptable periphery that is population- and context-specific. The format and timing of the intervention were suggested to be part of the periphery that could be adapted to women with a history of GD. They also highlighted the important role of the healthcare provider as a trusted source of information in both groups of mothers.

My results also broadly agree with determinants of healthy behaviour and corresponding intervention approaches in the wider adult population, where the behaviour change techniques of goal setting and self-monitoring of behaviour have been suggested to be effective (300,301). Nonetheless, there appears to be a different emphasis: mothers with previous GD appear to weigh relational factors (like the possible impact of their behaviour on others) higher than other populations, and place less emphasis on environmental factors and personal health benefits.

7.5.3 Implications

As outlined in Table 7.3, this qualitative review informs approaches for promoting healthier lifestyles among this population. These recommendations could be used to develop new interventions or adapt existing ones. For example, although the DPP intensive lifestyle intervention was effective, it may be difficult for women to commit to because it includes repeated face-to-face meetings with a case manager (163). Indeed, it has already been adapted for the STAR MAMA intervention by using telephone calls including pre-recorded education and supportive narratives so that women could engage with the intervention in their own language from their homes (294). Total diet replacement and stepped food reintroduction in a population with diabetes (DiRECT trial) resulted in diabetes remission in half of their participants (302), but a diet that is so controlled and different to the rest of the family's may not be attractive to mothers. Web-based interventions with additional face-to-face or remote support from a nurse (POWeR+ trial) have led to weight loss in the general population (303), and could be adapted to meet the specific requirements of this population.

I have also identified areas that need further research. Despite including a number of recent studies, I was not able to examine the use of technologies like smartphone applications and social media, which is growing across the world. In a study that was published after we conducted our literature search, participants suggested that more support should be provided

via online forums and information on general practice websites (304). The authors reported that technology could provide information, enable personalised self-management and meet social needs, with flexibility noted as a benefit. Additionally, I was unsure whether promoting change in the wider family would specifically facilitate mothers to be healthier based on this review. However, the risk of diabetes is higher in partners and children of mothers with GD (305,306) and maternal behaviour strongly correlates with childhood obesity (307) therefore it should be carefully considered.

Furthermore, how best to apply these recommendations should be given careful attention. For example, tailoring for working and single mothers or those experiencing postpartum mental health disorders, and the appropriateness of additional behaviour change techniques (such as '14. Scheduled consequences' (190)).

7.6 Summary

Maintaining a healthy diet and regular physical activity after GD can help women mitigate their future risk of developing T2D. In this chapter, I sought to understand the influence that different factors had on lifestyle choices in this population and corresponding approaches to support them using a systematic review and qualitative synthesis.

I found that many factors make it difficult to adopt and maintain healthy lifestyles after GD, yet how women interpret these situations can motivate or prevent changes that reduce their diabetes risk. Women's needs and experiences should be considered when designing strategies to promote healthier lifestyles. I made key recommendations based on a synthesis of qualitative data that will inform the development of feasible interventions, or adaptation of existing ones, to educate and support women in achieving and maintaining a healthy postpartum lifestyle in order to reduce their risk of developing T2D.

Together with Chapter 6, these findings informed the interview study reported in the next chapter in which I sought to understand the attitudes of a local population who had recently had GD towards healthy behaviours to prevent T2D, with a focus on their need for additional support.

Chapter 8 The DAiSIeS study

Diet, Activity and Screening after gestational diabetes: an Interview Study

In the final study of my thesis, I extend the findings of my previous systematic reviews with primary research. Using qualitative interviews, I wanted to understand the experiences of women with recent GD and their views towards potential interventions in order to develop practical, appropriate and useful approaches to improving postpartum support.

In this chapter, I report the findings relating to healthy diet and exercise, and attending diabetes screening tests concurrently. This follows the sequence of the interviews and facilitates a broader overview and discussion of the views of these participants. Nevertheless, I will submit the findings for publication as two papers.

8.1 Background

As I identified in Chapter 4, development of T2D after GD is a serious problem that tends to be underappreciated by mothers and clinicians. Screening for the anticipated glucose intolerance after pregnancy is important to reduce exposure to hyperglycaemia and hence reduce risk of longer-term complications. BMI is a modifiable diabetes risk factors that is associated with 18% higher diagnoses for each unit higher BMI, highlighting the importance of weight management through diet and exercise.

In the UK, screening should occur at around six weeks postpartum, followed by lifelong annual screening in order to monitor glucose levels and to identify those at highest risk of progressing to diabetes and with prevalent undiagnosed diabetes (2). FPG tests are recommended up to 13 weeks postpartum, and HbA_{1c} tests should be used thereafter (2). Short term follow-up in the UK has been reported between 19% and 80% (153,154,240,241) (and Chapter 5), with even

lower annual rates thereafter (154,155). In the qualitative synthesis reported in Chapter 6 (208), I found that women's experience of the healthcare system and personal factors influence both opportunities and motivation to attend testing. They understood the importance of testing based on the maternity care received; were put off by an unpleasant procedure that could be inconvenient to attend; were focused on childcare; and had varying levels of concern about T2D that could increase or decrease motivation to attend testing.

In addition, most women either do not attempt or are unable to sustain behaviour changes to reduce modifiable risk factors; instead, many maintain lifestyles that increase their diabetes risk (172). Existing behaviour change interventions have had positive effects but their impact has been limited due to poor engagement (166–168). In the second qualitative synthesis in Chapter 7 (209), I found that after GD, women identified themselves primarily as mothers who prioritised their family above themselves. This motivated some to adopt healthy diets and to be active, whereas this identity plus a need for resources, time, energy, information and support prevented many others from making changes.

Based on the findings of the literature reviews, I developed recommendations for promoting healthy lifestyle and attendance at screening after GD (Table 6.2 and Table 7.3). I evaluated my confidence that these recommendations were suitable according to the literature, but understanding the views of women living in the UK was identified as an area requiring further investigation, such as what they would emphasise as most beneficial to them and how to deliver such interventions. Furthermore, I was not able to identify how personal circumstances or characteristics may influence behaviour after GD.

8.2 Aim

The objective of this study was to explore and develop practical approaches to promote behaviour changes in women who have had GD that would reduce their risk of going on to develop T2D and of prolonged exposure to hyperglycaemia. This focussed on adopting a healthy lifestyle (in terms of eating a healthy diet and being physically active) and attending regular diabetes screening.

The aims were:

1. To understand how GD has or has not affected women's diet and participation in physical activity;
2. To understand women's views towards making changes to their lifestyle after GD;
3. To understand women's views towards attending diabetes screening after GD;
4. To elicit women's evaluation of strategies for promoting healthier diet and physical activity levels;
5. To elicit women's evaluation of strategies for promoting attendance at diabetes screening;
6. To explore their preferences for delivery of these messages.

8.3 Methods

The methods are described in detail in Section 3.3. The relevant study materials are presented in Appendices 1 to 4.

8.3.1 Recruitment and inclusion criteria

Research staff from the Rosie Hospital and Peterborough Hospital identified eligible participants using their medical records and sent them an invitation and information sheet. Those who were interested in taking part responded to the research staff, who passed their contact details onto me to arrange the interview.

We invited participants who were:

- Diagnosed with GD during any previous pregnancy;
- 12 weeks to four years postpartum;
- Over 18 years old.

We did not invite those who:

- Would be unable to give informed consent or were considered unsuitable to take part for any other reason at the discretion of the hospital research staff;
- Did not have a successful, uncomplicated, full-term pregnancy at the discretion of the hospital research staff;
- Had a diagnosis of T2D or T1D before GD;

- Had participated in a pregnancy-related intervention.

8.3.2 Semi-structured interviews

I interviewed each participant face-to-face at a time and place of their choice, with their child or children present if preferred. The interviews were audio-recorded after the participants confirmed they understood the plan and purpose of the interviews, and gave informed consent.

Each interview was guided by the interview schedule (Table 3.5). I began by introducing myself and the purpose of the interview (an opportunity for them to share their experiences and opinions). Initially we discussed their experience of GD. I then invited them to describe their current eating and physical activity habits, whether they felt that their previous GD diagnosis had influenced their diet and physical activity, and any preferences for support that would help or have helped them to be healthier. These questions were then repeated for attending diabetes screening: whether they had attended, plans for future screening, and what might help them attend. I first asked if they had any ideas for support, then sought their opinions on 20 suggestion cards (if I considered this to be appropriate according to their earlier responses) that were based on the findings of the qualitative literature reviews (Chapters 6 and 7) (208,209). The interview ended with a short demographic questionnaire. I then recorded field notes.

8.3.3 Analysis

The interview recordings were transcribed, then I checked the transcriptions for accuracy. After the first few interviews, I began analysis using a framework approach (210,211). This involved familiarisation with the data, identifying a thematic framework, coding, charting, and mapping and interpretation.

I used NVivo 12 for the coding and charting stages. The thematic framework, including 62 codes in total, is reported in Table 3.6. Rachel Fox also coded and charted four interviews. Table 8.1 shows a sample of one of the 21 charts. These included general comments on the topic (to give the context for each response), their prompted response to the corresponding suggestion card(s), and any relevant unprompted suggestions that the participant initiated.

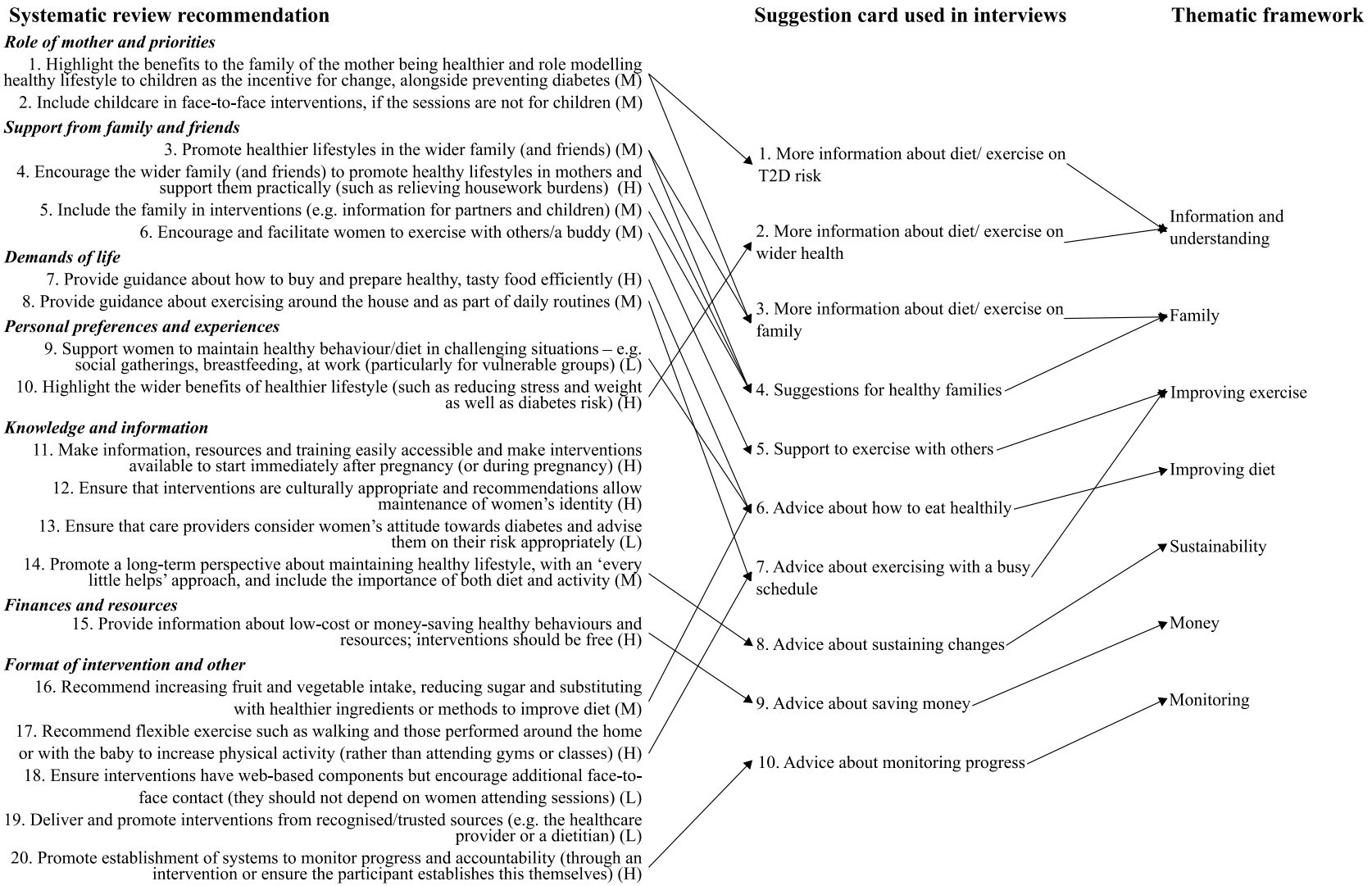
Table 8.1: Excerpt from the chart 'information and understanding' used in the thematic framework analysis of the DAiSIeS study.

	06. General comments	07. Prompted #1 More information about the impact of healthy diet/exercise on your diabetes risk	08. Prompted #2 More information about the impact of healthy diet/ exercise on your wider health	09. Unprompted suggestions
Rachael Age: ≥41 yrs Med: Yes PP test: Yes Ethnicity: W	Has diabetes in the family, so aware/worried about prevent-ion. Especially worried her children will develop it. Frustrated that she might get T2D when is careful to look after herself – wants to do what she can to limit it. Is there anything else she should do?	Agreed - always welcome to receiving more and new information (e.g. influence of processed food is big at the moment).	Agreed? Finds that exercise and yoga are good for stress relief and help you lose weight too.	None.
Suzanne Age: 31–35 yrs Med: No PP test: Yes Ethnicity: A	Did lots of their own research, and are now more health-conscious and changed their lifestyle. Especially after the first 2 months, because when her baby was littler, she was too busy just trying to brush her teeth. Important for her to take time to be healthy.	Helpful for a health professional to reinforce that information.	Agreed.	Wanted this information to include more specific advice about exercise (e.g. how strenuous the exercise needs to be, about rice).
Kimberly Age: 31–35 yrs Med: No PP test: Yes Ethnicity: W	At the start of the interview, she was more concerned about being healthy to prevent cancer.	"100% it would help... I didn't even know I had an increased risk, to be honest, I didn't know anything... Well hence why I ate all those Easter eggs. I probably would have only eaten half."	Feels that there is already lots of advice available – less important in support for GD.	Had a long discussion about T2D – she asked lots of questions as she had the impression they were isolated. Definitely wants more info if there is a link.

A: Asian ethnicity; med: medication for GD; PP: postpartum; W: White European or British ethnicity; yrs: years.

Figure 8.1 illustrates the relationship between the recommendations developed in the qualitative syntheses, the interview schedule suggestion cards and the thematic framework. For example, the first recommendation for increasing uptake of diabetes screening after GD in the qualitative synthesis was 'educate clinicians to, and how to, promote screening throughout GD and postpartum/subsequent care.' I sought to understand whether the participants felt that it was important for their clinicians to promote screening during and after GD (that is, whether it would be beneficial to educate the clinicians to do this) by suggesting 'discussing postpartum tests during pregnancy'. Alongside reminders for tests, this informed the theme 'booking tests', where some participants appreciated that their postpartum test was booked during pregnancy.

A


Systematic review recommendation
Suggestion card used in interviews
Thematic framework
Role of mother and priorities
1. Highlight the benefits to the family of the mother being healthier and role modelling healthy lifestyle to children as the incentive for change, alongside preventing diabetes (M)
2. Include childcare in face-to-face interventions, if the sessions are not for children (M)
Support from family and friends
3. Promote healthier lifestyles in the wider family (and friends) (M)
4. Encourage the wider family (and friends) to promote healthy lifestyles in mothers and support them practically (such as relieving housework burdens) (H)
5. Include the family in interventions (e.g. information for partners and children) (M)
6. Encourage and facilitate women to exercise with others/a buddy (M)
Demands of life
7. Provide guidance about how to buy and prepare healthy, tasty food efficiently (H)
8. Provide guidance about exercising around the house and as part of daily routines (M)
Personal preferences and experiences
9. Support women to maintain healthy behaviour/diet in challenging situations – e.g. social gatherings, breastfeeding, at work (particularly for vulnerable groups) (L)
10. Highlight the wider benefits of healthier lifestyle (such as reducing stress and weight as well as diabetes risk) (H)
Knowledge and information
11. Make information, resources and training easily accessible and make interventions available to start immediately after pregnancy (or during pregnancy) (H)
12. Ensure that interventions are culturally appropriate and recommendations allow maintenance of women's identity (H)
13. Ensure that care providers consider women's attitude towards diabetes and advise them on their risk appropriately (L)
14. Promote a long-term perspective about maintaining healthy lifestyle, with an 'every little helps' approach, and include the importance of both diet and activity (M)
Finances and resources
15. Provide information about low-cost or money-saving healthy behaviours and resources; interventions should be free (H)
Format of intervention and other
16. Recommend increasing fruit and vegetable intake, reducing sugar and substituting with healthier ingredients or methods to improve diet (M)
17. Recommend flexible exercise such as walking and those performed around the home or with the baby to increase physical activity (rather than attending gyms or classes) (H)
18. Ensure interventions have web-based components but encourage additional face-to-face contact (they should not depend on women attending sessions) (L)
19. Deliver and promote interventions from recognised/trusted sources (e.g. the healthcare provider or a dietitian) (L)
20. Promote establishment of systems to monitor progress and accountability (through an intervention or ensure the participant establishes this themselves) (H)
1. More information about diet/ exercise on T2D risk
2. More information about diet/ exercise on wider health
3. More information about diet/ exercise on family
4. Suggestions for healthy families
5. Support to exercise with others
6. Advice about how to eat healthily
7. Advice about exercising with a busy schedule
8. Advice about sustaining changes
9. Advice about saving money
10. Advice about monitoring progress
Information and understanding
Family
Improving exercise
Improving diet
Sustainability
Money
Monitoring

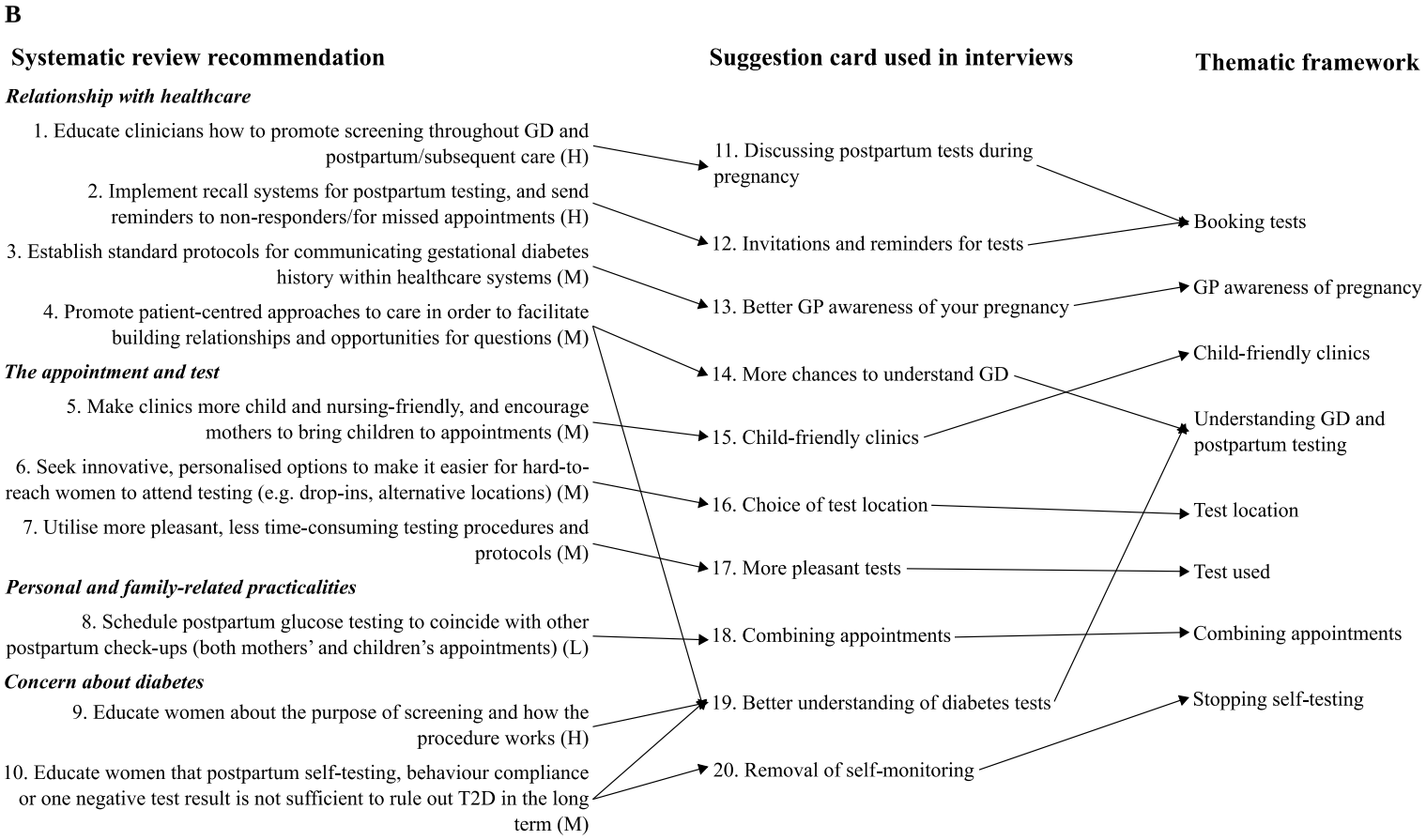


Figure 8.1: Adaptation of recommendations developed in the qualitative syntheses reported in Chapters 6 and 7 to the DAiSIeS interview schedule and the thematic framework: (A) healthy diet and physical activity, (B) attendance at postpartum testing.

H: high confidence; M: medium confidence; L: low confidence in the recommendation in accordance with the GRADE-CERQual evaluation.

8.4 Results

Firstly, I report an overview of the participants who took part in the interviews, describing the demographics of the group then a profile or summary of each participant (Section 8.4.1). Secondly, I describe the findings of the analysis in the remainder of Section 8.4, with an emphasis on the participants' views towards improving the healthiness of their diet and physical activity (Section 8.4.3), diabetes screening attendance (Section 8.4.4), and what support might help them (Section 8.4.5). I record personal reflections on this study in the discussion (Section 8.5.3).

Participants' quotes are presented in italics. For each participant referenced, I report their ethnicity (simplified as White [British or European] or Asian), whether they were on medication for GD, and whether they had attended a diabetes screening test since pregnancy.

8.4.1 Included participants

Between June 2019 and February 2020, I interviewed 20 participants who were between three months and four years postpartum. Their characteristics at the time of the interview are reported in Table 8.2. According to their preference, 18 interviews took place in participants' homes, where children were often present, and two took place in a private hospital room. Eleven participants had been patients at Peterborough Hospital during their pregnancy and nine were at the Rosie Hospital, Cambridge. The median (IQR) number of pregnancies per participant was 2 (1 to 2.25), with 1 (1 to 2) pregnancy affected by GD. No one had been diagnosed with T2D.

The interviews lasted for a mean 38 minutes (range 21 to 62 minutes).

A brief profile of each participant is given in the text below, including a summary of their diet, physical activity and the screening behaviours discussed in the interview. As described in the methods, each participant was assigned a pseudonym and age from within the appropriate age category. They are presented in alphabetical order.

Table 8.2: DAiSIeS participant characteristics at the time of the interview.

	N (percent)
Age band	
26 to 30 years	3 (15)
31 to 35 years	9 (45)
36 to 40 years	6 (30)
41 years or more	2 (10)
Ethnicity	
White British or European	14 (70)
Asian*	6 (30)
Education level	
Secondary or further	5 (25)
Higher	6 (30)
Postgraduate	9 (45)
Employment	
Full-time	10 (50)
Part-time	9 (45)
Home parent	1 (5)
On maternity leave	11 (55)
Lives with partner	18 (90)
Number of children	
1	6 (30)
2	9 (45)
3 or more	5 (25)
All pregnancies affected by GD	13 (65)
On medication for GD (metformin and/or insulin)	10 (50)
Experience of GD pregnancy and postpartum**	
GD management required significant/challenging lifestyle changes	17 (85)
They were attempting to maintain a healthy postpartum lifestyle	14 (70)
They felt adequately supported to maintain a healthy postpartum lifestyle	10 (50)
Attended any postpartum diabetes test	16 (80)
Intended to attend future testing**	13 (65)

**Including Chinese, Japanese and Indian ethnicities.*
***Elicited from transcripts.*

Amber

Amber was 31 years old, lived with her husband and had a postgraduate degree. She worked full time, and was on maternity leave at the time of the interview. She was diagnosed with GD at the end of her second pregnancy, and managed blood glucose levels by diet.

She described herself as very active and her usual diet was low in carbohydrates to help symptoms of irritable bowel syndrome. Postpartum she had been keen to maintain the dietary changes to mitigate T2D risk, and saw this risk in the future. Over the course of the interview, she became aware of the limited advice about diet and exercise she had received postpartum.

Amber's GP sent her for the diabetes screening test around six weeks postpartum. She had not realised that annual testing was recommended therefore we discussed this at the end of the interview.

Christine

Christine lived with her husband and recently had their first baby. She was Asian ethnicity, 32 years old and on maternity leave. She was not on any medication for GD during pregnancy, managing it by strictly controlling her diet and walking, which she did not enjoy. Christine found that as teacher, it was hard to follow some of the advice and to fit glucose monitoring around lessons. She felt that GD was the focus of her pregnancy and managing it took over her life.

She was keen to keep up a healthier lifestyle but was also realistic about the long-term challenges postpartum. At the time of the interview, she was eating more due to breastfeeding, but had learnt that she might not need to eat as many carbohydrates as before pregnancy. She had started walking with the baby in the sling after recovering from a caesarean. She had benefitted from support from antenatal and social media groups during and after pregnancy.

Christine attended the six weeks postpartum test, saying that it brought GD to an end. She thought that subsequent testing would help motivate a healthy lifestyle. This would be important because T2D was common in her family.

Danielle

Danielle was a primary school teacher with two children. She usually worked part time but was on maternity leave at the time of the interview. She was 29 years old, White British, and lived with her husband. She found her blood glucose was unpredictable and managed her second GD pregnancy with insulin. While some clinicians had been supportive, she felt unhelpfully judged by others.

Danielle was aware of the increased risk of T2D. Danielle had become more conscious of what she was eating so tried to lower her carbohydrate intake and eat more vegetables since pregnancy. This was a big change, motivated by wanting to lose weight and be healthy for her children. Exercising was difficult after a recovering from complications at the end of pregnancy, and she hoped that when her youngest child sleeps better she would have more energy for walking. Previously, most of her activity came from work.

At the time of the interview (several months postpartum) she had not had a diabetes screening test and had not been invited for one. She felt that there needed to be much more general postpartum support, including emotional support.

Emma

Emma was 38 years old. She had a postgraduate education, and experience in biological and social sciences research. She was on maternity leave from her full-time job. She was White British and lived with her husband and their baby. She was diagnosed with GD late in pregnancy after having a normal first OGTT, and was not on diabetes medication.

Emma had always cooked food from scratch, and made changes during pregnancy about how much and when she ate. Although Emma returned to eating lots of sugar after the birth, she hoped to start to some of the elements of GD diet again now that life with the baby was settling down and she started to think about weaning. She also planned to exercise more.

She had been tested for diabetes postpartum and intended to go for annual testing. She felt that if it was worth NHS resources for her to be tested, it was important for her to attend.

Francesca

Francesca was 39 years old. She was White European ethnicity and lived with her husband. She had a higher education and worked part time, and was on maternity leave at the time of the interview. She had GD with both pregnancies, and managed the latter with metformin and insulin.

Francesca admitted that after six months of eating the same foods to manage GD, she had eaten what she wanted to over Christmas. She was starting a calorie-controlled diet to lose weight by the time of the interview. Exercise was difficult at that time because of tiredness (her older child did not sleep well), so most of her activity was pushing her double pushchair. She considered diet to be most important for weight loss, so was keen to maintain it in the long-term and not develop T2D in the next few years.

Her postpartum test was booked for that week. She was apprehensive about the test, but eager to find out the result rather than being in denial about it.

Holly

Holly was 29 years old and lived with her husband. She worked part time in a healthcare-related role and was on maternity leave at the time of the interview. She had three children,

with GD diagnosed in her first pregnancy only. She had controlled her blood glucose through diet alone. She then fell just below the GD cut-off in her second pregnancy, and monitored her blood glucose in the third pregnancy until an OGTT confirmed that she did not have GD.

Holly found the GD pregnancy confusing and challenging. She felt unsupported during and after all three of her pregnancies. She particularly hated attending the appointments because she felt that she was told off for having high readings rather than helped to lower them. She also said that no one checked on her postpartum, or only asked how she was in a patronising way. Holly struggled to exercise and made sporadic changes to her diet causing her weight to fluctuate.

She had not had a test for diabetes after having GD (apart from pregnancy OGTTs). She was vaguely aware of postpartum testing, and the interview reminded her to follow this up.

Jennifer

Jennifer was 38 years old, White British and lived with her husband. She had one child. Because she was a full-time midwife, Jennifer had access to blood testing equipment and found that her FPG was high early during pregnancy. She felt upset that metformin and overnight insulin medicalised her pregnancy. She reported having no support postpartum, but that she did not want or need any. Jennifer felt that reducing medicalisation of pregnancy was the most important thing to change about GD care.

She reported a restricted diet during GD. She could not eat any carbohydrates without her sugars going very high, even though she had been advised to eat a small quantity. Postpartum, she had returned to a similar diet as before pregnancy, and she was aware of the impact that carbohydrates had on her blood sugar when making food choices. Work made it difficult to exercise, such as walking after meals.

Jennifer had attended diabetes screening postpartum, and received text messages reminding her to book a blood test. The tests reassured her that her blood glucose control was okay, and she described how it would give her to time to make changes if she became ‘pre-diabetic’.

Kelly

Kelly was 38 years old and White British ethnicity. She had a further education and worked a few days in each week. She lived with her partner and had three children. She had GD in the last two pregnancies, which she managed by a strict diet, metformin and insulin. She found the

diet challenging, and followed a high protein, high fat and very low carbohydrate diet in the last pregnancy, which was advised by a recommended Facebook group and not the NHS.

Kelly's doctor did not advise her to make further changes to improve her T2D risk because she usually had a healthy lifestyle; regaining the weight lost during pregnancy was positive for her. Kelly tried to eat healthily, cooking from scratch and being sensible about treats. Since having children, she had not had time to play sport or go to the gym so most of her exercise was walking.

She attended her annual diabetes screening tests, and had kept a record of the level so that she could detect any increases over time, even if it remained in the normal range. It had been straightforward for Kelly to attend, including taking her children along.

Kimberly

Kimberly was a secondary school teacher who was on maternity leave at the time of the interview. She was 33 years old, White British and lived with her husband. She was diagnosed with GD during her second pregnancy, although assumed that she also had GD in the first because of her child's high birth weight. She managed diabetes by diet. She felt as if she had been left to look after herself during pregnancy, and relied on websites and a relative who was a midwife for advice.

After delivery, she ate lots of sweets that she had saved up during pregnancy. Her weight was stable due to breastfeeding, and her overall diet was similar to that before pregnancy. GD had not had a lasting impact on her, but pregnancy had: before having children, she was very active and loved running and going to the gym. At the time of the interview, she was starting to walk more after recovering from a caesarean section and subsequent surgeries. She planned to increase walking after taking her older child to nursery each day.

Kimberly wanted to be healthier in order to reduce her risk of cancer, but was not aware that GD is associated with T2D. She asked lots of questions about this during the interview, and felt that more information about this was very important.

Kimberly had an HbA_{1c} test at 16 weeks postpartum at the GP, after receiving a letter, but was not contacted about the results so assumed she was okay. She had not been aware of the recommendation for annual testing, but was keen to initiate this with the GP when the time came.

Komal

Komal was 32 years old. She was working full time as a nurse. She was Indian ethnicity and lived with her husband and two small children. She had GD with both pregnancies and was on metformin.

Komal was working with her GP to lose weight. Her diet had changed from eating lots of white bread and rice to seeded bread and avoiding rice as much as she could. She also wanted to finish meals earlier in the evening as this had helped her to lose weight in the past. She was strict not to have takeaways and sometimes made healthier versions of unhealthy food that her children and husband wanted to eat. She enjoyed doing yoga but found it hard because she was tired because one child did not sleep well. She also hoped to walk more.

She had attended postpartum diabetes testing, and recently had an HbA_{1c} test. She described herself as health-conscious and concerned to prevent T2D.

Laila

Laila was 42 years old and of Asian ethnicity. She had a postgraduate education, worked part time, and was on maternity leave at the time of the interview. She lived with her husband. She had two children and had GD with both pregnancies. This was managed by metformin in the second pregnancy.

She found GD harder to manage the second time; for example, it was harder to exercise when she had a toddler. Postpartum, she put on lots of weight although had been losing it through the Slimming World diet. Normally, Laila and her family were fairly healthy but enjoyed sweet things. She used to do lots of exercise (such as aerobics classes at the gym) before having children. She currently went for walks and a weekly dance class, although she hoped to do more when the children were older.

Laila attended the screening tests after GD, and planned to book it each year at around her child's birthday. She was confused because she had an HbA_{1c} test at six weeks postpartum, then was told by the nurse to go back a few weeks later to have it again so that the pregnancy blood glucose would not be taken into account.

Lizzie

Lizzie was 39 years old and White British ethnicity. She had a postgraduate education and worked full time, although was on maternity leave at the time of the interview. She was a single

mother and lived with a family member. She had recently had her first baby, and was diagnosed with GD but was not on diabetes medication.

Lizzie said she learnt a lot about diet and diabetes during pregnancy. She hoped to lose weight postpartum in order to reduce her risk of diabetes. She had planned to follow a diet similar to her GD diet because she had lost weight during pregnancy, but was currently restricted in what she could eat because she was breastfeeding and her baby had severe food allergies. She also wanted to be more active even though she did not like exercising, saying that she needed to stop using the excuse of having a new baby. She was keen for her child to be active, and was planning to take her child swimming. Previously, she walked to work but now lived in a small village where a car is needed to leave the village.

Lizzie's first postpartum test, which she attended, was booked for her while she was pregnant. Her GP planned to do a diabetes test at her annual medication review.

Megan

Megan was 28 years old. She was White British and had a secondary level education. She was single and a home parent for her two children. She had GD in the second pregnancy and was treated with insulin. She felt that GD had ruined her pregnancy and now it was ruining her life, due to the impact on her relationships, the lifestyle changes she needed to make, and the ongoing uncertainty.

Megan described her second pregnancy as "*horrific*", including time spent in hospital and a lack of awareness of what was happening. Since pregnancy, she had undergone more tests for what she felt was hypoglycaemia. As a result, she had made large changes to her diet: previously she used to eat whatever she wanted, and now was careful to eat a more balanced diet of fruit and vegetables, more meat, carbohydrates and not have sugar in her tea. However, she felt abandoned by her doctors in trying to understand and manage these symptoms outside of pregnancy. She went to the gym, which was financially possible because of a referral from her GP for depression.

Megan attended her diabetes screening tests, but felt that annual testing was too infrequent.

Monika

Monika was 31 years old and of White European ethnicity. She worked full time and was currently on maternity leave, lived with her husband, and had a further education. She had four

children and had GD during the last two pregnancies (although she did not have an OGTT during the fourth pregnancy and questioned having GD). She controlled GD by diet, although was confused by inconsistent results when self-monitoring her blood glucose.

Monika did lots of cooking for the family. She liked to walk and was busy around the house. She felt that she had a good understanding of how to be healthy and had wisdom that she wanted to share to support other women, especially if they were struggling during GD.

She was not invited for a postpartum test after the third pregnancy, which was worrying because she expected to be, but was invited by the GP after the fourth. However, she understood that her blood sugar level was "*perfect*", which meant she was no longer at higher risk of T2D.

Nicole

Nicole was 34 years old and White British. She worked part time and had a higher education. Nicole and her husband (who was nearby and occasionally joined in with the interview) had two children. She was diagnosed with GD in the second pregnancy but thought she had in it the first one too. Although metformin helped her to manage GD, she found the pregnancy diet hard, and felt like she could not eat anything.

Nicole said that her diet had always been quite healthy; for example, they did not eat processed food and were trying to eat less sugar. Although it was not as much exercise as before pregnancy, Nicole did classes at the gym and tried to run at weekends, as well as staying active as a family.

Nicole knew but had forgotten the increased risk of T2D, but was not concerned because she kept a healthy lifestyle. Although she initially thought that they did not need more information or advice about healthy lifestyle, she agreed with many of the suggestion cards.

Her GP tested her HbA_{1c} alongside another blood test ordered at approximately 15 months postpartum, but she had not had any other glucose test and was not aware of further follow-up.

Puja

Puja was 32 years old and a secondary school teacher working part time. She was Asian ethnicity and lived with her husband and toddler. She was prescribed metformin for GD.

She found that the advice for a healthier diet during GD pregnancy was helpful and tried to maintain some of these changes after pregnancy, such as eating 50/50 white and wholemeal

bread and reducing the sugar in her tea. She wanted to avoid diabetes in the future because she found the diet very restrictive. She did not do specific exercise, but would have liked to go for a walk with the pushchair once a week, but not every day like she had to during pregnancy.

Puja's blood glucose was measured immediately after giving birth in the hospital. She was unaware of the possibility of having another postpartum test, but felt that it would be reassuring to find out whether she was back to normal rather than assuming that she was fine. She planned to contact her GP to ask.

Rachael

Rachael worked part-time in her family business. She was 40 years old, White British and lived with her husband. She had a further education. She had two teenage children and two younger children, having GD in the latter two pregnancies. She was prescribed metformin and insulin to manage her blood glucose. She was worried about whether GD would increase the likelihood of her children developing diabetes.

Rachael had family members with T1D: she had witnessed the impact that diabetes had on daily life therefore was concerned about preventing T2D. She felt that she looked after herself, therefore GD was a surprise and she was frustrated that her blood glucose control was deteriorating. She had been doing Slimming World because she had recently given up smoking and wanted to be careful not to eat sweet snacks instead. She described her diet as healthy, but previously with too large portion sizes. Exercise was part of her weekly routine, particularly walking or cycling with her children in the summer.

She had attended all of the diabetes screening tests that she was eligible for and saw these as an opportunity for advice and support.

Overall, she felt that the emphasis should be on individuals to look after themselves. She also said, "*I would welcome any sort of additional support, but then if I wasn't following the guidelines I would expect to be chucked off course*."

Saki

Saki was Japanese ethnicity and 39 years old. She had a postgraduate education and was on maternity leave from working full time. She lived with her husband. Saki had GD in both pregnancies, and controlled GD by diet. Monitoring her blood glucose was challenging but it helped her to remember to stick to the diet.

She was trying to keep up some of the healthy changes from pregnancy, particularly walking, to avoid T2D. Exercise could be hard to plan around breastfeeding, but she noticed the benefits related to sleep and stress. She was also eating fewer treats, like chocolate and biscuits, and much less rice.

Saki's diabetes team discussed the risk of developing T2D with her towards the end of her pregnancy and booked the six week test before she delivered, which was helpful. She knew the advice to be tested annually, although did not know how it would work (she assumed she would need to flag it to the GP).

Samantha

Samantha worked part time as a midwife. She was 35 years old, White British, and lived with her husband. She had three children, with GD in each pregnancy. The diagnosis was a surprise because she was otherwise healthy, but she felt supported by the midwifery and diabetes teams. She managed GD by diet, cutting out carbohydrates, and lost weight during pregnancy.

Although she made up for the sugar she had not had during pregnancy while she was breastfeeding, Samantha said that her diet has improved: she was more aware of what she ate particularly regarding carbohydrates. She was careful during night shifts when she craved sugar. She was not able to go to the gym as she did before having children, but liked to be active with them and did a daily home workout. She hoped to be more active when her youngest child went to school.

Samantha had attended all of her postpartum diabetes screening tests. Although it was a bit hard to attend and take the children to school, testing was a priority so she managed.

Suzanne

Suzanne was 35 years old, Chinese ethnicity, had a higher education and worked part time. She was currently on maternity leave. She lived with her husband, who was present for part of the interview. She found GD diagnosis scary and overwhelming, and was particularly fearful about the consequences for her baby. She managed it by diet, cutting carbohydrates and walking lots, because she was keen to avoid taking medication.

On one hand, Suzanne was concerned about developing T2D in the future; on the other hand, she had been so busy since the pregnancy she had hardly thought about diabetes – particularly in the first two months postpartum. She and her husband had been more health conscious after

the pregnancy, such as eating more wholegrains and fewer carbohydrates and smoothies, and doing more exercise. Suzanne tried to walk for at least an hour each day, and planned to build in higher intensity exercise. This was informed by their own research about diabetes.

Suzanne attended the first postpartum test, which was booked during pregnancy. However, she needed to rearrange the first one after not being able to fast overnight at that time. She planned to book her annual diabetes check. However, she was not completely convinced that she did not have diabetes still.

8.4.2 Overview of qualitative findings

I developed 16 themes considering healthy diet and exercise, diabetes screening and format of interventions. These are discussed in Sections 8.4.3 to 8.4.5, in addition to the experience of GD pregnancy (Section 8.4.2.2).

Table 8.3 indicates the participants' agreement with each suggestion card, if they responded to it.

8.4.2.1 Participant trends

As shown in Table 8.3 below, 12 participants were positive towards several of the suggested ways to increase postpartum support, six had mixed reviews and two tended not to want further support.

Nearly half of the participants were positive towards all or almost all of the support suggested for diet and exercise, despite some of these participants reporting making healthy changes themselves. Some identified where they had already benefitted from the areas suggested, whereas the others wanted any support. Some went on to agree with all of the suggestions for increasing uptake of screening for the same reasons.

Other participants disagreed with many of the suggestions for supporting healthy diet and exercise. Jennifer held the strongest of these views, and said "*I think they're [the suggestion cards] all quite similar, aren't they? You know, I think I know those things already…*" [White, GD metformin and insulin, tested]. Kimberly felt that she already had this support available through other sources [White, no GD medication, tested but no plans for another test]. Megan and Monika had identified specific areas that they wanted more support in [White, GD insulin, tested; and White, no GD medication, tested but no plans for another test respectively].

During the interview, I did not follow all lines of questioning with all of the participants. In particular, if women were not aware that they should have had postpartum screening tests, it did not feel appropriate to ask them about support for attendance. In this case, I tended to suggest they discuss diabetes screening with their GP because it is recommended by the national guidelines. I then asked them what benefits they anticipated from a test.

8.4.2.2 General comments

Before discussing their postpartum behaviour, I sought to grasp an understanding of the experience of GD pregnancy to facilitate rapport and explain some of the context of their feelings, attitudes and behaviours after pregnancy. The participants found GD pregnancy to be a challenging time, with many making significant lifestyle changes and feeling as if their lives revolved around blood glucose levels. GD was the "*focus*" of pregnancy (Christine [Asian, no GD medication, tested]), or even "*ruined*" it (Megan [White, GD insulin, tested]) and caused them to "*hate*" being pregnant (Holly [White, no GD medication, not tested]). Several mentioned not wanting to have another child because they did not want to experience GD again or in fear of impact on their health. Nevertheless, most felt that the care they received during pregnancy was good.

Table 8.3: DAiSIeS participants' agreement with whether the suggestion cards will support healthy diet, exercise and screening attendance (based on the authors' interpretation of their responses).

	Healthy diet and exercise										Diabetes screening										
	1. More information about diet/exercise on T2D risk	2. More information about diet/exercise on wider health	3. More information about diet/exercise on family	4. Suggestions for healthy families	5. Support to exercise with others	6. Advice about how to eat healthily	7. Advice about exercising with a busy schedule	8. Advice about sustaining changes	9. Advice about saving money	10. Advice about monitoring progress	11. Discussing postpartum tests during pregnancy	12. Invitations and reminders for tests	13. Better GP awareness of your pregnancy	14. More chances to understand GD	15. Child-friendly clinics	16. Choice of test location	17. More pleasant tests	18. Combining appointments	19. Better understanding of diabetes tests	20. Removal of self-monitoring	Overall response
Amber	✓	×	×	×	✓	✓	✓	×	✓		✓	✓	✓	✓	×	✓	×	✓	✓	×	A
Christine	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×	✓	✓	✓	×	✓	×	×	M
Danielle	✓	✓		✓	✓	✓	✓		✓	✓											A*
Emma	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	×	✓	×	✓	×	✓	✓		A
Francesca	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×	✓	×	✓	A
Holly	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										✓	A*
Jennifer	×	×	×	×	×	×	×	×	×	×	✓	✓				✓					D*
Kelly	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×	×		×	✓	M
Kimberly	✓	×	×	×	×	✓	×	✓	×	✓		✓									M*
Komal	✓			✓	✓	✓	✓	✓	×	✓	×	✓		✓		✓			✓		A
Laila	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	×	✓	×	✓	M
Lizzie	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓		A
Megan	×	×	×	×	×	✓	✓	✓	✓	✓				✓		✓					M*
Monika	×	×	×	×	✓	✓	✓	×	×	×											D*
Nicole	✓		×	×	✓	✓	✓	✓	✓	✓		✓	✓					✓			A*
Puja	✓	✓	×	×	×	✓	✓	✓	✓	✓											A*
Rachael	✓	✓		✓		✓				✓	✓	✓	×	×	×	✓	×	✓	×	×	M
Saki	✓	×	×	×	✓	×	✓	✓	×	✓	✓	✓		×		✓	✓	✓			A
Samantha	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓						×	A*
Suzanne	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	A
Overall response	A	M	M	M	A	A	A	A	M	A	A	A	M	M	M	A	D	A	M	M	

Not all participants were shown each card, and some did not comment or agreement was unclear.

** Based on diet and exercise cards only.*

Dark green: strongly agree; green: agree; red: disagree; dark red: strongly disagree; grey: not shown or agreement is unclear. A: overall agreement; M: overall mixed response; D: overall disagreement.

Seven participants were also happy with their postpartum care, generally having sufficient knowledge of how to have a healthy diet and exercise going forward, or where to find more support if required. Seven other participants acknowledged that more postpartum GD follow-up "*would be helpful*" (Francesca [White, GD insulin and metformin, tested]), but they were able to manage. Christine said, "*...after birth you have breastfeeding support, you have weaning support, a lot of different support but maybe that is another thing, post-GD support kind of thing would be really good for mothers if I am honest*" [Asian, no GD medication, tested]. The remaining six participants felt the absence of postpartum support strongly, particularly in comparison to the close monitoring of pregnancy: "*I don't feel like I've been given the help that I think there should be really out there*" (Megan [White, GD insulin, tested]). Kimberly said, "*I'm not being unkind, I know the NHS is busy, no-one really cares about me anymore… don't feel sorry for me, but in terms of, is anyone checking on me? Absolutely not*" [White, no GD medication, tested but no plans for another test]. No one talked to Nicole about the future risk of diabetes [White, GD metformin, tested but no plans for another test], and Kimberly was unaware that there was an association between GD and T2D [White, no GD medication, tested but no plans for another test]. It was particularly challenging for those who also struggled through pregnancy.

Overall, the participants were eager to make changes to and take responsibility for their health. They spoke about the individual's mind set "*because it's just you know what you need to do and it's just trying to make sure you're staying healthy isn't it, that's the main thing*" (Jennifer [White, GD metformin and insulin, tested]). Rachael felt that whether someone wanted to be helped was a key factor, and that resources should not be wasted [White, GD metformin and insulin, tested]. This sentiment was particularly strong in those who felt that they did not need more postpartum support than they had received.

8.4.3 Healthy diet and physical activity

The following sections describe the findings of the interviews regarding improving the healthiness of diet and increasing exercise. These covered seven themes: information and understanding, improving diet, improving exercise, family, money, monitoring and sustainability.

Conversations that arose in response to specific questioning and suggestion cards are reported alongside things that the participants brought up. This is not always reported in the order that occurred during the interview.

8.4.3.1 Information and understanding

Information and understanding	Improving diet	Improving exercise	Family	Money	Monitoring	Sustainability
Suggestion card 1 (overall agreement): the participants wanted more information about the impact of healthy diet and exercise on their diabetes risk. Suggestion card 2 (mixed agreement): the participants had differing views regarding more information about the impact of healthy diet and exercise on their wider health.						

Most of the participants felt that they would benefit from more information about the impact of healthy diet and exercise on their diabetes risk, and opinions varied about information for their wider health (suggestion cards 1 and 2). Despite existing knowledge, some participants welcomed any extra information because, for example, it would help them to make good choices (Komal [Asian, GD metformin, tested]). Others had poor awareness of the long-term implications of GD because they had not been told or had missed it at GD diagnosis (Amber said, "*But it's a small enough detail that it could be easy for someone to forget about it or not notice it in the first place. And because there's no sort of specific attention given to it postnatally*" [White, no GD medication, tested but no plans for another test].) Some were therefore particularly keen for more information. Kimberly, who was unaware of any link between GD and T2D, said, "*100% it would help... I didn't even know I had an increased risk, to be honest, I didn't know anything... Well hence why I ate all those Easter eggs. I probably would have only eaten half*" [White, no GD medication, tested but no plans for another test].

Although most participants agreed with both suggestions, they tended to anticipate more benefits from information about their future risk of diabetes (card 1) than about the broader health benefits of healthy diet and exercise (card 2). They already had general awareness of the wider benefits or found that existing postpartum support focused on this, such as that provided by children's centres.

It was important that information was adapted to postpartum mothers who had had GD and perceived themselves to be knowledgeable ("*not sort of trivial, such as 'eat a healthy balanced diet, exercise more*'" [Emma; White, no GD medication, tested]), and practical, as described

in the themes below. With the exception of those with no awareness of T2D risk, they preferred information that focussed on how to be healthy in relation to T2D, rather than on why they were at a higher risk. Several had specific questions about how to do this, such as how strenuous the exercise should be and the impact of different exercise durations.

8.4.3.2 Improving diet

Information and understanding	Improving diet	Improving exercise	Family	Money	Monitoring	Sustainability
Suggestion card 6 (overall agreement): the participants wanted more advice about how to have a healthy diet.						

The majority of the participants were attempting to eat a healthier diet, but felt that further advice or tips would help them to do this (card 6). Many commented that the GD dietary guidance that they were given was comprehensive, helping them to become very aware of what they were eating and make quite radical changes (e.g. it was an opportunity for Lizzie to "*learn how to eat properly… literally I had no idea about food from the sounds of it*" [White, no GD medication, tested]). In contrast, they received little or no advice about what to eat after delivery. They tended to intend to continue selected elements of the GD diet, for example, increasing their intake of fruit, vegetables and wholegrains, and/or reducing treats, sugar and carbohydrates.

There was a range of views among those who wanted more advice. At one extreme, Rachael thought she was managing diet appropriately by following the Slimming World diet but adapting it to be lower in carbohydrates, but wanted reassurance about whether there was anything else she should do [White, GD metformin and insulin, tested]. Conversely, Megan was anxious for professional input, saying "*…if you did have issues or problems you could speak to them and find out how to go about it, again, I just don't feel like the doctors take into consideration*" [White, GD insulin, tested].

A couple of participants commented that the GD diet was not a 'normal' healthy diet, such as eating peanut butter instead of fruit. Emma therefore asked, "*What are we defining as being a healthy diet in this [postpartum] context?*" [White, no GD medication, tested]. Others wanted advice that was relevant to other aspects of their new situations, including managing cravings and hunger during night feeds (Holly [White, no GD medication, not tested]), about balancing a healthy diet with the calorie intake needed when breastfeeding (Christine [Asian, no GD

medication, tested]), and with children of different ages and a husband who came home from work at variable times (Samantha [White, no GD medication, tested]). It was important for this to be individualised (e.g. "*how to keep your diet… right for you*" [Megan; White, GD insulin, tested] and in accordance with their palate or ethnic background.

The three participants who did not want any more advice about having a healthy diet were attempting to be healthier, like many other participants, but felt that they already had enough information by drawing on previous experiences and GD diets, and that any more advice would not help them. Two participants thought that they had knowledge about having a healthy diet themselves, but that other people needed this.

8.4.3.3 Improving exercise

Information and understanding	Improving diet	Improving exercise	Family	Money	Monitoring	Sustainability
Suggestion card 5 (overall agreement): the participants wanted support to exercise with others. Suggestion card 7 (overall agreement): the participants wanted advice about how to exercise with a busy schedule.						

Although many of the participants reported doing less exercise than before pregnancy, four considered themselves to be active and enjoyed exercise. Some had particular support, such as their husband looked after the children so that they could go running or a gym referral for another condition. Four participants reported exercise that was part of their routine, such as dance classes or daily home workouts. Others did regular but lower intensity activity, such as pushing the buggy up the hill on her way home from town. Many wanted to do more exercise, and felt this would be achievable when the children were older, at school or they finished breastfeeding. Six participants were not active at the time of the interview: some were waiting to recover from caesarean sections or pregnancy in general (which some participants above had previously experienced), while others just found it too much at that time. Two participants were not interested in increasing exercise at all.

Amber, who ran regularly, said, "*I think you have to [prioritise exercise], otherwise it just doesn't happen. It is so easy to just go, 'oh I haven't got the time' because most, pretty much every single new mum does not have the time… [it] is really good for your mental health as well as your physical health… it is a bit like once you start doing it you get into it… but starting*

out is really difficult, definitely, and it can be quite demoralising because your body doesn't quite move in the same way when you've just had a baby. Everything is a bit clunky and a bit wobbly and not quite how it used to be and it can be quite hard to get over that initial starting block. Yes, and perhaps does need to be a bit more dedicated support for that…" [White, no GD medication, tested but no plans for another test].

The majority of the participants were positive that help for them to exercise with others (card 5) might facilitate physical activity. Several mentioned how exercising with other people (such as friends) had been helpful for them in the past, or was anticipated to help by making exercise less boring. Others had preferences for specifically parent-friendly or mother-and-baby classes, or postpartum GD groups. Such classes would be much more accessible for them and provide an opportunity for socialising and meeting other mums with GD to share experiences. Exercising at home "*tend[ed] to be quite isolated*" at a time that was already isolating (Danielle [White, GD insulin, not tested]). These groups might need signposting or prompting; e.g. the health visitor could give information about local activities, because the participants thought they existed but did not know where to find them or had not thought to look. Conversely, a few did not like to exercise with others because it was distracting or they liked to exercise at their own pace.

Almost all the participants were eager for advice about how to exercise with a busy schedule (card 7), saying that was what would help the most or was the thing they had issues with. Several said that they had not received any advice about this. Specifically, they wanted guidance about how to fit physical activity in amongst busyness, how to do it around the home, and ideas that were suitable for the whole family to do together. Appropriateness for postpartum period was important: Danielle suggested cards with postpartum-friendly exercises "*like little diagrams and exercise routine that build the further on you get in your health… especially to what kind of birth you've had*" [White, GD insulin, not tested].

Several participants shared what had helped them, including:

- "*Split[ing] my exercise schedule so I did exercise for 15 minutes in the morning and 30 minutes in the evening*" after work (Komal [Asian, GD metformin, tested]);
- "*Having a baby carrier… you can keep an eye on them and they are happy because they're [at your chest]. But also it gives you both your hands free to do stuff. Also it is exercise because you're carrying them around and they're getting heavier and heavier.*

Just make sure you get a good one that supports your back" (Francesca [White, GD insulin and metformin, tested]);

- "*Try to use the pushchair more than the car seat*" (Saki [Asian, no GD medication, tested]).

8.4.3.4 Family

Information and understanding	Improving diet	Improving exercise	Family	Money	Monitoring	Sustainability
Suggestion card 3 (mixed agreement): the participants had differing views regarding more information about the impact of diet/exercise on their family. Suggestion card 4 (mixed agreement): the participants had differing views regarding suggestions for being healthier as a family.						

The participants found that their young family made having a healthier lifestyle harder than it was before they had children. Several used to play sports or go to the gym, and had to stop this because they had less spare time or now wanted to spend it with their children instead. As a result, most did less intense exercise, such as family walks or generally running around with the children. Similarly, they had to try to balance family members' dietary preferences or compromise on menu choices (Komal said, *"…sometimes [my children] won't agree to what you give… there's green food – 'I don't want', they want some kind of pizza or burger all those things but still I somehow try to convince them with this kind of food*" [Asian, GD metformin, tested]). On the other hand, parenthood could provide new opportunities for a healthy postpartum lifestyle: Komal's older child encouraged her to exercise, saying "*it's your time for exercise, come, we do it together*" [Asian, GD metformin, tested], and Christine met other mothers from her antenatal group for walks [Asian, no GD medication, tested]. Some also found that their children motivated them to be healthier because they wanted to stay well for their family and/or wanted to prevent unhealthy habits in their children (e.g. teaching them to eat well). Some were supported in healthy changes by their husbands (e.g. Suzanne and her husband "*both changed our lifestyle*" [Asian, no GD medication, tested]) whereas Francesca's husband was "*more of a cheerleader than a participant*" [White, GD insulin and metformin, tested] and others even disagreed over getting a takeaway (Komal [Asian, GD metformin, tested]).

The participants had mixed views regarding whether more information about the impact of healthy diet and exercise on their family (card 3) would be helpful to them. Some participants reasoned that it was important for children to be healthy too: it was something they would do as a family. Others felt that they already knew this or the information had already been provided by their health visitor (although not everyone had received this kind of guidance). In addition, Samantha felt that the children "*don't struggle with blood sugars, they don't struggle with not being able to get out and get fresh air*" [White, no GD medication, tested] and Puja did not want to influence or restrict other adults in the family [Asian, GD metformin, not tested].

The suggestion of ways for their children and wider family to be healthier (card 4) received mixed agreement in a similar light to card 3. Some participants suggested practical support that would be helpful: practicalities of how to fit a healthy lifestyle in with family life, ideas for activities involving wider family and friends, and recipes that were suitable for children and how to easily adapt them for parents.

8.4.3.5 Money

Information and understanding	Improving diet	Improving exercise	Family	Money	Monitoring	Sustainability
Suggestion card 9 (mixed agreement): the participants had differing views regarding advice about saving money.						

Twelve participants were in favour of advice about saving money and maintaining a healthy lifestyle (card 9). Amber didn't "*think there's much useful guidance about maintaining that kind of healthy, diabetes-friendly diet on a budget actually*" [White, no GD medication, tested but no plans for another test].

Healthier food (such as that which is higher in wholegrains and proteins and low in carbohydrate) was frequently perceived, or experienced, to be more expensive than unhealthy food. Amber went on to say that some of the normal advice about saving money through batch cooking was not "*necessarily the right thing for someone who is trying to like minimise diabetes risk to be eating*" [White, no GD medication, tested but no plans for another test], and Suzanne suggested looking at the ingredients list rather than buying from the more expensive ranges [Asian, no GD medication, tested]. Exercising at home was beneficial because it was free or much cheaper than going to the gym or exercise classes. There was also a need for healthy

options for the family to do, particularly as costs increase with a larger family and as they get older.

The participants who disagreed that this suggestion would help them to be healthier tended to find that cost was not associated with diabetes; that is, that it did not prevent people from being healthy because cheap or free options were available. Cooking from scratch was already cheaper than buying prepared food, therefore they had fewer options for saving more money.

8.4.3.6 Monitoring

Information and understanding	Improving diet	Improving exercise	Family	Money	Monitoring	Sustainability
Suggestion card 10 (overall agreement): the participants wanted advice about monitoring their progress.						

Almost all of the participants had positive views towards monitoring their progress after pregnancy (card 10). Several felt that is was the thing that would make the biggest difference to them. They discussed either monitoring themselves (by recording their weight, diet, exercise levels, calories in and out, or 'nice' things like going out to the park) or through meeting with a health professional. Importantly, it was seem as a way to maintain motivation for changes or to get more information and feedback on their efforts.

Monitoring was perceived to be helpful because it would stimulate them to see their achievements and the benefits, or repeatedly reinforce the need to be healthy. Christine, who discussed in length that one of the reasons that she could maintain the GD diet was that there was "*something imminent*", thought that a monthly weight check would provide a "*destination*" to keep her on track [Asian, no GD medication, tested]. However, monitoring calories or steps might not be as motivational as self-monitoring blood glucose because the results would not be immediate (Emma [White, no GD medication, tested]). Several were also cautious that monitoring could have the opposite effect: Lizzie was wary of tracking her weight in case she became demoralised and gave up [White, no GD medication, tested]; Komal's GP had set her weight loss goals but this was too stressful at that time due to changing jobs [Asian, GD metformin, tested]; Lizzie felt that Slimming World was too judgemental [White, no GD medication, tested].

Others wanted monitoring as an opportunity for more guidance. They thought it would help them to keep track of how their body was doing with regards to diabetes risk factors and blood glucose control. Danielle thought that the option to attend an appointment with a specialist in the first few months postpartum would make a big difference because it would enable them to discuss any problems and talk through ideas (because sometimes they do not know who to ask for advice) [White, GD insulin, not tested] and Megan wanted to discuss how to manage diet in relation to the diabetic symptoms that she felt [White, GD insulin, tested].

8.4.3.7 Sustainability

Information and understanding	Improving diet	Improving exercise	Family	Money	Monitoring	Sustainability
Suggestion card 8 (overall agreement): the participants wanted advice about sustaining healthy diet and exercise changes.						

The majority of the participants agreed with the suggestion of advice about sustaining changes (card 8). They felt that this would be helpful because they knew that maintaining a healthy lifestyle would be challenging. In practice, they felt that this could be facilitated through the earlier themes; for example, that advice about healthy food that was suitable for the whole family, exercises that could be done around the house, and more follow-up would all help them to maintain diets to reduce their risk of T2D.

8.4.4 Attendance at diabetes screening

Of the 20 participants interviewed, 16 had a postpartum diabetes test (and one was booked for soon after the interview). Three participants had not attended testing because they had not been offered or invited: Danielle and Puja did not know postpartum testing was possible and thought that no contact was normal [White, GD insulin and Asian, GD metformin, respectively] and Holly had not initiated it [White, no GD medication].

During the interview, four more participants revealed that they were unware of the recommendations for subsequent, annual testing. Monika understood from her GP that her blood test results were so good she was no longer at higher diabetes risk [White, no GD medication]. Despite having had a postpartum test, Kimberly was not aware of her higher T2D risk and had not heard about lifelong testing [White, no GD medication]. Nicole only had a test approximately 15 months postpartum after her GP ordered a blood test for another condition,

and felt that this had been too long to wait [White, GD metformin]. Amber expected the six weeks postpartum test to be the end of GD follow-up unless she became pregnant again [White, no GD medication].

Six participants returned to the hospital for the postpartum test, four of whom had the appointment booked during pregnancy. Six had their first postpartum test at the GP: either because they had been invited to go to the GP, they had it as part of the six week check, or because they did not know where to go for testing so asked the GP who arranged it. Those who were longer than one year postpartum attended the GP for annual testing. Some received reminders while others initiated it themselves each year.

Most of the participants initially said that they went for testing because they were invited to: "*I thought, 'Oh I've got an appointment.' It didn't really occur to me not to go*" (Lizzie [White, no GD medication, tested]). This reason was often followed-up by the desire to find out whether the diabetes had gone (for interest or reassurance) and therefore whether they needed to take further action such as increasing exercise or initiating pharmacological treatment, because they understood diabetes to be a serious condition. Additionally, several participants commented on the lack of feedback on the outcome of the test, unless they were diagnosed with IFG or IGT. Kelly requested the specific numbers from the GP so that she could monitor and notice if it started to creep up [White, GD metformin and insulin, tested]. Other participants, including a midwife, felt that annual testing was not regular enough.

Where I suggested that the participants who did not have plans to return annually contact their GP surgery to discuss this, they were keen to do so for similar reasons to the participants who had attended; that is, they wanted reassurance. In particular, Puja had been concerned that she still had diabetes [Asian, GD metformin, not tested].

Discussions regarding attendance at diabetes screening covered eight domains: booking tests, test location, test used, combining appointments, child-friendly clinics, GP awareness of pregnancy, understanding GD and postpartum testing, and stopping self-testing. I discussed what would have made it easier to go to testing with the participants who had attended a test, and what would help them to go in the future. Generally, the themes relate to the difficulty of attendance rather than preventing attendance altogether.

8.4.4.1 Booking tests

Booking tests	Test location	Test used	Combining appointments	Child-friendly clinics	GP awareness of pregnancy	Understanding GD and postpartum testing	Stopping self-testing
Suggestion card 11 (overall agreement): the participants wanted to discuss postpartum testing during pregnancy. Suggestion card 12 (overall agreement): the participants wanted invitations and reminders for tests.							

Of the participants who attended their first postpartum test, most had been invited. Regardless of their booking experience, the participants agreed that the postpartum test being discussed by their clinical team during pregnancy (card 11) was important for follow-up, mostly because they had a positive experience or thought it would help for the clinical team to "*be hotter on this*" (Danielle [White, GD insulin, not tested]).

The participants tended to be positive about having the postpartum test booked early (such as at the last pregnancy scan): although discussing postpartum follow-up during pregnancy was a bit of a surprise, it was not worrying and helped them to know what was coming. It also provided an opportunity for doctors to explain the importance of the tests in advance, which would "*help people to prioritise it*" (Lizzie [White, no GD medication, tested]). Four other participants arranged their own tests because they knew this was important after being told during pregnancy: several mentioned that midwives regularly reminded them to have a postpartum test, and another said it was emphasised while she was on the delivery ward.

Several participants explained that they attended the first postpartum test because they received a letter with an appointment time or asking them to book it. Although many had not yet become eligible for annual testing, only Jennifer received text reminders to book a blood test, which she knows is for GD follow-up [White, GD metformin and insulin, tested]. Others were told that they would receive a letter but did not. Of those who were aware of the recommendations for subsequent testing, most mentioned that they were advised to book the test; that is, they did not anticipate any contact from the GP about this.

In general, the participants were eager to be responsible for their own health (for example, by setting an annual reminder for the test on their phone and "*pretend it's a birthday*" [Kimberly; White, no GD medication, tested but no plans for another test]). Nonetheless, they all felt that a reminder from the GP would be useful (card 12), including Rachael who worried whether postpartum interventions would be a suitable use of NHS resources [White, GD metformin and

insulin, tested]. Others considered this as the change that could make the most difference. They thought it would be helpful because life gets "*hectic*" with the baby (Danielle [White, GD insulin, not tested] and Christine [Asian, no GD medication, tested]), it was easy to forget (Komal [Asian, GD metformin, tested] and Lizzie [White, no GD medication, tested]), and it can be easy to put off (Kelly [White, GD metformin and insulin, tested]). In particular, Laila said, "*Because they're the ones that sent you for the test while you're pregnant so you assume they have the same responsibility to look after you postpartum as well*" [Asian, GD metformin, tested]. Additionally, a couple of participants said that annual testing was hard to remember because it was not frequent enough to form a routine. They suggested emails, letters, text messages, or a notification in their online GP portal. Several likened it to having a cervical smear test, where a letter is sent from the GP.

8.4.4.2 Test location

Booking tests	Test location	Test used	Combining appointments	Child-friendly clinics	GP awareness of pregnancy	Understanding GD and postpartum testing	Stopping self-testing
Suggestion card 16 (overall agreement): the participants wanted to be able to choose where to have their diabetes screening test.							

The participants either suggested or agreed when asked that the test should be available at a location of their choice (card 16). They thought that having blood taken at the general practice, alternative clinic, or even a local hospital (rather than the centre that managed their GD) would facilitate attendance. This was because it was not "*trivial*" to travel to the hospital with a small baby (Saki [Asian, no GD medication, tested]). It was often a long journey with a higher cost, and required them to make alternative arrangements for taking older children to school. In contrast, the GP surgery was closer, easier to get to, and had more availability and flexibility in appointment times.

In the busyness of the early postpartum period, going to the hospital for the blood test did not seem like a worthwhile investment of their time. Lizzie lived less than 15 miles from her hospital and said "*they need to offer that from your GP*" because she got up at 5.00 am to attend the test at 8.30 am, and was still late for it. Anticipating the 2 hour OGTT, she was frustrated that the FPG test was so short compared to the preparation time and reacted with, "*sod it, I don't care about calories or gestational diabetes, I'm just going to go and eat [a] McDonald's [breakfast]*".

The two participants who did not agree with this suggestion found it easy to attend either their hospital or general practice.

8.4.4.3 Test used

Booking tests	Test location	Test used	Combining appointments	Child-friendly clinics	GP awareness of pregnancy	Understanding GD and postpartum testing	Stopping self-testing
Suggestion card 17 (overall disagreement): the participants did not want more pleasant screening tests.							

The participants who had attended postpartum screening had had an FPG or HbA_{1c} test. When asked whether a shorter or more pleasant postpartum blood test would make it easier for them to attend (card 17), a couple of participants noted how the postpartum FPG or HbA_{1c} was better than the OGTT that was used during pregnancy. However, the majority were indifferent since "*you are jabbed with needles so many times when you are pregnant, one more is really not an issue*" (Amber [White, no GD medication, tested but no plans for another test]), or that it was "*quick and easy*" (Kelly [White, GD metformin and insulin, tested]) and "*no one sticking a needle into you is [ever] pleasant so…*" (Emma [White, no GD medication, tested]).

8.4.4.4 Combining appointments

Booking tests	Test location	Test used	Combining appointments	Child-friendly clinics	GP awareness of pregnancy	Understanding GD and postpartum testing	Stopping self-testing
Suggestion card 18 (overall agreement): the participants wanted to be able to combine their diabetes screening test with another appointment.							

The participants felt that being able to have their blood test alongside another appointment at their general practice (card 18) would make it easier to be screened for diabetes. They described "*having an awful lot of appointments just in life*" (Nicole [White, GD metformin, tested but no plans for another test]) and with children generally, therefore one less trip would ease this burden. This challenge was exacerbated by the long time that it took to leave the house with the newborn (as described in Section 8.4.4.2) and some of the worries of being out with them.

Some participants suggested that the six weeks check was a suitably-timed appointment to combine testing with, and considered that it might increase uptake because most women attend. Suzanne had wanted to discuss GD follow-up in more detail at this appointment, therefore it coinciding with the blood test may make it a salient time to discuss GD [Asian, no GD

medication, tested]. Laila thought that it could coincide with children's vaccinations, saying, "*If we're thinking HbA_{1c} at three months, then the babies have their three month jabs don't they so that would work. I think that would help*" [Asian, GD metformin, tested].

On the other hand, Komal was concerned that her children would distract her from talking to the doctor [Asian, GD metformin, tested].

8.4.4.5 Child-friendly clinics

Booking tests	Test location	Test used	Combining appointments	Child-friendly clinics	GP awareness of pregnancy	Understanding GD and postpartum testing	Stopping self-testing
Suggestion card 15 (mixed agreement): the participants had differing views regarding the benefits of more child-friendly clinics and waiting rooms.							

The participants had different experiences of attending appointments with their children, and held differing views towards the suggestion to make waiting areas more child-friendly (card 15).

The most common experience was that GP surgeries, which tended to be mentioned over hospital clinics, were already appropriate, such as with children's books and toys. These kind of resources were valuable; for those without them, the surgery was a "*nightmare*" (Kelly [White, GD metformin and insulin, tested]) or taking a toddler "*would be havoc*" (Samantha [White, no GD medication, tested]). Emma, however, thought that parking facilities and a choice of appointment times made the appointment more child-friendly than the waiting room [White, no GD medication, tested].

Other participants were not affected by the suitability of the clinic because they did not take their children to the appointment. Some made sure the appointment was at a time when their husband could care for the children, or that the children were at school. Komal said she did this so that she would not be distracted: "*…you might be have hundreds [of] thousands of questions in your mind but when you go with your kid you can't ask even one or two*" [Asian, GD metformin, tested].

8.4.4.6 GP awareness of pregnancy

Booking tests	Test location	Test used	Combining appointments	Child-friendly clinics	GP awareness of pregnancy	Understanding GD and postpartum testing	Stopping self-testing
Suggestion card 13 (mixed agreement): the participants had differing views regarding the benefits of their GP knowing more about their GD pregnancy.							

Some participants thought that their GP knowing more about their pregnancy would improve their postpartum care (card 13) because GD could be mentioned at other appointments. They often linked this to needing more postpartum support – both in general because postpartum care was focussed on the baby, and in relation to blood glucose screening.

Two participants, who agreed that this suggestion would help follow-up, had positive experiences of GPs initiating care. Nicole was impressed that her GP had noticed GD in her notes and requested the diabetes test as part of a blood test she was having for a different reason [White, GD metformin, tested but no plans for another test]; Lizzie, whose GP planned to do the test at her medication reviews, thought that the GP was well-placed to re-emphasise what was said during pregnancy because "*that's the person you're used to seeing, so its definitely going to make it more likely that you will go to tests and things if your GP knows about it*" [White, no GD medication, tested].

However, several disagreed that this would help or thought it would be inappropriate because it was the midwives' role to manage pregnancy care and not the GPs'.

8.4.4.7 Understanding gestational diabetes and postpartum testing

Booking tests	Test location	Test used	Combining appointments	Child-friendly clinics	GP awareness of pregnancy	Understanding GD and postpartum testing	Stopping self-testing
Suggestion card 14 (mixed agreement): the participants had differing views regarding more opportunities to understand GD Suggestion card 19 (mixed agreement): the participants had differing views regarding more opportunities to understand the diabetes screening tests							

There was disagreement among the participants about whether a better understanding of the implications of GD on their future health (card 14) and the purpose of postpartum testing (card 19) would facilitate attendance.

Half of the participants asked felt that they already had enough information because they learned from their clinicians (therefore this area of care was already done well), did their own research, or were healthcare professionals with existing knowledge themselves. Saki explained that she had talked about the risk of T2D with the hospital team towards the end of pregnancy, and that "*just hearing from the consultant directly, I think has a bigger effect on people, than just kind of reading about it on the leaflet*" [Asian, no GD medication, tested]. She also noted that this might have been possible for her because her GD had been easy to manage, whereas others' consultations might need to focus on glucose control.

The other participants wanted more information and opportunities to understand GD or postpartum testing, although they did not always agree with both suggestions. Some participants wanted to understand the ongoing implications of GD – "*how it affects you in the long-term as well*" (Lizzie [White, no GD medication, tested]). A couple of participants raised specific questions about the tests, some of which suggested a high level of understanding, such as whether a FPG could tell you as much as an OGTT or whether a FPG was suitable for them because their fasting results had been normal throughout GD pregnancy. Laila had her HbA_{1c} measured six weeks after both pregnancies: "*I just don't understand why the doctors tell you to go and get it at six weeks after… but then that's not accurate because obviously it's taking into account when you're pregnant so I don't understand the point of me having had that test*" [Asian, GD metformin, tested].

8.4.4.8 Stopping self-testing

Booking tests	Test location	Test used	Combining appointments	Child-friendly clinics	GP awareness of pregnancy	Understanding GD and postpartum testing	Stopping self-testing
Suggestion card 20 (mixed agreement): the participants had differing views regarding removal of the option to self-monitor their blood glucose.							

The participants had mixed views about this suggestion, but none strongly felt that an inability to do finger prick tests would cause them to favour attending a screening test (card 20). Some participants said that they did not want to do any more self-testing: they did not like it so would prefer someone else to do it for them, and understood that the formal test was more accurate. Holly wanted the clinical team to take the self-testing kit back because it would mark the end of GD [White, no GD medication, not tested].

On the other hand, some participants had or wanted the option to monitor their blood glucose postpartum. This tended to be out of curiosity because they had become accustomed to knowing what their blood glucose was immediately after a meal and were interested to see how different foods affected their blood sugar now they no longer had GD. Samantha said, "*Then you can actually get a feel of what you're eating and how that affects your blood sugar… directly affects your blood sugar, rather than just putting it onto an average*" [White, no GD medication, tested]. Some participant suggested that they would test their blood sugar again if they suspected symptoms of diabetes, and Saki was not sure that she did not have diabetes still because she had not monitored postpartum, even though she had the FPG test [Asian, no GD medication, tested]. Megan wanted a record of her blood glucose as evidence of the ongoing symptoms she experienced to show her GP "*because then at least I've got the proof, look at these times I'm getting like this…*" [White, GD insulin, tested].

8.4.5 Delivery of support or interventions

To follow-up the discussions of what support the participants felt they would benefit from, I also asked about how this could be delivered. This was mostly considered in the context of diet and exercise support and included the preferred format, source and timing.

8.4.5.1 In-person peer groups

Seven participants wanted to be part of a peer support group. This could start during pregnancy and continue postpartum to share experiences from different stages of GD pregnancy because "*unless someone else has been in that position you do feel kind of alone*" (Megan [White, GD insulin, tested]). "*Mum-centric*" postpartum groups (Laila [Asian, GD metformin, tested]) could include tips for reducing diabetes risk and be linked to an exercise class. They could be hosted through children's centres, where other information classes such as for breastfeeding and postpartum mental health already took place.

8.4.5.2 Appointments with a healthcare professional

Follow-up with a clinician or healthcare professional was the most frequently mentioned intervention. It could range from an instructive appointment to a casual conversation where they were signposted to other resources. Midwives, hospital diabetes teams, health visitors and GPs were the logical providers because they had provided GD care and were a trustworthy and

respected source of information. Emma said, "*There is something about a medical professional saying, 'You need to get a grip on this*'" [White, no GD medication, tested].

During pregnancy

Several participants discussed being given advice about postpartum diet and exercise, and long-term diabetes risk during pregnancy, such as by the consultant. It was good for this to be introduced, knowing that more information would follow. Towards the end of pregnancy, Emma's friends were cooking meals for her to eat after the birth and "*at no point did we think, 'Right, what is the healthiest follow-up way we can do this?*'" [White, no GD medication, tested]. Kimberly said that the advice should be given during pregnancy because that is when you are most aware of GD (because of monitoring blood glucose) and there are many distractions afterwards [White, no GD medication, tested but no plans for another test], whereas Samantha thought pregnancy was too early because there was so much going on already [White, no GD medication, tested].

On the ward and at discharge from hospital

Similarly to during pregnancy, four participants felt that follow-up should be mentioned, in a casual way, while they were on the maternity ward or at discharge from hospital, whereas another disagreed because she lost all of the many discharge papers she was given. Amber explained that she had other conversations on the ward, such as guidance about recovery from the caesarean section and that GD could be mentioned among these [White, no GD medication, tested but no plans for another test]. Women who had more complicated births spent more time in hospital and generally felt abandoned with regards to GD at that time, therefore would like someone to take the opportunity to make sure that they "*knew the plan of action*" (Holly [White, no GD medication, not tested]) before discharge. Saki thought that there would be time to give them "*a little leaving parcel of like here's a little pack of how to keep going with the good work you've done*" [Asian, no GD medication, tested], along with the acknowledgement that it would be "*hectic*" (Danielle [White, GD insulin, not tested]).

Postpartum

Thirteen participants discussed a postpartum appointment with a clinician. Sometimes they did not know who to ask for support (Danielle [White, GD insulin, not tested]). Although some participants considered an optional follow-up appointment with a hospital specialist e.g. a

dietician or the diabetes team, many suggested GD follow-up become part of the six week mother-and-baby check, which would be after the initial, overwhelming stage.

In practice, this appointment focused on the baby, which was very important, but they too needed to some time with an expert to be asked how they were and how things were going, to debrief and have some reassurance, and discuss what to do next. Holly was struggling by the time of her six week check but did not feel able to tell the GP this because they did not ask [White, no GD medication, not tested].

As discussed in Section 8.4.3.6, they wanted this to be linked to their blood test results as an opportunity to receive feedback. Similarly, the annual blood test appointment was a chance to discuss what they had been doing and whether there is anything to be concerned about and gain any extra feedback or advice.

8.4.5.3 Written information

During pregnancy, the participants sought information about GD from a range of sources: information leaflets from the hospital, their own research on the NHS website, online forums such as Facebook groups, and other online GD resources (e.g. Gestational Diabetes UK website). Additionally, they sought more general diabetes and healthy lifestyle information postpartum (including from Dr Michael Moseley [diabetes dietary advice], Joe Wicks ['The Body Coach'], Slimming World, and Eat Well for Less television programmes). NHS resources tended to be more trusted than forums, but forums or smartphone apps had the benefit of an interactive community with opportunity to share tips.

Lizzie found that Facebook groups were useful for information [White, no GD medication, tested]. The groups had been recommended by a friend and someone on one of the groups. Online conversations were understanding and supportive (she left the groups that felt judgemental). Even if she did not participate by posting a question, it was reassuring to read about someone else who had had a similar experience. Komal used a calorie counting app that she inputted food and was linked to her smart watch, which she found very motivational [Asian, GD metformin, tested]. Emma felt that an app would be beneficial, although her baby was jealous of her mobile phone (which she used to track their routine) and was concerned about screen time [White, no GD medication, tested].

Similarly, they thought that written information about postpartum lifestyle would be beneficial, such as a booklet, website or app. Suzanne proposed a "*website that can make suggestions or to have a community of people with GD who share recipes, what their concerns are*" [Asian, no GD medication, tested]. Several mentioned that written resources had the benefit of being available all the time: "*especially when you're doing feedings… late night feeds or whatever, you can sit and have a look at your phone and get that support 24/7*" (Kelly [White, GD metformin and insulin, tested]).

Many participants implied that information could be provided in a variety of formats; that is an intervention would not be required to cover all aspects of support. Written information, regardless of format, would be most beneficial if it was provided alongside face-to-face care. Similarly, if the clinician directed them to such resources or reinforced it, they would pay more attention to it.

8.4.5.4 Delivery of messages

Six participants felt strongly that the manner in which support was provided was important for it to actually be helpful; that is, information should be shared in an individualised and sensitive fashion. The participants who described specific struggles during pregnancy and/or postpartum particularly emphasised this. Danielle felt judged for her weight during pregnancy, and thought that information should come as part of a gentle chat in a positive frame, such as "*here's a few ideas, it'd be really good to keep it up*" [White, GD insulin, not tested]. Lizzie said that postpartum diet and exercise should be managed delicately due to hormones and stress: "*if somebody had said to me at that point, 'You need to be eating this, this and this,' I think I'd have probably cried*", and didn't want to feel checked up on or "*like you're failing your child*" [White, no GD medication, tested]. Although she was supported and knowledgeable about GD, Suzanne was particularly scared by the diagnosis and felt that clinicians should take more time to consider the mother's viewpoint [Asian, no GD medication, tested]. Moreover, Emma was very positive about the GD experience, and felt that messages should "*transition from a sort of deficit reaction of 'I can no longer have this, this and this' to a more positive reaction of 'well I can have this, this and this if I do that*'" [White, no GD medication, tested].

8.5 Discussion

In this study, 20 mothers with recent GD shared their experiences of pregnancy and postpartum, focussing on their diet, physical activity and screening attendance in relation to their risk of developing T2D. These women thought that additional advice about how to eat healthily and exercise when they were busy, and practical suggestions for making these changes sustainable in their context, would most help them to reduce their risk. Many wanted more specific information about long-term T2D risk, but they often knew enough about the universal benefits of a healthy lifestyle. Although written information in any format would be acceptable, access to other mothers with GD and a clinician talking to them about follow-up in a supportive manner was anticipated to be beneficial. Both the participants who had strategies to remember to book their annual diabetes test and those who were not aware that they were eligible for any follow-up felt that being invited to attend by a clinician would facilitate screening, particularly if they could choose the location.

8.5.1 Comparison to Chapters 6 and 7

This study was designed to build on the two qualitative syntheses reported in Chapters 6 and 7 (208,209). In particular, I sought to further understand some of the observations from other qualitative studies, fill gaps identified in the literature and elicit the response of a local population to suggestions for promoting a healthy lifestyle after GD and attendance at diabetes screening. In this section, I compare the findings of the DAiSIeS study with these literature reviews.

8.5.1.1 Healthy diet and physical activity

The qualitative synthesis was based on 21 studies (209), one of which was set in the UK (256) and many of the others in high-income countries including Australia, Canada, Denmark and Sweden. I identified six barriers to and facilitators of healthy postpartum lifestyle (Table 7.1).

Firstly, I had found that a woman's identity and role as a mother was particularly influential on her views of healthy postpartum behaviours. The DAiSIeS participants had similar experiences of many of the practical aspects of motherhood. Many did less vigorous exercise so that they could spend time with their children instead and wanted suggestions for healthy food that the whole family could eat so that the children learnt healthy habits, if they had not already received

such advice. However, they tended not to discuss the emotional side, where participants in the review had referred to their "*guilt*" (282) or "*moral tug*" (288) for not staying with their children. I also found that, despite this identity and role as a mother, the majority of the participants did not support interventions that related to their family directly; instead, they tended to want help to fit diet and exercising around their families.

Secondly, in the reviews I had found that social support facilitated healthy behaviour whereas its absence was a barrier. The participants I interviewed discussed how support from family and friends had helped healthy behaviours, and anticipated social support to help them. For example, Amber and Nicole's husbands encouraged them to exercise, and most of them anticipated benefits from exercising with others. Additionally, many wanted more opportunities to share experiences with others with GD, echoing the sentiment from Jones *et al.* 2015 that "*…we're all in that group together*" (288).

Thirdly, I had identified the theme of 'demands of life' in the literature review, where lack of time and energy were barriers to healthy diets and particularly doing exercise. For the participants in the DAiSIeS study, this was particularly true for the early postpartum period, which was not considered a time for a healthy lifestyle but for learning to adapt to life with their new baby. Guidance could therefore be developed to help mothers to transition out of this stage to longer-term healthy lifestyle. While they shared the view from the review that exercise required "*set[ting] aside time*" (278) and "*taking time out for themselves*" (282), several identified the holistic benefits of doing this. In particular they wanted advice about how to exercise with a busy schedule (card 7), which had moderate confidence in the review (recommendation 8), and about sustaining the changes in the long-term (card 8; although informed by the reviews, this was not explicit in previous studies).

Fourthly, I had found that personal preferences and previous experiences (such as their food preferences, cravings, and whether they enjoyed exercising) influenced behaviour. In the interviews, many of the aspects relating to diet had been dealt with during pregnancy, e.g. learning to adapt their normal diet to be healthier but still eating what they wanted, to a degree. After pregnancy, the participants reverted back to their previous diets (as a relief or reward) while maintaining a selection of elements from the GD diet, because that had been healthier but too extreme to sustain in the long-term. Interventions may be able to focus on adapting previously tested elements of healthy lifestyle to be sustainable.

Fifthly, I had found that diabetes risk perception was associated with intention to prevent T2D through a healthy lifestyle. As in many of the studies in the literature review, I observed a range of views from fear of T2D to not knowing there was an association between GD and T2D. I also spoke to participants who would empathise with feeling "*abandoned*" (252,264,283) postpartum, whereas some had felt supported and knew how to proceed after pregnancy. Nonetheless, more information about T2D risk and risk prevention were seen to be important, particularly if it was adapted to them, in agreement with a participant in Lindmark *et al.* 2010 who said "*…even if it is old knowledge it is good to hear it once more*" (284).

Sixthly, I had found that a lack of finances and resources could be a barrier to healthy lifestyles. Some of the DAiSIeS participants reported similar challenges such as healthy food and going to the gym being expensive, although not all participants associated cost with healthiness. Other participants felt they already had cheaper or free options available and so some disagreed that advice about how saving money and maintaining a healthy lifestyle would be of use (despite this recommendation having high confidence).

8.5.1.2 Attendance at diabetes screening

The qualitative synthesis of attendance at diabetes screening was based on 16 studies (208), also only including the same study set in the UK (256) plus several in countries with similar healthcare systems such as Australia and Denmark. Influences on attendance at diabetes screening related to the healthcare system or were personal factors, and could be described as either permissive or motivational (Figure 6.4).

Firstly, I had reported that interaction with the healthcare system influenced patients' intentions towards screening in the review (specifically, the behaviour of the clinicians, the process of booking tests, continuity of healthcare, and ability to understand diabetes risk). Each of these subthemes affected the participants in the DAiSIeS study. Whether they had had their postpartum test arranged for them or a clinician emphasised that they needed to book it were particularly influential factors; that is, this could be the reason that they did or did not attend. The clinician would discuss why testing was recommended, here combining the behaviour of the clinicians and the process of booking tests and sometimes ability to understand diabetes risk. I had high confidence based on the review that invitations for tests would facilitate attendance, and almost of the participants in this study agreed for similar reasons (reassurance and busyness). Additionally, several participants felt that the clinician had some responsibility

for their care. This could be positive, such as when the GP was informed about the GD pregnancy (such as for Nicole) and planned subsequent follow-up (such as for Lizzie), or negative as in the case of Monika. Although it is unclear whether it was the GP's intention, Monika understood that she was not required to attend testing again due to one good result. This false reassurance is perhaps more dangerous than Svensson *et al.* reported, where one participant was left confused or unconvinced by her GP: "*I thought I should book an appointment for [the diabetes test]. Then [GP] said that there was no need to go more into that, and then she didn't talk about it any further*" (264). Unseen in the review, this study also found that mothers were less likely to engage with clinicians if they had had a negative experience during pregnancy.

Secondly, I had reported that the appointment and test influenced opportunity to attend screening in the review (specifically the logistics of the appointment and an unpleasant, poorly understood testing procedure). I found that logistics were also an issue for some of my participants: travelling to a specific hospital could be associated with a financial and time cost. They also emphasised that morning appointments, which were required due to an overnight fast, could be particularly inconvenient when they had a young baby (e.g. being up in the night caring for them and taking a long time to leave the house) and other children that need taking to school. In the literature review, I classified the appointment as a permissive barrier to attendance whereas this current study suggests that it could more of an issue of inconvenience and motivation. On the other hand, the test itself was not often a barrier to attendance in the DAiSIeS study, like it was in other studies. Many did understand the testing procedure and although it could be unpleasant, this was not a major issue. Most of the studies in the literature review referred to a postpartum OGTT, whereas a postpartum FPG has been recommended in the UK since 2015 (2). These participants were already benefitting from a shorter, more pleasant test (recommendation 7).

Thirdly, I had reported that family-related practicalities influenced their opportunity to attend screening in the review (such as caring for the baby, support and work). In the DAiSIeS study, the participants discussed challenges relating to each of these subthemes, but they also tended not to relate to the opportunity to attend screening directly. For example, two participants included in the review felt "*just tired... because I'm burnt out, frustrated*" (255) and "*I had no time to go... Always I tell I do it tomorrow... But I do not gone again, because I have to do*

another duty...” (251) and did not attend screening, yet in the DAiSIeS study, feelings of tiredness and being overwhelmed were experienced but seemed to have affected daily activities of diet and exercise more than rare events of attending screening appointments. As such, associated suggestions such as child-friendly clinics and combing appointments received mixed reviews.

Fourthly, I had reported that concern about diabetes influenced their intentions towards screening in the review (in general that those who were concerned about T2D tended to attend whereas those who were not concerned did not). The positive view was shared among most of the DAiSIeS participants: they were interested or wanted reassurance that GD had resolved, and otherwise would start treatment for the serious condition. Those who hadn’t been tested were keen to be for these same reasons. No participants in the DAiSIeS study knowingly decided not to be tested because they “*could not be bothered*” (262) or were too scared to find out the result, although some were less concerned about T2D after taking the test. Furthermore, although it was more subtle and tended not to prevent attendance like reported in the review, I found that the participants’ concern about T2D risk was influenced by how healthy they perceived their lifestyle to be and they, too, placed high importance on self-monitoring.

8.5.1.3 Delivery of support or interventions

Finally, this study came to a similar conclusion to the qualitative synthesis: that the need for further support was more important than how the support was provided (209). Similar to Nicklas *et al.* 2011 and a study published after completion of the review (279,308), multiple or a combination of formats including online and face-to-face resources would meet different needs. These could deliver both individualised and generalised advice.

Other studies have reported different preferences regarding the timing of intervention initiation – during pregnancy (281,288) or postpartum (256,308). Based on different participants’ views, I suggest that women with GD should be prepared for more specific follow-up interventions during their pregnancy, provided that this is done in a sensitive manner. In general, any healthcare professional involved in the care of women with GD can have a role in promoting a longer-term view.

8.5.2 Strengths and limitations

8.5.2.1 Strengths

This study used qualitative interviews in order to understand the participants' own views and experiences, which is important for any future support to be relevant and suitable for them. While the nature of semi-structured interviews allowed discussion of what the participants felt was important (for example, one participant took the opportunity to recommend hypnobirthing), the aims of the study, the interview schedule and the thematic framework used in the analysis were based on systematic review evidence. This theory of the post-GD context meant that the interview could be guided to key questions for support to improve care. This structure continued to the analysis, where I used a thematic framework based on the suggestion cards but adapted to the participants' responses. Additionally, I asked for participants' own suggestions for better support before prompting them with the suggestion cards.

Data were collected until I felt that the interviews provided little or no further insight into the views of this population. As a result, lots of data were available for analysis (20 interviews and 12.4 hours of recordings). A range of experiences and opinions were explored in detail, such as support that some participants found beneficial and could be extended to those who were lacking it. Overall, the participants were very engaged in the interviews, which allowed understanding of the subtleties and complexities of their views. They were also realistic about some of the challenges anticipated, that external support would be beneficial but not remove the need for them to work hard, and the time and financial cost that such interventions would pose on health services. This is presented context of the individual experience of GD pregnancy.

Finally, the study had few participant exclusion criteria, meaning that many postpartum women were eligible to take part (unless a clinically-trained person with access to their medical records considered they were unsuitable). They therefore represented a range of ethnicities, religions, single or living with their partner (their spouse, for the participants of this study), occupations, number of pregnancies overall and with GD, GD management, time since pregnancy, etc.

8.5.2.2 Limitations

Despite the range of demographics represented, there was higher representation of mothers with graduate or postgraduate degrees (75% in total; 8/9 [89%] of women from Cambridgeshire

and 7/11 [64%] of those from Peterborough) and income level was not recorded. In the UK in 2017, 42% of adults aged 21 to 64 years old had a degree (309) therefore this study population may not be representative of the UK. It is expected that those with a greater level of education and/or socioeconomic status will have higher health literacy and a better understanding of their long-term health risks (310). Recently, self-care skills and knowledge (domains of health literacy) have been associated with improvements in weight, diet, and physical activity in postpartum women (311). Other women across the UK may therefore have even stronger views or greater needs for follow-up. Many participants in this study had a higher or medical education, but this was not necessarily associated with lower requirements for support. Jennifer (a midwife) had access to the postpartum knowledge that she needed, whereas Holly (who worked in maternity care) felt generally unsupported. Additionally, Kimberly stated in reference to GD care that "*I'm quite fortunate because I'm quite educated, I'll do my research, my mum is a midwife, but I don't think that was that great for other women*", but later revealed that she was unaware of the association between GD and T2D.

In addition, there will have been recruitment bias, with women who are more health-conscious more likely to engage in the study. Holly said that she knew other women with GD who "*cheat the system... they'll have their little food and they'll do their blood sugar and then they'll have their big food*". In contrast, the DAiSIeS participants were diligent with blood glucose control, particularly during pregnancy. Women with these experiences are likely to have different attitudes postpartum that I did not capture, and may be less eager to be healthy and not seek out support. In addition, the invitation letter stated the aim 'to find ways to help women to reduce their risk of developing diabetes in the future' therefore those who recognised their T2D risk or were particularly in need of support might have been more likely to respond. This was seen in some participants who wanted to highlight specific areas of their care that they felt could be improved. However, the majority were positive and one participant did not want any more support. The numbers of women invited to the study and reasons for not taking part were not collected, therefore this could be a highly selected population.

Furthermore, social desirability bias may have influenced the participants' responses in this study. The 'tendency to present oneself and one's social context in a way that is perceived to be socially acceptable, but not wholly reflective of one's reality' can lead to more positive and homogenous responses than would be observed without this bias (312). This may have caused

the participants to exaggerate how healthy they were before or after pregnancy, or say they had made more changes than they had. Some participants reported a similar diet as before pregnancy with a few elements of the GD diet carried forward; some participants introduced this as a big change whereas others perceived the same behaviour as a small thing. Similarly, they might have been wary of criticising their care yet, as discussed below, this did not appear to be the case for many and I was careful to introduce myself as someone who was there to listen to them. Social desirability bias may explain some of the high frequency of agreement with the suggestion cards, despite me saying that it is very useful to hear if they disagreed with them. Bergen and Labonté 2020 suggest strategies to reduce social desirability bias including explaining the purpose of the study, humour, self-disclosure where appropriate, and carefully worded questions (312). I used these approaches in the DAiSIeS interviews, such as inviting the participants to share what might help them or someone like them based on their own experiences.

8.5.3 Reflexivity

It is valuable to consider the relationship between myself as a researcher and the research participants, and the influence this had on the interviews and analysis. At the start of each interview, I introduced myself as a non-clinical PhD student. This lay role tended to help me probe the participants about what they had said, giving me insight to their actual experiences because they did not assume that I had expertise in GD care. I thought that they disclosed their experiences in ways that they would not have done to a clinician, particularly one who was involved in GD care. Although many were eager to share positive experiences, several also mentioned painful things and where there 'needed' to be changes. One participant had had unpleasant experiences with her clinicians, and said that the conversations should be non-judgemental such as the one we were having. Since I sought to understand their experiences in order to improve postpartum care, it felt as if we were 'on the same side'. I had a good rapport with some participants, particularly those who were approximately the same age as me. Despite being younger than the remaining participants, I had the role of a professional/university researcher with others. Although I could not relate to pregnancy and motherhood, I could relate on other levels such as enjoyment of certain foods and the local area.

After the initial interviews, I changed the start of the interview schedule from asking about their current diet (which I had expected to be an easy, less delicate starting point) to their

experience of GD. The first participants (those given the pseudonyms Komal and Monika) appeared surprised to be asked about their diet because they had expected to talk about GD, which remained the stand-out memory of their pregnancies. I also included more signposting to the flow of the interview, such as saying 'Before we talk about [X]…' and 'So that I can understand if GD has had a lasting impact…'. I also tried to summarise the key points before moving on, which provided an opportunity to add more information or correct my understanding.

Some of the participants disclosed specific and personal challenges. These tended to arise at the start of the interview, as if they had been waiting to tell me (or somebody). To a certain extent, this affected the whole interview. They also tended to keep coming back to it in response to later questions, such as Holly's distress during antenatal appointments and how Megan felt unsupported by her GP. I found this could be upsetting, and valued debriefing with colleagues after the interviews. It also highlighted the importance of giving the participants time to say what they wanted to rather than trying to follow my interview schedule. Monika kept referring back to pregnancy, and it is unclear at some points of the interview whether she is referring to GD or follow-up. Jennifer had interesting views: she did not want any postpartum support for a healthy lifestyle after GD – which is an opinion that might be held by many women who did not want to take part – yet had a low engagement in the interview that made it hard to understand why she had such a different experience.

In the survey at the end of the interviews, I asked whether the participants had any comments on the interview. Most did not, but a couple gave feedback such as "Informal, laid back, friendly. Appropriate in length. Accessible (came to home)".

In acknowledgement that the participants may have consciously or unconsciously said what they thought I wanted to hear, I considered this in reflecting on and interpreting the interviews, such as looking for inconsistencies across the transcripts. In the analysis, I gave more weight to the suggestions for improving care that the participants initiated themselves, rather than the suggestion cards that may have incited agreement. Overall, I feel that the participants were honest because they wanted to benefit other mothers through the study findings. Also, it has been valuable for other researchers to read the interview transcripts as they may have had alternative interpretations to what I or the participant said.

If I were to begin the study again, I would make some changes. Firstly, I would collect more quantitative data from the medical record or questionnaire (such as time since each pregnancy, where the postpartum test took place and NHS number for administration purposes) as well as asking the research nurses to record and report the number of women approached. These data were not collected in order to minimise the amount of personally identifiable information held but would have facilitated interpretation of the interviews. Moreover, I was unsure whether Megan should have been recruited due to her very challenging pregnancy (prolonged hospitalisation for sickness, hypoglycaemia and distressing psychological symptoms). On one hand, she understood the purpose of the interview, consented to take part and it was important for her to be able to share her experiences and suggestions for follow-up. On the other hand, her abnormal pregnancy acutely shaped her postpartum experience and was the focus of the interview. The Patient Advice and Liaison Service (PALS) may have been a more appropriate way for her to give feedback. Suitability to take part could have been discussed when I spoke to the participants to book the interview. Finally, not all of the participants understood the focus on postpartum follow-up in the earlier interviews (for example, some seemed to think that some of the suggestion cards were for GD pregnancy support). While I could address this during the interview (such as asking if they also held the same views towards the postpartum test), it would be beneficial to clarify this in all recruitment information and during the interview to ensure they understood the postpartum focus after discussing their pregnancy experiences.

8.5.4 Implications

In this study, the participants were keen to have a healthier diet and increase their physical activity after pregnancy, in addition to attending T2D screening. Some wanted to be a healthier family and others wanted to mitigate their increased risk of T2D. Many recognised the challenges that this would pose, and the dedication that they would need to sustain changes that many of them had achieved during pregnancy. This emphasis on how to maintain a healthy lifestyle over time had not previously been presented in detail in this population.

Intention and self-efficacy have been associated with exercise and healthy diet at one and two years postpartum (313,314), indicating the importance of nurturing these attitudes. Lipsky *et al.* 2016 (314) go further to discuss how self-efficacy is influenced by past experience (315); i.e. that women who have previously been successful in controlling their diet are more likely to report higher self-efficacy. The participants in the DAiSIeS study referred to the GD diet

that they initially had not thought was maintainable and some were even surprised to have lost weight during pregnancy, which will help to form their attitudes towards continuing changes. Similarly, the experience of care during pregnancy, as well as postpartum, was influential on follow-up.

In the exploration of strategies for promoting healthier diet and physical activity levels, I identified a need for a better understanding of their long-term T2D risk and the role of diet and exercise on risk management. Alongside support to exercise with others and advice about how to exercise with a busy schedule, eat healthily, sustain changes and monitor progress, the participants wanted this information to focus on how to be healthy in relation to T2D rather than why. Postpartum, they felt they would benefit from being able to be tested for diabetes at a more convenient location, perhaps alongside another appointment, and felt that it was important to receive reminders to attend testing. The only recommendation that the participants were not favourable towards was about the type of test used: they were happy to have a single test as recommended in the revised NICE guidelines.

This wide range of requirements could be addressed through various multi-faceted approaches. I explore these in the final discussion of this thesis (Section 9.3), bringing together the findings from each chapter.

8.5.5 Summary

In the research reported in this chapter, I aimed to explore and develop approaches to promote behaviour changes (specifically increase healthiness of diet, increase physical activity levels and encourage attendance at diabetes screening tests) after GD to in light of the heightened risk of T2D. I used qualitative interviews with an interview schedule based on systematic review evidence to elicit the views of a local population and extend the literature by focussing on what specific support is required and when, how, where and who should deliver it.

My findings highlight that changes to current practice and interventions throughout pregnancy and particularly postpartum are important. Each of these require further refinement, testing and evaluation. Some would be a relatively small change to current practice, such as healthcare providers preparing pregnant women with GD to receive subsequent information about postpartum follow-up in a sympathetic manner. Implementing other suggestions may require resources that are currently available to other populations being made available to women with

GD, such as reminders to attend annual tests, and investment of GP's time for longer postpartum appointments in order to discuss blood test results and health behaviours. Directing women to existing trusted resources or groups, or adapting existing interventions to this population is also likely to improve care for mothers after GD.

Chapter 9 Discussion

The overall aim of this thesis was to better describe the problem of progression to T2D after GD, and to identify primary care-based approaches that can be used to reduce T2D risk in this population. In this final chapter, I summarise the findings of Chapters 4 to 8 and discuss the implications of this work as a whole.

9.1 Thesis summary

There were three main streams of this thesis, as illustrated in Figure 2.1. Firstly, I reported the incidence of T2D after GD (Chapter 4). Secondly, I focussed on postpartum diabetes screening by describing uptake (Chapter 5), exploring reasons for (non-)attendance (Chapter 6) and gauging approaches to increase attendance among women with GD (Chapter 8). Thirdly, I focussed on promoting a healthy lifestyle after GD by exploring barriers and facilitators to healthy diet and physical activity (Chapter 7), and informing approaches to influence these behaviours (also Chapter 8). The key findings and implications of each stream are outlined below.

9.1.1 The incidence of type 2 diabetes after gestational diabetes

I completed a systematic review and meta-analysis of T2D incidence in women with GD to improve understanding of the natural history of T2D after GD. When starting this study, no review had focused on absolute estimates of the progression to T2D after GD in the last 20 years, and no reviews had yet synthesised the findings through a meta-analysis. Inclusion of more recent studies enabled incorporation of the important changes in GD prevalence, and GD and T2D diagnosis and management over time. I therefore wanted to assimilate all of the data

that were available to date regarding this question, and explore the impact of co-variables on absolute and relative T2D risk (thereby investigating heterogeneity).

I included 129 studies reporting T2D outcomes after GD. These studies represented each major world region and followed up over 310,000 women with a history of GD, plus 4,000,000 parous women without GD. Overall, 17.0% (95% CI 15.1 to 19.0%) of women across the studies developed T2D; mean duration of follow-up was 5.7 years (range 0.6 to 29.9 years). Using multivariable random-effects meta-regression, the percentage developing T2D was 12% higher for each additional year of follow-up after pregnancy and 18% higher for each additional unit of BMI at follow-up, and White European populations had 57% lower proportion developing T2D compared to non-White European populations. Women with GD had a relative risk of T2D of 8.3. Heterogeneity between studies was substantial throughout.

These findings strengthen the need for T2D risk to remain a focus for women affected by GD and the clinicians who care for them. In particular, it is important for diabetes screening to be sustained over time because the number of women diagnosed with T2D increased each year since pregnancy (i.e. it was not true that if someone had not progressed to T2D by five years postpartum, they could be assumed to have reverted to the population risk). In addition, postpartum BMI had a clinically significant impact on T2D progression therefore women should be supported to maintain a healthy weight after GD. Reflecting a higher background T2D risk, screening and weight management may be even more important in women of certain ethnicities.

9.1.2 Postpartum diabetes screening after gestational diabetes

Data on uptake of diabetes screening after GD is sparse in the UK. Furthermore, there has been limited understanding of the reasons for poor attendance and women's perspectives on how to facilitate attendance.

In the first study of this stream, I sought to describe attendance at diabetes screening and characteristics associated with attendance in the women attending the Rosie Hospital in Cambridge. Of 556 women with GD, 74.6% had evidence of a postnatal test in the medical record up to one year postpartum, which was most commonly performed using an OGTT that is no longer recommended in the UK. Average interval between delivery and test attendance was 6.8±2.1 weeks; 70.8% of all of the postpartum tests were performed in the recommended

six to 13 weeks postpartum. Using two-level logistic regression analyses, greater parity was associated with a third lower odds of testing and women who received insulin and/or metformin treatment were more than twice as likely to undergo testing than those who did not. Higher patient satisfaction with their general practice was significantly associated with higher odds of testing, particularly using an HbA_{1c} test.

These findings highlight that a significant minority of women do not attend diabetes screening after GD, in line with analyses of hospital records from other parts of the UK, and that this is not necessarily carried out as recommended by NICE. This study was the first to investigate associations with attendance and general practice variables. It is therefore important to ensure that follow-up of these women – those who are most likely to progress and who are least likely to attend – is facilitated.

Reasons for lower attendance was the focus of my next study, a thematic synthesis of women's views on screening for T2D after GD (208). This study was the first to focus on this question, therefore I had an opportunity to present the findings in more detail than previous studies that have also considered lifestyle behaviours or quantitative studies. Based on 16 studies and 746 women with a history of GD, I developed four themes. These could relate to the healthcare system or be personal factors, and be permissive or motivational factors affecting attendance:

- Relationship with healthcare: the degree to which clinicians promoted postpartum screening, helped mothers to book a test, and the continuity between appointments influenced prioritisation of testing;
- The appointment and test: logistics (such as distance to travel and time spent at the clinic) and the unpleasant test (such as painful and nauseating) meant that it was difficult for some women to attend screening;
- Family-related practicalities: a focus on their baby and other children affected women's opportunity to attend screening, such as caring for them and the implications of having more children on energy levels;
- Concern about diabetes: women who were more concerned about T2D were, in general, more motivated to attend diabetes screening.

An important part of the study was the resulting recommendations for improving attendance based on the barriers and facilitators identified. In accordance with the four themes, I suggested ten ways to promote prioritisation of testing and make it less burdensome for women with GD

to attend. I then elicited the views of women with recent GD in Cambridge and Peterborough on these suggestions. To facilitate diabetes screening, they felt that discussing postpartum testing with their clinician during pregnancy, invitations and reminders for tests, a choice of test location and combining appointments would be useful. The participants had mixed views towards improving their GP's awareness of their pregnancy, more chances to understand GD, child-friendly clinics, better understanding of diabetes tests and removal of self-monitoring. They disagreed that changing the test itself would improve uptake.

9.1.3 Lifestyle changes to reduce the risk of developing type 2 diabetes after gestational diabetes

In the first qualitative systematic review to focus on this question, I synthesised women's views towards sustaining a healthy diet and being physically active after GD to reduce their risk of T2D, including barriers and facilitators, with an aim to identify approaches to support these behaviours (209). Based on 21 studies and 926 women with a history of GD, I developed six themes relating to healthy lifestyles and one about the format of interventions. These were wide-ranging and interrelated:

- Role as mother and priorities: women prioritised their families, meaning they focused on the children or partner's needs; some were motivated to be healthy by their family;
- Support from family and friends: practical support and encouragement facilitated healthy behaviours;
- Demands of life: lack of time and energy, busyness and work were barriers to a healthy lifestyle;
- Personal preferences and experiences: behaviour was determined by whether women had positive experiences or perceptions from healthy/unhealthy lifestyles;
- Diabetes risk perception and information: relevant (including culturally-appropriate) information facilitated healthfulness;
- Finances and resources: resources were needed to help women sustain a healthy lifestyle, and their lifestyle affected the family's finances;
- Format of interventions: advantages and disadvantages of multiple types of interventions were discussed. There was no consensus on intervention timing or provider.

I developed 20 recommendations for promoting healthier lifestyles based on the themes. As noted for the study above, I elicited women's views on ten of these in the next study. Overall, the participants wanted more information about the impact of a healthy lifestyle on T2D risk, support to exercise with others and advice about how to eat healthily, exercise within a busy schedule, sustain changes and monitor progress to support healthy diet and exercise after GD. They had mixed responses regarding more information about the impact of diet and exercise on wider health and their family, suggestions for healthy families and advice about saving money. Peer support groups, meetings with a clinician and written resources (such as websites and apps) were all considered to be suitable means of providing support.

9.2 Overall strengths, limitations and evaluation

I have presented the strengths and limitations of each study in the discussion section of Chapters 4 to 8, therefore will not repeat them in this section.

Overall, a strength of this thesis is that I have considered the two key, closely-related aspects of managing diabetes risk after GD (screening and lifestyle behaviour, focusing on diet and physical activity) separately and then brought these together into a cohesive set of strategies to improve care. Furthermore, the latter projects were informed by the earlier ones such that the final strategies are evidence-based. In particular, the observations made on synthesised systematic review findings informed the recommendations for promoting a healthy lifestyle and screening attendance. In turn, these informed the design (including interview schedule), analysis framework and interpretation of the DAiSIeS interviews.

I led this research, but several medical students had an opportunity to contribute (in addition to the other researchers noted throughout this thesis). This strengthened the research through increased rigour in the systematic reviews and enabled a different viewpoint in interpreting the findings. It was also of value for the students themselves to gain research skills and experience.

Overall, a limitation of this thesis is that the primary research was focused on Cambridge and the surrounding area. On one hand, it is important to study this region as much as anywhere else. On the other hand, the findings may not be generalizable to the rest of the UK because Cambridgeshire is an affluent area with a high average level of education, and Cambridge University Hospitals NHS Foundation Trust is a tertiary centre to which women with more

complicated pregnancies may be referred. If I were to do the DAiSIeS study again, I would try to engage women with a wider range of backgrounds who may express different views towards GD and T2D. This may be facilitated through recruiting in a different area, non-clinical setting or inviting women to take part during pregnancy when they interact with the recruiting hospitals most frequently (although this would require more time to wait for the postpartum period and may influence their behaviour). Alternatively, a research method that requires lower commitment, such as a questionnaire, may provide insights into the views of a broader population.

9.3 Implications for practice

An important output from the research in this thesis is a series of recommendations for future pregnancy and postpartum care of women with GD. Eight suggested amendments are outlined in Figure 9.1 and Table 9.1, in comparison to current practice, and explained below.

9.3.1 Discussion about diabetes risk during pregnancy

Similar to other research (149), the findings presented in this thesis indicate the valuable role clinicians play in education about GD, promoting a healthy lifestyle and screening, and signposting to resources during pregnancy and postpartum. My findings suggest that it would be acceptable for the longer-term implications of GD to also be discussed in an informal, low-key manner throughout pregnancy and mentioned while new mothers are on the delivery ward. This could involve a conversation or giving an information leaflet, with the expectation of further follow-up. This is in contrast to many clinicians' current practice, where they are cautious about overwhelming or frightening their patients and so focus on the pregnancy itself (269).

Many studies have reported pregnancy to be a 'teachable moment' due to increased motivation and regular contact with health professionals for a range of behaviours from handwashing (316) to smoking cessation (317), therefore informing women with GD of postpartum recommendations early is likely to be beneficial.

Figure 9.1: Summary of key proposed amendments to gestational diabetes pregnancy and postpartum care.

Proposed amendments are shaded in grey.

Table 9.1: Summary of key proposed amendments to gestational diabetes pregnancy and postpartum care.

Experience of current practice	Suggested amendments
Pregnancy	
• Daily blood glucose self-monitoring • Low glycaemic index diet • Regular/post-meal exercise • Metformin or insulin treatment as required • Regular diabetes team appointments (e.g. with a consultant and dietician)	• Additional conversations about long-term T2D risk and follow-up as part of at least one appointment with the diabetes team [1] • Book postpartum screening test six weeks after due date [2]
Delivery	
• Information such as about breastfeeding and recovery from caesarean surgery given at discharge from hospital	• A GD follow-up information leaflet be given and/or a brief conversation outlining the importance of a postpartum test [1]
Postpartum period	
• FPG test • Six week mother and baby check	• Specification of the location of postpartum test [3] • Extended six week mother-and-baby check to cover [4]: – T2D risk after GD – Diet and exercise advice – Annual testing recommendations • Offer information regarding local (GD) mother-and-baby groups and online resources from the GP and/or health visitor [5, 6] • A diabetes prevention programme for women with GD (postpartum period onwards) [7]
Annual	
• HbA_{1c} diabetes screening test	• Reminder (e.g. text message or letter) to book a diabetes screening test [8] • Feedback on HbA_{1c} result and opportunity to discuss diet and exercise [4]

Numbers in square brackets refer to headings 9.3.1 to 9.3.8.

9.3.2 Booking the postpartum test during pregnancy

Despite recruitment from only two hospitals, a wide range of experiences in the process of arranging the first postpartum test were observed in the DAiSIeS study. This highlights inconsistencies in healthcare provision, corresponding to healthcare providers' uncertainty about who is responsible for postpartum testing (158,269).

Having a test booked for them during pregnancy, or their need to book it carefully reinforced, both appeared to be acceptable to women and conducive to screening. Those who were not aware of postpartum testing recommendations had a high chance of falling through the net. Ensuring that the postpartum screening test is booked during pregnancy for approximately six weeks after the due date may be a suitable way to make more women are aware of the test and remove the extra task of booking it themselves during the busy postpartum period. Based on

the finding of the qualitative synthesis in Chapter 6, it may also encourage women to place a high value on attending – particularly for the first postpartum test but possibly going forward.

In one hospital where pre-arranged postpartum tests were the norm, one of the highest attendance rates in the UK was reported (76% attendance at the six weeks postpartum test) (157). Alternatively, although information and education alone do not lead to behaviour change (318), going to a screening test may be a rare enough event in a generally well-motivated population that instruction to do so may be of some benefit.

9.3.3 Clarifying the location of the postpartum test

Akin to the different experiences of booking the test, there appeared to be uncertainty about where it should take place, and women in different settings found returning to the hospital to be a significant barrier to attendance. Half of hospital clinicians reported that their patients had it at the hospital, whereas only 15% of GPs agreed (158). Currently, the NICE guidelines for the management of diabetes in pregnancy do not clarify location of testing (2), therefore a clearer delegation of responsibility for this test is needed. The findings of my studies suggest that specification of primary care may remove barriers to attendance for women with GD, and may mark the transition from hospital to primary care management of diabetes risk in this population. However, this recommendation is unlikely to be compatible with the hospital booking the test during pregnancy. As with management of all chronic conditions in primary care, there is a need for a register, recall system and regular review, as well as clear communication between primary and secondary care and defined responsibilities.

9.3.4 Extending the postpartum consultation

The DAiSIeS participants also expressed interest in a postpartum follow-up appointment. This would provide an opportunity to ask outstanding questions such as which of the changes to their diet or exercise they should continue, and the risk of GD in subsequent pregnancies. It would also allow the GP to raise specific issues such as the risk of T2D after GD and the lifelong screening recommendations.

Discussing diet and physical activity with the GP has been effective for postpartum weight management (298). A six week check, where '…[clinicians should] offer consistent information and clear explanations to empower the woman to take care of her own health…'

is currently recommended by NICE (238). If the blood was collected and analysed in advance, this consultation could be extended in women with GD to include feedback and follow-up based on their diabetes screening test result. Since half of mothers receive inadequate time to discuss their own mental and physical health at this appointment (319), both the mother and GP should have aligned expectations about this appointment (320).

Similarly, feedback on the annual HbA_{1c} result should also be offered and instruction on preventative behaviours given in light of the result. Although the DAiSIeS participants understood that they would not find out the result of their HbA_{1c} test unless they fell into the IGT or IFG range, feedback on the HbA_{1c} measurement has been found to be associated with improved blood glucose control (321,322).

9.3.5 Signposting to existing resources

The consultation is also an opportunity for the GP or health visitor to signpost mothers to other resources. The DAiSIeS participants expressed similar experiences and needs relating to physical activity as postpartum women without GD. Although some participants preferred to meet with other mothers with GD, flagging more generic resources could be beneficial for many of them. A recent study interviewed and surveyed mothers in Cambridgeshire and Hertfordshire, half of whom were defined as moderately active, in order to understand influences on their physical activity (323). They identified increasing capability through signposting to suitable mother-and-baby exercise classes (which would be an environment where they felt comfortable themselves and about bringing their baby), and guidance about how to exercise safely after the birth. Even though women with GD had more contact with clinicians than many of these women, the need for more guidance or signposting was not met.

9.3.6 Providing online or mobile resources

Postpartum women, including those with GD studied in this thesis, also reported accessing and interacting with websites, forums, social media and other sources of written information during pregnancy and postpartum. For example, mothers reported accessing Facebook more frequently in the postpartum period (324), such as during breastfeeding in order to connect with other mothers for advice (325,326). Information was accessible at all times and could be informative and supportive, but users raised doubts about trustworthiness (325,327,328). Apps received mixed responses (308). Instead of searching for such groups or resources themselves,

women with GD could be directed to reliable resources provided by a trusted professional or body.

9.3.7 Offering a bespoke diabetes prevention programme

Alongside these modifications to existing practice, a bespoke and potentially individually-tailored diabetes prevention programme should be made available to all for mothers with GD. As informed by the research presented in this thesis, important elements include clear information about the effects of diet and exercise on diabetes risk, and advice about how to eat healthily and include exercise within busy daily routines so that these changes can be maintained in the long-term. Previous research suggests that interventions that start earlier than six months postpartum are most likely to be effective (169); my findings are in agreement although add that consideration of the postpartum stage is vital.

This could involve adapting existing interventions, such as the NHS Diabetes Prevention Programme. As discussed in Chapter 7, one intervention modified the US DPP to Latina women with GD by replacing the intensive face-to-face counselling with telephone calls so that mothers with young children would not be required to travel (293).

9.3.8 Sending annual screening test reminders

Finally, and perhaps most importantly, prompts or invitations for on-going screening should be sent to women with a history of GD. This is routine practice for comparable and relatively infrequent screening appointments in the UK (such as cervical screening (329) and NHS Health Checks (330)), therefore an absence of invitations downgrades the perceived importance of testing. Invitations and prompts have been suggested to be the most important method for increasing uptake in multiple systematic reviews, and proactive contact can double screening attendance (143,145,146). Despite this potential, the benefits observed are inconsistent; one study suggested that contact from women's general practice may be more effective than a central or national mail out (161). Consequently, research may be required to optimise the approach and include personalisation and behaviour prompts in letters (330), inviting people face-to-face (331), and raising general awareness (332) as is being done for NHS Health Checks. Electronic reminders can be sent from electronic health systems to reduce the burden on administrative staff and are acceptable to clinicians (268).

9.4 Implications for research

This research has focused on generating data to inform improvements to current follow-up care and development of a specific complex intervention to promote healthy diet and physical activity after a pregnancy affected by GD. This intervention should now be developed, evaluated and implemented in line with guidance for developing complex interventions such as that published by the MRC (177). It is likely that an effective intervention will focus on one (or a small number) of the above elements. For example, a mobile app that provides information about postpartum-friendly exercises, dietary advice and an opportunity to interact with others with GD, or implementation of double-length appointments at the six week mother-and-baby check in order to dedicate time to discuss the mother's future T2D risk and prevention behaviours.

For instance, an app to support healthy postpartum lifestyle should be developed with input from mothers with GD to ensure that it is accessible for this population. If the information provided is overseen by a clinician or expert, my studies suggest that it is likely to be trusted by the users because it is seen to be more accurate. Women with diverse characteristics, including of various parity and ethnicity, should be included in piloting the app. Outcomes to evaluate effectiveness could include change in self-reported or objectively-measured diet, activity levels and weight, a qualitative evaluation such as usability and usefulness of the resources provided, and follow-up T2D outcomes in the long-term.

My findings also point towards the utility of different diabetes screening intervals. In the US, screening is recommended every one to three years, although it is recommended every year in the UK (1,2). Although the DAiSIeS participants were eager for reassurance that they did not have T2D and that some felt that waiting until a year postpartum was too long, they were all within four years of GD and had not experienced several years of annual testing. If screening intervals were more flexible (e.g. every three years if they received a normal result) or risk-stratified (e.g. more frequent in those with a higher risk according to their ethnicity or BMI), this may be perceived to be something that could be maintained for the rest of their lives. In addition to a feasibility study, modelling the implications of this approach on T2D outcomes and an economic evaluation, research should be conducted to evaluate women with GD's perceptions of this. Focus groups would be valuable, and approaches such as community juries

have the advantage of presenting the participants with information about the proposed programmes before discussing it and coming to a conclusion from a collective, societal perspective (333).

In addition, these studies have identified the need for more observational research in the UK. Firstly, long-term screening attendance remains largely unknown. Daly *et al.* is the largest study of this to date (153), examining screening attendance using a national database (the THIN database). However, only screening up to three years postpartum was reported. Other studies have reported uptake up to five years after pregnancy in primary care, with a maximum sample size of 2,016 women with GD (154). Consequently, significant unanswered questions remain including: patterns of screening attendance over time (e.g. time to the last or latest diabetes test and frequency of attendance), which screening tests are used, and predictors of long-term attendance (associated with the participant and general practice). This study could be conducted in the UK Clinical Practice Research Datalink (CPRD), which includes anonymised records from a large number of patients and can be linked to other databases such as the IMD. However, only women with a history of GD recorded in the medical records will be identified (thus screening attendance will be missed in women without this Read code), there will be missing data (on demographics, screening tests, and when women change general practice) and data will become more sparse as time since pregnancy increases.

The UK is also missing information about healthy lifestyle behaviours after GD. The US has completed national surveys that elicit the population's self-reported health behaviours and intentions (such as the Behavioral Risk Factor Surveillance System and the National Health and Nutrition Examination Survey). These suggested that women with GD were not meeting healthy lifestyle guidelines (171–173). Although these are subject to significant error and bias (e.g. recall and social desirability bias), similar research in the UK population might provide further justification for healthy lifestyle interventions after GD and may inform who to prioritise for support.

There is also paucity of data regarding T2D diagnoses in a population that is screened regularly after GD, as recommended. These data will provide more accurate estimates of time to glucose intolerance than if testing occurs when symptoms of diabetes develop or women take part in cross sectional studies where everyone in a cohort is tested unless they have already been diagnosed. Northern Sweden is a suitable setting for such a study because OGTTs have been

offered to everyone at ages 40, 50 and 60 years through primary care as part of assessment of CVD risk factors and lifestyle behaviours in the Västerbotten Intervention Programme (VIP) (334). This can be used to better estimate time to T2D diagnosis than women who present with T2D symptoms. VIP was developed in the 1980s and data from over 140,000 individuals has been collected. In addition, the VIP database is linked to the Swedish Medical Birth Register that can be used to confirm details of the birth and GD status (in addition to self-reported history of GD in the VIP database) and the Diabetes Register in Northern Sweden (DiabNorth) to identify cases of diabetes through OGTT diagnosis and purchase of diabetes medication (335). On the other hand, there is a low incidence of GD in this population that will reduce the number of eligible records (0.6% in 2018 (336)) and there may be significant amounts of missing data. Identifying additional cohorts suitable for such analysis is therefore also needed.

9.5 Conclusion

In this thesis, I have justified the need for a focus on follow-up of GD in primary care. After exploring current influences on a healthy postpartum diet, exercise and attending diabetes screening, I have put forward and begun to evaluate various strategies for supporting these behaviours. Focused interventions, such as to enable women with GD to meet and exercise together, are desirable and have the potential to facilitate behaviour change. Other changes to healthcare provision will require clinicians and other healthcare professionals to consider and prioritise women's history of GD, such as taking time to discuss behavioural changes to prevent T2D. I have shown that some of these strategies should begin during pregnancy and continue postpartum and beyond. These findings will also be useful to develop or adapt an intervention to attenuate the heightened risk of developing T2D in women with GD.

Chapter 10 References

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Appendices

Appendix 1: DAiSIeS study participant invitation letter.

UNIVERSITY OF CAMBRIDGE
Public Health and Primary Care
The Primary Care Unit

Cambridge University Hospitals NHS Foundation Trust

DAiSIeS Diet, Activity and Screening after gestational diabetes: an Interview Study

Date [date]

Dear [invited participant]

Invitation to take part in a research interview

We are working with a team of researchers from the University of Cambridge to run a research study to find ways to help women to reduce their risk of developing diabetes in the future. The research team would like to speak to women who have had a pregnancy affected by gestational diabetes to hear their views and experiences of diet, physical activity and about blood glucose testing (diabetes screening) after pregnancy, and any suggestions that they have. This will help us to develop and improve approaches to best support mothers.

Please see the information about the study included in this letter. Please read this carefully. If you would like to take part or ask any questions, contact us using the details below.

Yours sincerely

[Recruiting site]

[Insert contact details]

Appendix 2: DAiSIeS study participant information sheet and data transparency statement.

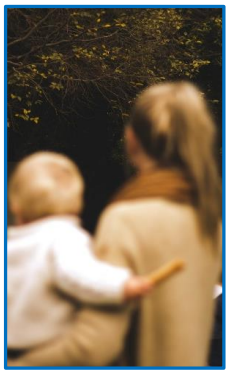
UNIVERSITY OF CAMBRIDGE
Public Health and Primary Care
The Primary Care Unit

Cambridge University Hospitals NHS
NHS Foundation Trust

DAiSIeS

Diet, Activity and Screening after gestational diabetes: an Interview Study

Participant information sheet



Invitation

We would like to invite you to take part in an interview to discuss your experience of gestational diabetes. We would like to find better ways of helping women reduce their chances of developing diabetes in the future.

Joining the study is entirely up to you, and before you decide we would like you to understand why the research is being done and what it would involve. This Participant Information Sheet tells you the purpose of the study and what will happen if you take part. Please feel free to talk to the study team or others about the study if you wish. We will do our best to answer any questions you may have.

What's involved?

Why are we doing this study?

As your clinical team will have explained to you, women who have had gestational diabetes are more likely to develop type 2 diabetes in the future compared to other women of the same age. We are researching how to help women to reduce their risk of developing diabetes after having had a pregnancy affected by gestational diabetes. In particular, we are interested in hearing your views and experiences of diet, physical activity and about blood glucose testing (diabetes screening) after your pregnancy, and any suggestions that you have. This will help us to develop and improve approaches to best support mothers.

Why am I being asked to think about taking part in this study?

We are looking for women who have recently had a pregnancy affected by gestational diabetes to take part in this study. We hope to recruit about 25 women with different experiences and from different backgrounds, so we may not be able to include everyone who would like to take part.

What would taking part involve?

If you agree to take part in this study, we will arrange an interview with a member of the study team. This can take place at a time and in a private location that is most suitable for you, and you're welcome to have your child or children with you. The interview is likely to take between 30 minutes and an hour. You will be able to stop the interview at any time or to choose to not answer specific questions. With your permission we will audio-record the interview so that we can transcribe it and keep a written record of what was said. This record will not include identifying information.

What are the possible benefits of taking part?

There will not be any direct benefits to your health from taking part and your healthcare will not be affected in any way. However, it is an opportunity to share your views and suggestions, which we will consider carefully, and you will be contributing to research that aims to support and improve care for people like you.

What are the possible disadvantages and risks of taking part?

We do not expect there to be any risks of taking part, although talking about diabetes and your diet or exercise can be sensitive issues. You can choose which parts of your experience you tell us about and will be free to pause or end the interview at any time. If the questions raise issues you would like support with, we can direct you to some useful services.

Will I receive any payment for taking part?

You will receive no payment or compensation for your time but we can reimburse reasonable travel costs if you need to travel to the interview venue.

What do I do if I want to take part?

It is entirely up to you whether or not to take part. Taking part in the study is completely voluntary and you can withdraw from the study at any time.

If you would like to take part, please reply using the contact details supplied on the invitation letter. The hospital team will pass your details on the researchers who will contact you to arrange an interview. You can also contact the hospital team to ask any questions before you decide whether to take part.

Other information

What will happen if I don't want to carry on with the study?

You can choose to withdraw from the interview any time before or during the interview. If you choose to withdraw after the interview has been completed, we will ask you if the interview data we have obtained may be kept and used to contribute to the study results. However, should you request that your interview data be destroyed, we will ensure that this takes place.

What if something goes wrong?

If you have any questions about the research or any concerns about the way you have been approached or treated, please contact Dr Claire Meek, the Chief Investigator, by emailing claire.meek@nhs.net.

How will my information be kept confidential?

The University of Cambridge and Cambridge University Hospitals NHS Foundation Trust are the sponsors for this study based in the United Kingdom. They will be using information from you in order to undertake this study and will act as the data controller for this study. This means that they are responsible for looking after your information and using it properly. The sponsor organisations will keep identifiable information about you for 12 months after the study has finished to ensure your safety and allow the study to be reviewed by the authorities after it is finished.

Your rights to access, change or move your information are limited, as the sponsor organisations need to manage your information in specific ways in order for the research to be reliable and accurate. To safeguard your rights, we will use the minimum personally-identifiable information possible.

You can find out more about how the sponsors use your information using the information below:

- For CUH NHS Foundation Trust, please visit: www.cuh.nhs.uk/corporate-information/about-us/our-responsibilities/looking-after-your-information, or email the Data Protection Officer at: gdpr.enquiries@addenbrookes.nhs.uk

- For University of Cambridge, please visit: www.medschl.cam.ac.uk/research/information-governance, or email the Information Governance team at: researchgovernance@medschl.cam.ac.uk.

What will happen to the results of this study?

When the study is completed, the results will be presented at scientific meetings and published in scientific journals. They will also make up part of a PhD thesis. Your identity and personal details will be kept confidential: no information that could identify you, like your name, will be published in any report about this study. We can share these publications and a summary with you.

Who is organising and funding this study?

The study is being organised by the University of Cambridge and funded by the School of Primary Care Research.

How have patients and the public been involved in this study?

Patients and the public have helped with the design of the research, and will be involved all the way through the research process. This includes managing the study, looking carefully at the results and sharing the findings.

Who has reviewed this study?

All research in the NHS is looked at carefully by an independent group of people, called a Research Ethics Committee, to protect your safety, rights, wellbeing and dignity. This study has been reviewed and approved by the London – West London & GTAC Research Ethics Committee.

Research team

Mrs Becky Dennison,
PhD Student
(Study Researcher)

Dr Claire Meek,
Senior Clinical Research Fellow and Consultant Diabetes Physician (Chief Investigator)

With Prof Simon Griffin, Dr Juliet Usher-Smith and Dr Catherine Aiken.

UNIVERSITY OF CAMBRIDGE
Public Health and Primary Care
The Primary Care Unit

Cambridge University Hospitals NHS Foundation Trust

Dr Claire Meek
Senior Clinical Research Associate
Consultant Metabolic Physician

DAiSIeS GDPR Transparency Statement
Version 1
Date 13/3/2019

Transparency Statement – Data Use in the DAiSIeS Study
FULL TITLE: Diet, Activity and Screening after gestational diabetes: an Interview Study

The use of your personal data in the DAiSIeS study

Cambridge University Hospitals NHS Foundation Trust and the University of Cambridge are the joint sponsors for this study based in the United Kingdom. We will be using information from you and your medical records in order to undertake this study and will act as the data controller for this study. This means that we are responsible for looking after your information and using it properly. Cambridge University Hospitals NHS Foundation Trust and the University of Cambridge will keep identifiable information about you from this study for 1 year after the study has finished.

Your rights to access, change or move your information are limited, as we need to manage your information in specific ways in order for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we have already obtained. To safeguard your rights, we will use the minimum personally-identifiable information possible.

You can find out more about how we use your information by contacting either:
Dr Claire Meek, the Chief Investigator on clm70@cam.ac.uk
Your local study team at <insert contact details>

How we collect and use your personal data

Cambridge University Hospitals NHS Foundation Trust and the University of Cambridge will use your name, NHS number, date of birth and contact details to contact you about the research study, and make sure that relevant information about the study is recorded for your care, and to oversee the quality of the study. Individuals from Cambridge University Hospitals NHS Foundation Trust, University of Cambridge and regulatory organisations may look at your medical and research records to check the accuracy of the research study. They will pass these details to Cambridge University Hospitals NHS Foundation Trust and University of Cambridge along with the information collected from you and your medical records.

The only people in Cambridge University Hospitals NHS Foundation Trust and University of Cambridge who will have access to information that identifies you will be people who need to contact you about your results or study participation or audit the data collection process. The people who analyse the information will not be able to identify you and will not be able to find out your name, NHS number or contact details.
Cambridge University Hospitals NHS Foundation Trust and the University of Cambridge will keep identifiable information about you from this study for 1 year after the study has finished.

Use of data in future research

When you agree to take part in a research study, the information about your health and care may be provided to researchers running other research studies in this organisation and in other organisations. These organisations may be universities, NHS organisations or companies involved in health and care research in this country or abroad. Your information will only be used by organisations and researchers to conduct research in accordance with the UK Policy Framework for Health and Social Care Research.

Your information could be used for research in any aspect of health or care, and could be combined with information about you from other sources held by researchers, the NHS or government.

Where this information could identify you, the information will be held securely with strict arrangements about who can access the information. The information will only be used for the purpose of health and care research, or to contact you about future opportunities to participate in research. It will not be used to make decisions about future services available to you, such as insurance.

Where there is a risk that you can be identified your data will only be used in research that has been independently reviewed by an ethics committee.

Local contact for information. Should you wish to discuss any issues related to this study, please contact the study team using the details below. Thank you for reading this leaflet.

Chief Investigator: Dr Claire Meek
Email: clm70@cam.ac.uk
Office: 01223 274218

Local Research Nurse/Midwife: <insert details>
Email: <insert contact details>
Office: <insert contact details>

Appendix 3: DAiSIeS recruitment poster.

UNIVERSITY OF CAMBRIDGE
Public Health and Primary Care
The Primary Care Unit

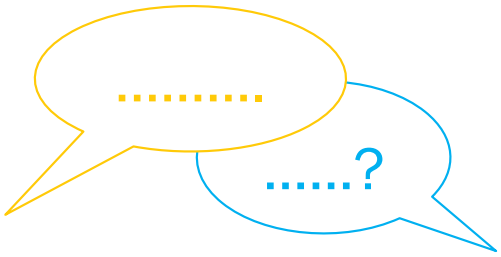
Cambridge University Hospitals NHS
NHS Foundation Trust

DAiSIeS

Diet, Activity and Screening after gestational diabetes: an Interview Study

We are looking for women who have recently had **gestational diabetes**

to take part in research **interviews**



to discuss their postpartum **experiences** and how we can **help others** to reduce their risk of developing diabetes in the future

Your care team might send you an information pack if they think you are suitable to take part.

If you would like to find out more now, please contact XXXXXXXXXXXX

Poster v1 12 Feb 2019 IRAS Project ID: 254300

Appendix 4: DAiSIeS participant questionnaire.

UNIVERSITY OF CAMBRIDGE
Public Health and Primary Care
The Primary Care Unit

Cambridge University Hospitals NHS Foundation Trust

DAiSIeS

Diet, Activity and Screening after gestational diabetes: an Interview Study

Closing questionnaire

Participant ID _____ **Date** _____

1) Which age band are you in?

◯ 18–25 years ◯ 26–30 years ◯ 31–35 years ◯ 36–40 years ◯ 41+ years

2) What is your ethnic group?

◯ White
◯ Mixed/multiple ethnic groups
◯ Asian/Asian British
◯ Black/African/Caribbean/Black British
◯ Other ethnic group

3) What is your highest level of education?

◯ Secondary education (GCSEs or equivalent) or below
◯ Further education (A levels, BTEC, apprenticeship or equivalent)
◯ Higher education (Bachelor's degree or equivalent)
◯ Postgraduate higher education (Master's degree, PhD or equivalent)

4) What is your current employment status?

◯ In full time employment ◯ and currently on maternity leave)
◯ In part time employment ◯ and currently on maternity leave)
◯ Stay at home parent
◯ Other full time role outside of the home
◯ Other (please specify): _____

5) What is your current living situation?

◯ Living with spouse or partner
◯ Single
◯ Other (please specify): _____

6) How many children do you have? _____

7) How many pregnancies have you had that have been affected by gestational diabetes?
_____

8) Did you take medication (insulin or metformin) to manage gestational diabetes during your most recent pregnancy?

◯ No
◯ Yes

9) Have you had a glucose tolerance test or test for type 2 diabetes since your most recent pregnancy? (Please tick all that apply)

◯ No
◯ Yes, at approximately 6 weeks postpartum
◯ Yes, after the postpartum period

10) Have you ever been told that you have type 2 diabetes?

◯ No
◯ Yes (If yes, when was this? _____)

Would you like to be made aware of the findings of this study?

◯ No
◯ Yes Please provide an email or postal address: _____
_____

Please use the space below to provide any feedback on the interview or other comments.

_____
_____
_____
_____
_____
_____

Thank you very much for completing this questionnaire.

Appendix 5: Details of studies included in the incidence of type 2 diabetes screening after gestational diabetes systematic review.

First author/ year	Country	Data source	Eligible pregnancies (years)	Duration of follow-up (years)		Diagnoses				Women with GD										Women without GD			RR	QA score (/6)
						GD		T2D					Study-level demographics											
													Age (years)			%	BMI (kg/m^2)		% with family history of diabetes				
				Duration	Category	Method	Sensi-tivity	Method	Sensi-tivity	N	n with T2D	% with T2D	Deli-very	Foll-ow-up	% White European	nulliparous at index pregnancy	Pre-preg-nancy	Foll-ow-up		N	n with T2D	% with T2D		
Africa																								
Chivese 2019 (337)	South Africa	Groote Schuur Hospital, Cape Town	2010–2011	Range: 5.0–6.0	3–5.9	MR (hospital)	H	Glycaemic test	H	150	47	31.3	31.7	37.2	3.2	-	-	34.9	76.8	-	-	-	-	4
Australasia																								
Lee 2007 (234)	Australia	Mercy Hospital for Women, Melbourne	1971–2003	Median 2.2, range: 0.1–29.9	<3	MR (hospital)	H	MR (hospital)	H	5,470	405	7.4	31.0	33.2	71.3	-	-	-	24.0	783	16	2.0	3.6	4
Cheung 2006 (338)	Australia	Westmead and Nepean Hospitals, Sydney	1988–1994	Mean±SD: 4.5±2.4, up to 8.0	3–5.9	MR (hospital)	H	Glycaemic test	H	102	30	29.4	32.4	36.9	27.7	-	-	-	49.0	-	-	-	-	3
Moses 2017 (339)	Australia	Personal records, Wollongong	1991–2010	Range 9.0–25.0	≥12	MR (hospital)	H	Glycaemic test	H	421	72	17.1	31.2	-	86.2	-	27.5	-	26.0	-	-	-	-	3
Barden 2013 (340)	Australia	King Edward Memorial Hospital and Joondalup Health Campus, Perth	1998–2001	10.0	9–11.9	Glycaemic test	H	Glycaemic test	H	112	20	17.9	32.9	42.9	74.7	18.7	-	-	60.7	48	0	0.0	-	3
Chittleborough 2010 (341)	Australia	South Australian Gestational Diabetes Mellitus Recall Register	2002–2009	1.3	<3	MR (registry)	H	Self-report or other	C	241	2	0.8	-	-	≥50	-	-	-	-	-	-	-	-	0
Lappas 2015 (342)	Australia	Mercy Hospital for Women, Melbourne	2003–2005	Median: 8.7, range 8.0–10.0	6–8.9	Glycaemic test	H	Glycaemic test	H	104	21	20.2	23.8	32.5	≥50	-	-	25.9	-	-	-	-	-	4
Chamberlain 2016 (343)	Australia	Cairns Hospital, Queensland	2004–2010	7.0	6–8.9	MR (hospital)	H	MR (hospital)	H	483	110	22.8	32.6	39.6	67.9	32.0	-	-	-	-	-	-	-	3
Ingram 2017 (344)	Australia	Launceston General Hospital, Tazmania	2007–2009	5.5	3–5.9	MR (hospital)	H	MR (hospital)	H	148	9	6.1	31.8	37.3	86.6	-	-	-	58.2	-	-	-	-	6
Central and South America																								
Ali 1990 (345)	Trinidad	Mount Hope Women's Hospital, San Juan	1981–1984	Mean±SD: 4.9±0.9, range 3.5–6.5	3–5.9	Glycaemic test	L	Glycaemic test	L	60	37	61.7	32.5	37.4	0.0	-	-	-	68.3	-	-	-	-	5
Gabaldi Silva 2003 (346)	Brazil	Hospital in Botucatu	1988–1997	Up to 12.0	6–8.9	MR (hospital)	L	Glycaemic test	H	159	56	35.2	-	-	<50	-	-	-	-	370	24	6.5	5.4	4

Saucedo 2012 (347)	Mexico	Hospital of Gynecology and Obstetrics, Medical Center La Raza, Mexico City	2007–2009	1.0	<3	Glycaemic test	H	Glycaemic test	H	52	25	48.1	32.4	33.4	<50	25.1	30.1	-	51.9	-	-	-	-	3
Europe																									
Dornhorst 1990 (348)	UK	St Mary's Hospital, London	1976–1982	Mean±SD: 8.6±0.3, range: 6.0–12.0	6–8.9	MR (hospital)	L	Glycaemic test	L	51	16	31.4	31.8	41.0	35.0	-	-	-	29.4	23	0	0.0	-	4
Lauenborg 2005 (349)	Denmark	Center for Diabetes and Pregnancy, Rigshospitalet	1978–1996	Mean: 9.8, range: 6.4–17.2	9–11.9	MR (hospital)	L	Glycaemic test	H	481	171	35.6	32.0	42.9	75.0	-	25.1	27.9	-	910	30	3.3	10.8	3
Cypryk 2005 (350)	Poland	Polish Mother's Health Center, Łódź	1980–1998	Mean±SD: 3.1±3.0, range: 0.5–18.0	3–5.9	MR (hospital)	C	Glycaemic test	H	200	34	17.0	30.9	34.0	≥50	-	-	26.5	-	-	-	-	-	1
Fahami 2019 (155)	UK	GP practices in Leister	1980–2017	Median: 5.0	3–5.9	MR (other)	C	MR (other)	C	408	91	22.3	-	-	17.4	-	-	-	-	-	-	-	-	3
Hanson 1996 (351)	Sweden	Karolinska Hospital, Stockholm	1981–1984	Range: 6.0–7.0	6–8.9	Glycaemic test	C	Glycaemic test	L	97	3	3.1	31.3	37.8	≥50	-	-	-	-	23	0	0.0	-	4
Wolff 1987 (352)	Germany	Leipzig Care Center, Leipzig	1981–1985	Range 0.1–2.0	<3	MR (hospital)	C	Glycaemic test	L	69	15	21.7	-	-	≥50	-	-	-	-	-	-	-	-	4
Järvelä 2006 (353)	Finland	Oulu University Hospital, Oulu	1984–1994	Mean: 5.7, range: 1.0–11.6	3–5.9	MR (hospital)	H	Self-report or other	C	435	23	5.3	31.9	37.5	≥50	-	-	-	-	435	0	0.0	-	4
Pirkola 2010 (354)	Finland	Northern Finland Birth Cohort 1986	1985–1986	20.0	≥12	Glycaemic test	L	MR (registry)	C	124	21	16.9	29.3	49.3	100.0	-	25.1	-	-	6,359	68	1.1	15.8	5
Albareda 2003 (235)	Spain	Hospital de Sant Pau, Barcelona	1986–1993	5.0, mean: 6.2, range: 0.1–13.7	6–8.9	Glycaemic test	L	Glycaemic test	H	696	39	5.6	31.3	37.4	≥50	35.7	23.3	24.5	53.7	70	0	0.0	-	4
Sokup 1999 (355)	Poland	Intensive Care Diabetology and Care Center, Bydgoszcz	1987–1996	Mean±SD: 0.9±4.1, range: 0.0–5.0	<3	MR (hospital)	H	MR (hospital)	L	140	26	18.6	30.7	31.6	≥50	-	-	-	-	-	-	-	-	3
Ijäs 2013 (356)	Finland	Oulu University Hospital, Oulu	1988–1993	Mean: 19.0, range: 16.0–21.0	≥12	MR (hospital)	H	Glycaemic test	H	61	40	65.6	35.9	52.2	≥50	-	27.1	-	-	55	3	5.5	12.0	3
Ziegler 2012 (357)	Germany	BABY-DIAB Study	1989–1999	15.0, up to 19.0	≥12	Glycaemic test	H	Glycaemic test	L	304	147	48.4	31.0	46.0	≥50	-	-	-	-	-	-	-	-	4

Konarzewska 2004 (358)	Poland	Instytutu Położnictwa i Chorób Kobiecych	1989–2001	Mean±SD: 1.5±1.4, range: 0.1–6.0	<3	MR (hospital)	C	Glycaemic test	H	192	55	28.6	-	-	≥50	-	-	-	-	-	-	-	-	1
Huopio 2014 (359)	Finland	Kuopio University Hospital, Kuopio	1989–2009	Mean±SD: 7.3±5.1	6–8.9	MR (hospital)	H	Glycaemic test	H	489	28	5.7	32.0	37.8	100.0	36.6	-	28.4	81.0	385	1	0.3	22.0	6
Dalfra 2001 (360)	Italy	Hospital in Padova	1990–1992	Range: 1.0–5.0	3–5.9	Glycaemic test	H	Glycaemic test	L	70	10	14.3	-	-	≥50	-	25.6	25.1	-	-	-	-	-	4
Corrado 2007 (361)	Italy	University of Messina	1990–1999	Mean±SD: 6.9±1.8, range: 5.0–11.0	6–8.9	MR (hospital)	H	Glycaemic test	H	58	6	10.3	34.9	41.8	100.0	-	28.5	-	39.6	56	1	1.8	5.8	6
Daly 2018 (153)	UK	The Health Improvement Network (THIN) database	1990–2016	Median: 2.9, range 1.0–25.0	<3	MR (other)	C	MR (other)	C	9,118	895	9.8	33.0	35.9	≥50	-	-	-	-	37,281	142	0.4	25.8	3
Heida 2015 (362)	Netherlands	European Prospective Investigation into Cancer and Nutrition (EPIC-NL)	1993–1997	Range: 9.0–13.0	9–11.9	Self-report	C	MR (registry)	C	1,089	121	11.1	-	51.2	≥50	9.7	-	26.9	-	-	-	-	-	4
Wender-Ozegowska 2007 (363)	Poland	Hospital in Poznań	1993–2002	Mean±SD: 6.0±2.7	6–8.9	MR (hospital)	C	Glycaemic test	H	153	86	56.2	28.6	34.6	≥50	-	26.0	26.6	-	155	2	1.3	43.6	3
Eades 2015 (364)	UK	Ninewells Hospital, Dundee	1994–2004	Up to 16.0	6–8.9	MR (hospital)	H	MR (registry)	H	164	41	25.0	30.3	-	≥50	35.0	-	-	33.0	-	-	-	-	5
Olesen 2014 (365)	Denmark	North Demark National Patient Register	1994–2011	Range: 4.0–6.0	3–5.9	MR (registry)	C	MR (registry)	C	2,171	124	5.7	31.2	-	92.3	-	-	-	-	-	-	-	-	4
Hunger-Dathe 2006 (366)	Germany	University Hospital, Jena	1995–1996	Mean±SD: 5.8±2.0, range: 2.0–10.0	3–5.9	MR (hospital)	H	Glycaemic test	H	173	16	9.2	30.1	35.9	100.0	-	25.6	27.5	62.4	-	-	-	-	2
Wahlberg 2016 (367)	Sweden	Swedish Medical Birth Registry (MBR)	1995–1999	Median: 11.3, range: 8.5–13.5	9–11.9	MR (registry)	L	Self-report or other	C	1,324	216	16.3	32.1	43.4	79.3	-	27.1	-	-	-	-	-	-	3
Anderberg 2012 (227)	Sweden	Skåne University Hospital, Lund and Malmö	1995–2001	Range 8.0–14.0	9–11.9	MR (hospital)	L	MR (hospital)	C	579	180	31.1	-	-	≥50	-	-	-	-	1,131	13	1.1	27.0	4
Sivaraman 2013 (368)	UK	Worcestershire Royal Hospital, Worcester	1995–2003	5.0	3–5.9	MR (hospital)	L	MR (hospital)	H	195	13	6.7	31.3	36.3	0.0	-	-	-	-	-	-	-	-	3

Rawal 2018 (369)	Denmark	Danish National Birth Cohort (DNBC)	1996–2002	Median: 13.0, range: 9.0–16.0	≥12	Self-report	C	Glycaemic test	H	607	183	30.1	31.9	43.7	≥50	38.6	27.1	29.2	42.4	619	9	1.5	20.7	3
Álvarez-Silvares 2016 (370)	Spain	University Hospital Complex of Ourense	1996–2009	Up to 18.0	9–11.9	MR (hospital)	L	MR (hospital)	H	495	51	10.3	-	-	≥50	-	-	-	-	-	-	-	-	3
Kousta 1999 (371)	UK	St Mary's, Hammersmith and Queen Charlotte's, Chelsea and Westminster, Ealing, and Central Middlesex Hospitals, London	1997–1998	Median: 2.3, range 0.1–7.2	<3	MR (hospital)	L	Glycaemic test	H	192	52	27.1	34.3	36.6	35.0	-	-	28.1	-	-	-	-	-	3
Costa 2000 (372)	Spain	Facultat de Medicina, Universitat, Barcelona	1997–1998	Range: 0.2–1.0	<3	Glycaemic test	L	Glycaemic test	H	120	3	2.5	33.6	34.2	100.0	-	-	25.6	-	-	-	-	-	2
Bo 2006 (373)	Italy	University of Turin, Turin	1997–2001	Mean±SD: 6.5±1.1, range: 4.0–8.0	6–8.9	MR (hospital)	H	Glycaemic test	H	182	16	8.8	34.0	40.5	100.0	55.7	24.3	-	48.9	161	4	2.5	3.5	4
Hummel 2013 (374)	Germany	Postpartum Outcomes in Women with Gestational Diabetes and their Offspring (POGO)	1998–2009	Median: 5.5, range 1.8–11.4	3–5.9	MR (hospital)	H	Glycaemic test	H	102	8	7.8	-	-	≥50	-	-	-	-	15	0	0.0	-	5
Zonenberg 2006 (375)	Poland	Klinika Chorób Wewnętrznych, Endokrynologii i Diabetologii, Warsaw	1999–2003	5.0	3–5.9	MR (hospital)	C	Glycaemic test	H	84	8	9.5	31.3	34.7	≥50	-	-	26.0	-	-	-	-	-	2
Göbl 2011 (376)	Austria	Vienna Post-Gestational Diabetes Project, Vienna	1999–2003	Up to 10.0	3–5.9	Glycaemic test	H	Glycaemic test	H	110	23	20.9	-	32.7	89.1	-	-	27.3	55.6	41	0	0.0	-	6
Apostolakis 2018 (377)	Greece	Alexandra Hospital, Athens	2000–2015	Mean±SD: 1.4±2.4	<3	MR (hospital)	H	Glycaemic test	H	1,336	83	6.2	33.9	35.3	100.0	-	-	26.7	-	-	-	-	-	5
Seghieri 2010 (378)	Italy	Spedali Riuniti Viale Matteotti, Tuscany	2001–2005	Median: 8.0	6–8.9	MR (hospital)	H	MR (hospital)	L	74	10	13.5	-	-	100.0	-	23.6	-	-	-	-	-	-	3
Carvalho Ribeiro 2015 (379)	Portugal	Hospital de Braga, Braga	2001–2010	Mean: 4.0, range: 1.0–10.0	3–5.9	MR (hospital)	C	MR (registry)	C	300	98	32.7	34.3	38.0	≥50	31.0	-	29.5	50.0	-	-	-	-	3
Akinci 2011 (380)	Turkey	Dokus Eylul University, İzmir	2002–2008	Mean±SD: 3.4±1.8	3–5.9	Glycaemic test	H	Glycaemic test	H	195	27	13.8	32.2	35.6	100.0	-	26.5	28.1	46.7	71	0	0.0	-	4

Pintaudi 2015 (381)	Italy	National administrative data	2002–2010	Median: 5.4, up to 8.0	3–5.9	MR (registry)	H	MR (registry)	C	3,851	773	20.1	30.0	35.4	≥50	-	-	-	-	11,553	128	1.1	18.1	5
Bljajić 2009 (382)	Croatia	University Hospital Centre, Zagreb	2003–2003	5.0	3–5.9	MR (hospital)	L	Glycaemic test	H	89	7	7.9	-	-	≥50	-	-	27.9	-	-	-	-	-	3
Claesson 2017 (383)	Sweden	Mamma Study, Skåne	2003–2005	5.0	3–5.9	Glycaemic test	L	Glycaemic test	H	196	73	37.2	33.6	38.6	73.0	-	-	-	-	-	-	-	-	6
Moleda 2016 (384)	Poland	West Pomerania	2003–2010	Mean±SD: 7.4±0.7, range: 5.0–12.0	6–8.9	MR (hospital)	C	Glycaemic test	H	199	13	6.5	31.0	38.4	100.0	-	22.4	25.5	-	50	0	0.0	-	4
Engeland 2011 (228)	Norway	Medical Birth Registry of Norway (MBRN)	2004–2008	Mean: 3.7, up to 6.0	3–5.9	MR (registry)	C	MR (registry)	C	2,198	308	14.0	32.3	36.0	≥50	-	-	-	-	224,634	899	0.4	35.0	3
Prados 2018 (385)	Spain	Hospital del Mar, Barcelona	2004–2016	1.0	<3	Glycaemic test	L	Glycaemic test	H	306	16	5.2	34.1	35.1	47.1	47.7	27.1	-	53.7	-	-	-	-	4
Kerimoglu 2010 (386)	Turkey	Etlik Zübeyde Hanım Women's Health Teaching Hospital, Ankara	2005–2007	1.0	<3	MR (hospital)	H	Glycaemic test	H	78	27	34.6	31.8	32.8	≥50	18.0	27.8	29.5	62.0	-	-	-	-	4
Andersson-Hall 2018 (387)	Sweden	Gothenburg area	2005–2009	Mean±SD: 5.6±0.5	3–5.9	MR (hospital)	C	Glycaemic test	H	237	44	18.6	33.8	39.4	49.4	-	27.6	27.3	-	-	-	-	-	3
Bartáková 2015 (388)	Czech Republic	University Hospital Brno, Brno	2005–2011	Up to 1.0	<3	MR (hospital)	H	MR (hospital)	H	305	16	5.2	32.3	-	100.0	-	27.9	-	75.0	-	-	-	-	4
Pellonperä 2016 (389)	Finland	Turku University Hospital, Turku	2006–2010	1.0	<3	Glycaemic test	H	Glycaemic test	H	321	9	2.8	31.6	32.6	≥50	42.5	-	-	65.5	-	-	-	-	4
Pérez-Ferre 2015 (237)***	Spain	Hospital Clinico San Carlos, Madrid	2007–2008	3.0	3–5.9	Glycaemic test	H	Glycaemic test	C	237	26	11.0	35.3	38.3	63.5	33.2	24.5	25.6	-	-	-	-	-	5
Goueslard 2016 (390)	France	National medico-administrative database	2007–2008	Up to 7.0	3–5.9	MR (hospital)	C	MR (hospital)	C	62,958	1,266	2.0	31.7	-	≥50	-	-	-	-	1,452,429	1,674	0.1	17.4	5
Noctor 2016 (391)	Ireland	ATLANTIC-DIP 2, Saolta Hospital Group	2007–2010	Mean±SD: 2.6±1.0	<3	Glycaemic test	H	Glycaemic test	H	270	6	2.2	34.3	36.6	100.0	-	-	29.7	65.2	388	0	0.0	-	2
De Mori 2015 (392)	Italy	Treviglio Hospital, Lombardy	2007–2011	Mean±SD: 4.8±1.4	3–5.9	MR (hospital)	H	Glycaemic test	H	66	8	12.1	34.9	39.6	95.5	-	25.7	26.6	75.8	-	-	-	-	5
Ozuguz 2011 (393)	Turkey	Ankara Numune Research and Training Hospital, Ankara	2008–2010	1.0	<3	Glycaemic test	H	Glycaemic test	H	55	5	9.1	31.0	32.0	100.0	-	27.0	-	70.0	-	-	-	-	4
Huvinen 2018 (394)	Finland	Finnish Gestational Diabetes Prevention Study (RADIEL)	2008–2014	Median: 5.4, range 4.0–6.0	3–5.9	Glycaemic test	H	Glycaemic test	H	179	9	5.0	34.6	40.0	≥50	-	27.8	-	35.8	-	-	-	-	2

Persson 2015 (395)	Sweden	Swedish Medical Birth Register (MBR)	2009–2009	4.0	3–5.9	MR (registry)	C	Self-report or other	C	107	19	17.8	33.8	37.8	≥50	-	26.2	-	7.2	333	0	0.0	-	1
Benhalima 2017 (396)	Belgium	"Sweet Pregnancy" project	2009–2011	Up to 6.0	3–5.9	MR (registry)	H	Self-report or other	H	868	63	7.3	-	-	≥50	-	-	-	-	-	-	-	-	3
Brink 2016 (397)	Netherlands	Maasstad Hospital, Rotterdam	2010–2010	Mean: 5.0	3–5.9	MR (hospital)	L	Self-report or other	H	52	10	19.2	33.3	38.3	29.4	-	-	-	58.8	-	-	-	-	3
Vince 2018 (398)	Croatia	Medical birth certificates (MBC) registry	2011–2011	5.0	3–5.9	MR (registry)	H	MR (registry)	C	853	32	3.8	31.0	36.0	≥50	-	24.6	-	-	-	-	-	-	4
Gar 2018 (399)	Germany	Prediction, Prevention, and Subclassification of gestational and type 2 Diabetes (PPSDiab)	2011–2016	Range: 0.3–1.3	<3	Glycaemic test	H	Glycaemic test	H	192	6	3.1	34.6	35.4	≥50	-	-	25.5	-	93	0	0.0	-	5
Żurawska-Kliś 2019 (224)	Poland	Outpatient Department of Diabetology, Lodz	2013–2016	Mean±SD: 1.5±0.1	<3	Glycaemic test	H	Glycaemic test	H	68	0	0.0	34.1	35.6	≥50	48.5	25.1	24.4	54.4	-	-	-	-	4
Fernandez Fernandez 1992 (400)	Spain	Virgen Macarena University Hospital of Seville, Seville	-	Range: 0.3–1.0	<3	Glycaemic test	L	Glycaemic test	L	155	23	14.8	30.4	31.0	≥50	17.0	27.0	-	53.0	-	-	-	-	3
Vambergue 2008 (401)	France	DIAGEST 2, Lille	-	Mean±SD: 6.8±0.8	6–8.9	Glycaemic test	H	Glycaemic test	H	295	53	18.0	-	-	≥50	-	-	-	-	286	12	4.2	4.3	3
Middle East and South Asia																								
Mahalakshmi 2014 (402)	India	Diabetes Electronic MR (DEMR)	1991–2011	Mean: 4.5	3–5.9	MR (registry)	H	Glycaemic test	H	174	101	58.0	29.3	33.8	0.0	-	-	-	70.0	-	-	-	-	3
Chodick 2010 (403)	Israel	Maccabi Healthcare Services	1995–2009	Mean±SD: 5.7±4.0	3–5.9	MR (registry)	H	MR (registry)	H	11,270	1,067	9.5	33.0	38.6	<50	26.3	-	-	-	174,146	1,125	0.6	14.7	3
Shahbazian 2013(404)	Iran	Imam Khomeini hospital, Ahvaz	1997–2007	Mean: 7.8, range 2.0–12.0	6–8.9	MR (hospital)	C	Glycaemic test	H	110	46	41.8	34.5	42.3	<50	-	-	-	-	-	-	-	-	4
Minooee 2017 (226)	Iran	Tehran Lipid and Glucose Study (TLGS), Tehran	1998	Median: 12.1, up to 15.0	≥12	Self-report	L	Glycaemic test	H	476	49	10.3	24.4	36.5	0.0	-	-	28.4	27.3	1,982	93	4.7	2.2	3
Valizadeh 2015 (405)	Iran	Endocrinology Clinic, Vali-e-Asr Hospital, Zanjan Province	2004–2010	Mean±SD: 1.9±0.2	<3	MR (hospital)	C	Glycaemic test	H	110	36	32.7	-	-	<50	-	-	28.3	34.5	-	-	-	-	2
Herath 2017 (406)	Sri Lanka	Birth and Immunization Register	2005–2005	Mean±SD: 10.9±0.4	9–11.9	MR (hospital)	L	MR (hospital)	H	119	73	61.3	32.0	42.8	4.2	33.6	-	-	47.1	240	14	5.8	10.5	3
Ghajari 2017 (407)	Iran	Rural health centers of Khuramshahr	2005–2015	Mean: 2.5	<3	MR (hospital)	C	Self-report or other	H	60	9	15.0	30.1	32.6	5.3	13.7	-	-	41.2	-	-	-	-	3

Gupta 2017 (408)	India	All India Institute of Medical Sciences, New Delhi and MHRT-Hospital and Research Trust, Hyderabad	2006–2013	Mean±SD: 1.6±1.3, median: 1.2, range 0.1–5.8	<3	MR (hospital)	H	Glycaemic test	H	366	119	32.5	28.6	30.2	0.0	-	23.6	-	27.9	-	-	-	-	3
Sreelakshmi 2015 (229)	India	Indo Danish Collaboration on Diabetes Epidemiology (INDADE) study	2007–2007	Up to 4.0	<3	MR (registry)	C	Self-report or other	C	60	6	10.0	-	-	<50	27.6	-	24.6	48.3	120	1	0.8	12.0	1
Mahzari 2018 (409)	Saudi Arabia	Tertiary care center, Riyadh	2011–2014	Up to 3.0	<3	MR (hospital)	C	MR (hospital)	C	123	82	66.7	34.3	-	0.0	-	-	-	56.0	-	-	-	-	3
Goyal 2018 (410)	India	All India Institute of Medical Sciences, New Delhi	2012–2016	Median: 1.7	<3	MR (hospital)	H	Glycaemic test	H	267	28	10.5	30.8	32.5	0.0	-	-	27.3	47.6	-	-	-	-	4
Sudasinghe 2018 (411)	Sri Lanka	Antenatal clinics, Gampaha	2014–2016	1.0	<3	Glycaemic test	L	Glycaemic test	H	59	11	18.6	-	-	0.0	32.5	-	-	-	57	3	5.3	3.5	3
Wahabi 2018 (412)	Saudi Arabia	King Khalid University Hospital, Riyadh	2017–2018	1.0	<3	Glycaemic test	H	Glycaemic test	H	133	15	11.3	-	-	0.0	21.8	29.0	31.7	80.5	-	-	-	-	4
North America																								
Coustan 1993 (413)	US	Women's and Infants' Hospital, Rhode Island	1979–1989	Range: 0.0–10.0	3–5.9	MR (hospital)	H	Glycaemic test	L	350	24	6.9	-	-	91.0	-	25.2	-	-	-	-	-	-	4
Go 2001 (414)	US	Jefferson County Health Department Clinics, Alabama	1981–1988	Median: 11.0, range: 3.0–18.4	9–11.9	Glycaemic test	H	Glycaemic test	L	289	103	35.6	28.3	39.0	0.0	-	-	35.0	85.0	-	-	-	-	4
Shen 2016 (230)	Canada	Population Health Research Data Repository, University of Manitoba	1981–2011	Up to 25.0	≥12	MR (registry)	C	MR (registry)	C	11,895	4,094	34.4	28.8	-	≥50	30.7	-	-	-	392,484	17,316	4.4	7.8	4
Steinhart 1997 (415)	US	Shiprock Hospital, New Mexico	1983–1987	Mean: 8.0, range: 7.0–11.0	6–8.9	MR (hospital)	H	Glycaemic test	L	111	47	42.3	31.4	39.3	0.0	-	-	-	-	-	-	-	-	5
Kjos 1995 (416)	US	Los Angeles County and University of Southern California Women's Hospital	1987–1993	7.5	6–8.9	MR (hospital)	L	Glycaemic test	L	671	146	21.8	-	-	0.0	-	-	-	-	-	-	-	-	5
Bao 2016 (417)	US	Nurses' Health Study II (NHSII)	1989–2001	15.3	≥12	Self-report	C	Self-report or other	H	4,502	722	16.0	27.5	38.0	92.5	81.1	-	-	-	-	-	-	-	3
Russell 2008 (418)	Canada	Nova Scotia Atlee Perinatal Database (NSAPD)	1989–2002	Up to 13.0	6–8.9	MR (registry)	H	MR (registry)	C	1,401	251	17.9	28.4	-	≥50	-	-	-	-	-	-	-	-	5

Chaudhry 2015 (419)	Canada	Ottawa Civic Hospital and Ottawa General Hospital, Ottawa	1990–1995	Range: 8.0–10.0	9–11.9	Glycaemic test	H	Glycaemic test	H	74	16	21.6	32.0	41.0	91.9	-	-	29.6	58.1	-	-	-	-	4
Bond 2017 (420)	Canada	Health insurance body of Quebec (RAMQ)	1990–2007	Mean±SD: 12.5±5.6, median: 12.5, range: 7.8–17.3	≥12	MR (other)	C	MR (registry)	C	34,686	6,147	17.7	30.5	43.0	80.0	49.3	-	-	-	34,686	472	1.4	13.0	4
Wang 2012 (421)	US	Louisiana State University Health Care Services Division hospitals	1990–2009	Mean: 8.6	6–8.9	MR (hospital)	H	MR (hospital)	H	1,142	327	28.6	27.1	35.7	31.2	46.5	-	-	-	18,856	1,067	5.7	5.1	5
Malcolm 2009 (422)	Canada	Children's Hospital of Eastern Ontario, Ontario	1991–1995	Range: 7.0–11.0	9–11.9	Glycaemic test	H	Glycaemic test	H	88	25	28.4	-	41.0	91.0	-	-	-	60.0	-	-	-	-	4
Buchanan 1999 (423)	US	Los Angeles County and University of Southern California Women's Hospital	1993–1995	Median: 1.3, range: 0.9–2.2	<3	Glycaemic test	L	Glycaemic test	H	103	26	25.2	30.7	32.0	0.0	-	29.5	31.5	-	-	-	-	-	3
Carr 2006 (225)	US	GENetics of Non-Insulin dependent Diabetes (GENNID) study	1993–2001	Mean: 29.9, range 1.2–74.0	≥12	Self-report	C	Glycaemic test	H	332	310	93.4	18.7	48.6	25.0	-	-	34.4	100.0	662	419	63.3	1.5	4
Reed 2002 (424)	US	Yakima Valley Farm Workers Clinics, Washington	1994–2000	Median: 2.3, range 0.2–7.0	<3	MR (hospital)	H	MR (hospital)	H	90	14	15.6	30.8	33.1	0.0	-	-	-	48.9	-	-	-	-	3
Retnakaran 2017 (425)	Canada	Ministry of Health and Long-Term Care of Ontario	1994–2014	Median 10.0	9–11.9	MR (hospital)	C	MR (registry)	C	56,884	15,585	27.4	32.0	42.0	≥50	-	-	-	-	1,458,195	49,397	3.4	8.1	4
Ferrara 2009 (152)*	US	Translating Research Into Action for Diabetes (TRIAD)	1995–2006	Range: 0.1–1.0	<3	MR (registry)	L	MR (registry)	H	5,524	191	3.5	32.3	32.9	28.0	40.4	-	-	-	-	-	-	-	3
Aroda 2015 (164)**	US	Diabetes Prevention Program Outcomes Study (DPPOS)	1996–1999	Mean: 12.0	≥12	Self-report	C	Glycaemic test	H	100	65	65.0	31.3	43.3	54.0	-	-	34.2	-	424	212	50.0	1.3	5
Kaul 2015 (231)	Canada	Alberta Perinatal Health Program (APHP)	1999–2010	Mean: 5.3	3–5.9	MR (registry)	H	MR (registry)	C	8,731	1,882	21.6	31.8	37.1	70.3	-	-	-	-	231,352	3,196	1.4	15.6	5
Lo 2017 (426)	US	Kaiser Permanente Northern California (KPNC)	2002–2005	5.0	3–5.9	MR (hospital)	H	MR (hospital)	H	186	25	13.4	33.2	38.2	30.7	-	32.4	-	64.6	-	-	-	-	3

Varner 2017 (427)	US	Eunice Kennedy Shriver National Institute of Child Health and Human Development trial	2002–2007	Median: 7.2, range 5.0–10.0	6–8.9	Glycaemic test	H	Glycaemic test	H	426	34	8.0	29.0	36.2	31.2	28.6	-	28.6	-	-	-	-	-	3
Khan 2017 (428)	Canada	Institute for Clinical Evaluative Sciences, Ontario	2002–2014	Median: 4.0, range 1.7–7.1	3–5.9	MR (registry)	C	MR (registry)	C	40,902	7,461	18.2	37.0	41.0	8.5	25.1	-	-	-	-	-	-	-	2
Mercier 2019 (429)	Canada	Régie de l'assurance maladie du Québec	2003–2013	Mean±SD: 5.9±3.0	3–5.9	MR (hospital)	H	Glycaemic test	H	281	30	10.7	37.3	43.2	<50	-	-	27.4	-	-	-	-	-	5
Bernstein 2017 (430)	US	OptumLabs Data Warehouse (OLDW)	2006–2012	3.0	3–5.9	MR (other)	C	MR (other)	C	12,622	957	7.6	30.3	33.3	67.4	-	-	-	-	-	-	-	-	3
Casagrande 2018 (431)	US	National Health and Nutrition Examination Survey (NHANES)	2007–2014	Mean: 17.8, median: 16.0	≥12	Self-report	C	Self-report or other	C	568	112	19.7	-	-	66.2	-	-	-	60.5	-	-	-	-	3
Gunderson 2015 (432)	US	Study of Women, Infant Feeding, and Type 2 diabetes mellitus after GD pregnancy (SWIFT), Kaiser Permanente Northern California hospitals	2008–2011	2.0, median: 1.8, range 0.2–2.6	<3	MR (hospital)	H	Glycaemic test	H	959	113	11.8	33.3	33.4	23.6	36.4	-	-	50.0	-	-	-	-	4
Metzger 1993 (433)	US	Northwestern University Diabetes in Pregnancy Center, Chicago	-	5.0	3–5.9	Glycaemic test	L	Glycaemic test	L	172	48	27.9	26.8	31.8	23.7	-	-	-	-	-	-	-	-	4
Nelson 2008 (434)	US	Harbor-UCLA Medical Center, California	-	Up to 2.0	<3	MR (hospital)	L	MR (registry)	H	188	88	46.8	31.7	-	<50	-	-	30.2	-	-	-	-	-	2
Kramer 2014 (435)	Canada	Mount Sinai Hospital, Toronto	-	3.0	3–5.9	Glycaemic test	L	Glycaemic test	H	105	5	4.8	35.3	38.3	65.7	50.5	25.0	25.4	59.1	172	3	1.7	2.7	4
Sodhi 2018 (436)	US	Harbor-UCLA Medical Center, California	-	1.0	<3	MR (hospital)	L	MR (hospital)	H	151	28	18.5	-	-	<50	-	-	-	-	-	-	-	-	3
Western Pacific																								
Lee 1994 (437)	Hong Kong	Tsan Yuk Hospital and Kwong Wah Hospital	1986–1986	Mean: 6.0	6–8.9	MR (hospital)	L	Glycaemic test	L	193	18	9.3	31.0	37.0	0.0	-	-	24.7	-	58	3	5.2	1.8	4
Cho 2006 (438)	South Korea	Four major hospitals	1995–1997	6.0, mean±SD: 2.1±1.8	<3	MR (registry)	L	Glycaemic test	L	909	116	12.8	31.2	33.3	0.0	38.8	-	23.4	43.0	-	-	-	-	4
Kwak 2013 (439)	South Korea	Cheil General Hospital, Seoul	1996–2003	Median 4.1	3–5.9	Glycaemic test	L	Glycaemic test	H	475	193	40.6	31.8	35.8	<50	-	22.5	-	40.8	-	-	-	-	4

Ho 2006 (440)	Taiwan	Medical center, Taipei City	1998–2002	Range: 2.0–6.0	3–5.9	MR (hospital)	L	Glycaemic test	H	152	15	9.9	-	-	<50	42.8	-	-	52.6	-	-	-	-	3
Wanthong 2017 (441)	Thailand	Siriraj Hospital, Bangkok	2001–2011	Mean±SD: 3.8±2.3, range 0.5–10.0	3–5.9	MR (hospital)	L	Glycaemic test	H	100	38	38.0	34.3	38.5	0.0	-	24.6	-	51.0	-	-	-	-	5
Kugishima 2018 (442)	Japan	National Hospital Organization Nagasaki Medical Center, Omura	2003–2014	Mean±SD: 1.3±1.2, range 0.1–5.6	<3	MR (hospital)	H	MR (hospital)	H	306	32	10.5	33.0	34.3	0.0	44.0	23.5	-	41.0	-	-	-	-	5
Han 2018 (443)	South Korea	National Health Insurance Service (NHIS) database	2004–2005	10.0	9–11.9	MR (other)	C	MR (other)	H	4,970	470	9.5	28.3	38.3	0.0	100.0	21.0	-	-	97,930	5,147	5.3	1.8	4
Oh 2019 (444)	South Korea	Seoul National University Bundang Hospital, Seongnam	2004–2006	Mean±SD: 5.2±1.7	3–5.9	Glycaemic test	H	Glycaemic test	H	146	38	26.0	32.3	37.6	0.0	-	22.3	22.7	43.0	-	-	-	-	5
Yang 2014 (445)	South Korea	Korea National Diabetes Program Study	2005–2010	Mean±SD: 1.3±0.2	<3	Glycaemic test	H	Glycaemic test	H	116	8	6.9	33.9	35.2	<50	-	-	26.7	-	-	-	-	-	4
Mai 2015 (446)	China	Guangdong Women and Children Hospital, Guangzhou	2009–2013	Mean±SD: 1.4±0.8	<3	MR (hospital)	H	Glycaemic test	H	453	24	5.3	-	-	0.0	-	-	-	-	1,180	0	0.0	-	3
Chew 2012 (447)	Malaysia	University Malaya Medical Centre (UMMC), Kuala Lumpur	-	Mean: 6.7, range: 0.3–15.0	6–8.9	MR (hospital)	L	Glycaemic test	H	448	159	35.5	38.5	45.1	0.0	-	-	-	60.8	-	-	-	-	3
Lin 2016 (448)	Taiwan	Medical center	-	Up to 9.0	3–5.9	MR (hospital)	L	MR (hospital)	H	71	29	40.8	32.0	-	0.0	53.5	24.9	-	74.5	-	-	-	-	4
Inoue 2018 (449)	Japan	Chiba University Hospital, Chiba	-	2.0	<3	MR (hospital)	H	MR (hospital)	H	77	17	22.1	34.6	36.6	0.0	-	23.9	-	42.3	-	-	-	-	4
Multiple																								
Lowe 2018 (450)	Multiple	Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study	2013–2016	Median: 11.4, range 10.0–14.0	9–11.9	Glycaemic test	H	Glycaemic test	H	663	71	10.7	32.2	43.6	40.2	43.0	-	28.9	53.9	3,946	63	1.6	6.7	4

Ordered by date of pregnancy within each region. Duration of follow-up is planned follow-up unless otherwise specified (e.g. mean).

[*]Practices were part of TRIAD intervention but participants were comparable to the rest of the region; [**]Only control arm included due to significant effect of intervention on diabetes incidence; [***]Intervention and control arms included as no significant effect of intervention on diabetes incidence.

-: not reported; C: clinical GD/T2D diagnosis; H: high sensitivity GD/T2D diagnosis; L: low sensitivity GD/T2D diagnosis; MR: medical records; QA: quality assessment; RR: relative risk of T2D; SD: standard deviation.

Appendix 6: The association between pregnancy and practice-related factors and postpartum diabetes screening (by OGTT or HbA_{1c} testing) in women with a history of gestational diabetes.

	OGTT						HbA_{1c} test					
	Univariable			Multivariable			Univariable			Multivariable		
	N	OR [95% CI]	P	N	OR [95% CI]	P	N	OR [95% CI]	P	N	OR [95% CI]	P
Personal and pregnancy characteristics												
Maternal age (years)	553	1.02 [0.99–1.06]	0.180	362	1.00 [0.95–1.05]	0.857	553	1.00 [0.96–1.04]	0.948	362	0.98 [0.93–1.03]	0.349
IMD decile[1] (1, most deprived, to 10)	532	1.07 [0.99–1.16]	0.107	362	0.95 [0.84–1.07]	0.422	532	1.04 [0.94–1.16]	0.434	362	1.07 [0.94–1.22]	0.319
Parity	553	0.72 [0.61–0.85]	<0.001*	362	0.69 [0.54–0.87]	0.002*	553	1.04 [0.87–1.25]	0.650	362	1.04 [0.82–1.32]	0.742
Pre-pregnancy weight (kg)	430	0.97 [0.96–0.98]	<0.001*				430	1.00 [0.99–1.01]	0.935			
Pre-pregnancy BMI (kg/m^2)	429	0.93 [0.90–0.96]	<0.001*	362	0.93 [0.89–0.96]	<0.001*	429	1.01 [0.98–1.04]	0.665	362	1.01 [0.97–1.05]	0.630
Premature birth (<37 weeks)	482	0.77 [0.38–1.53]	0.450				482	0.55 [0.23–1.31]	0.178			
Gestational weight gain (kg)	366	1.02 [0.98–1.06]	0.365				366	1.00 [0.96–1.04]	0.964			
Caesarean	489	0.99 [0.66–1.48]	0.953				489	0.94 [0.61–1.45]	0.795			
Birthweight z-score	481	0.96 [0.79–1.17]	0.699	362	1.11 [0.86–1.44]	0.408	481	1.05 [0.85–1.29]	0.676	362	0.99 [0.77–1.28]	0.942
Baby's gender (girl)	493	0.85 [0.57–1.26]	0.416				493	1.47 [0.96–2.25]	0.079			
GD diagnosis												
First OGTT before 22 weeks gestation	555	0.63 [0.36–1.12]	0.116	362	0.62 [0.26–1.47]	0.278	555	1.04 [0.52–2.07]	0.907	362	1.30 [0.56–3.04]	0.543
FPG at diagnosis (mmol/l)	554	0.68 [0.53–0.86]	0.002*	362	0.77 [0.52–1.13]	0.180	554	1.06 [0.82–1.39]	0.644	362	1.11 [0.75–1.64]	0.599
120 min plasma glucose at diagnosis (mmol/l)	555	1.07 [0.96–1.18]	0.239				555	1.04 [0.92–1.17]	0.518			
HbA_{1c} at diagnosis (mmol/mol)	497	0.95 [0.91–0.98]	0.004*				497	1.04 [1.00–1.09]	0.044*			
GD treatment by or at 36 weeks gestation	556	1.03 [0.72–1.47]	0.862	362	2.38 [1.31–4.33]	0.004*	556	1.37 [0.91–2.08]	0.134	362	1.23 [0.69–2.21]	0.478
Insulin	556	0.97 [0.68–1.39]	0.873				556	1.55 [1.03–2.34]	0.037*			
Metformin	556	0.93 [0.62–1.40]	0.728				556	0.90 [0.55–1.45]	0.659			
Practice characteristics and performance[2]												
Number of registered patients (per 1000)	555	0.98 [0.94–1.02]	0.346				555	0.94 [0.87–1.00]	0.054			
Practice IMD score[1] (range 3 to 66, most deprived)	555	0.97 [0.94–1.01]	0.123				555	0.94 [0.88–1.00]	0.060			
Total QOF score	555	1.01 [0.95–1.08]	0.701				555	0.98 [0.89–1.07]	0.615			
Percentage recommending practice	555	1.02 [1.00–1.03]	0.058	362	1.02 [1.00–1.05]	0.062	555	1.04 [1.01–1.08]	0.006*	362	1.05 [1.02–1.09]	0.005*

Percentage with blood test[3]	522	1.06 [0.97–1.16]	0.178				522	1.18 [1.02–1.38]	0.026*			
Percentage with foot examination[3]	555	1.02 [1.00–1.04]	0.084	362	1.00 [0.97–1.04]	0.885	555	1.05 [1.01–1.10]	0.012*	362	1.01 [0.97–1.06]	0.546
Percentage with HbA_{1c} <59 mmol/mol (7.5%)[3]	555	1.01 [0.98–1.04]	0.497				555	1.07 [1.01–1.12]	0.011*			
Percentage referred for education[3]	555	1.00 [1.00–1.01]	0.289				555	0.99 [0.98–1.01]	0.372			

All regressions are adjusted for clustering by practice. The multivariable regression considered all variables for which an outcome is reported.

[1] IMD is weighted and considers income, employment, education, skills and training, health and disability, and living environment deprivation, crime, and barriers to housing and services. [2] See Table 3.4 and https://fingertips.phe.org.uk/profile/general-practice for full definitions. [3] Percentage of diabetic patients with measure.

95% CI: 95% confidence interval; BMI: body mass index; IMD: Index of Multiple Deprivation; N: number of participants; OGTT: oral glucose tolerance test; QOF: Quality and Outcomes Framework; OR: odds ratio.

Appendix 7: Characteristics of the studies included in the qualitative synthesis of diabetes screening after gestational diabetes.

Study (first author and year)	Sample size (n screened)	Setting (country)	Screening considered	Study aim(s) relevant to this analysis	Recruitment method	Participant inclusion criteria	Method of data collection	Time of data collection[1]	CASP rating (/10)
Soares 2006 (253)	56 (unclear)	Brazil	First postpartum programme visit (up to 60 days)	Discuss prevention of T2D after GD	Women who were part of a hospital-based diabetes care programme	hGD 1997–2003, controlled fasting glycaemia >95 mg/dL during gestation or >2 T2D risk factors, live in Metropolitan Region of Belo Horizonte	Interviews	3–9 years postpartum	3.5
Bennett 2011 (255)	22 (6)	US	First postpartum OGTT	Explore experiences, perspectives, and perceived barriers to and facilitators of postpartum follow-up care after GD	Consecutive sampling of women in third trimester from high-risk obstetric clinic	hGD, English-speaking, insurance coverage during and beyond postpartum visit	Face-to-face and telephone interviews	6–8 weeks postpartum	8.5
Sterne 2011 (254)	88 (47)	Australia	First postpartum OGTT	Examine barriers, facilitators and potential facilitators to attendance at postpartum diabetes screening after recent GD	Identified from a hospital database	GD outpatient care at Logan Hospital, Meadowbrook, Queensland 2006–2007, ≥18 years old, no history of T1D or T2D	Telephone interviews	~1.5–3 years postpartum	5.5
Lie 2013 (256)	35 (NR)	UK	First postpartum OGTT and annual testing	Explore views on postnatal lifestyle change to prevent T2D to inform development of intervention approaches	Purposive then theoretical sampling (contacted by diabetes obstetric clinic staff while attending appointments or from hospital records)	hGD within 2 years, English-speaking, ≥16 years old, successful pregnancy outcome, received antenatal care at specified sites, able to consent	Face-to-face interviews	Within 2 years postpartum	8.0
Abraham 2014 (257)	10 (3)	US	General screening after GD	Explore lived experiences of women in rural communities with GD and gain insight into low screening rates	Purposive sampling and a snowball approach via obstetric and healthcare-provider offices	hGD within 5 years, ≥18 years, reside in a county eligible for rural community grants, not since developed T2D	Interviews (face-to-face and telephone)	Between 2 and 5 years	7.0

Morrison 2014 (252)	393 (NR)	Australia	General screening after GD	Describe reflections on the experience of GD-pregnancy	Identified from NDSS database and contacted by mail	hGD within 3 years, ≥18 years old at time of registration, not residing in a Queensland postcode[2]	Questionnaire with free text open-ended questions	Within 3 years postpartum (mean 1.8±0.7)	6.5
Paez 2014 (258)	22 (17)	US	First postpartum OGTT/FPG and annual testing	Explore what helps and hinders diabetes testing after GD	Women not tested and those that were tested as part of ADAPT, recruited from a multispecialty group medical practice after a GD pregnancy from medical records	GD in most recent pregnancy, ≥18 years old, patients of HVMA, no history of T1D or T2D, internet/telephone access, no significant mental health disorders, physician approved participation	Survey and telephone interviews	6 months–4.5 years postpartum	8.0
Kilgour 2015 (259)	13 (7)	Australia	First postpartum OGTT	To explore and assess women's communication experiences of postnatal GD follow-up, and interpret them with CAT	Theoretical sampling from clinics and wards at a major maternity tertiary referral hospital	hGD, shared maternity care	Face-to-face[3] interviews	12–16 weeks postpartum	9.0
Nielsen 2015 (260)	7 (7)	Denmark	General screening after GD	Understand experience of GD care and how this influenced participation in follow-up screening	Random selection of women with previous GD eligible at Aalborg University Hospital	hGD 2010–2012, first GD pregnancy, representative of the hospital registered population	Face-to-face interviews	1–2 years postpartum	10.0
Bernstein 2016 (261)	27 (NR)	US	General screening after GD	Barriers and facilitators to testing and referral to testing (four domains: intervention attributes, individual characteristics, inner context and outer context)	Convenience sample of women in an urban safety net hospital in third trimester	In third trimester of a GD pregnancy	Face-to-face interviews	10–14 weeks postpartum	6.5

Campbell 2017 (262)	7 (NR)	Australia	General screening after GD	Enablers and barriers influencing screening after GD in Australian Indigenous women and how screening might be improved	Recruited by health service staff and project flyers in waiting area of health service	hGD, Indigenous	Face-to-face interviews	<5 years for 4 women, >5 years for 3 women	9.0
Pennington 2017 (263)	16 (NR)	Australia	General screening after GD	Investigate factors influencing engagement with diabetes preventative care (barriers and enablers)	Purposive sampling (approached or advertisements at general practices and MCHN centres)	hGD	Face-to-face and telephone interviews	NR	8.0
Rafii 2017 a and b (250,251)	22 (unclear[4])	Iran	First postpartum OGTT/FPG	Explore Iranian women's experiences of on obstacles of postpartum diabetes screening	Purposeful then theoretical sampling from (governmental and private) hospital records after GD	GD diagnosis by hospital records, delivered >6 months before interview	Face-to-face interviews	Mean 11.9 ± 4.8 months postpartum	7.5 and 9.5, respe-ctively
Svensson 2017 (264)	5 (NR)	Denmark	General screening after GD	Examine the experience of transition from a GD-affected pregnancy to postpartum	Random sampling (sent invitation letters via the hospital patient registry and telephoned)	hGD, recently delivered at the hospital	Face-to-face interviews	Between 3 and 5 months postpartum	7.5
Zulfiqar 2017 (265)	23 (unclear[5])	Australia	First postpartum OGTT and annual testing	Explore barriers and facilitators to following long-term healthy lifestyle recommendations, and whether there were differences between overseas-born- and Australian-born-women	Women managed by a hospital DIP Service who attended a GD-related health education programme	hGD, English-speaking, live singleton delivery, not pregnant or since developed T2D	Face-to-face interviews	More than 3 years postpartum	7.5

[1] In reference to/since GD pregnancy; studies collected data once postpartum unless otherwise specified; [2] Due to a concurrent study; [3] Face-to-face interview is implied; [4] Rafii 2017a reported 10/22 while Rafii 2017b reported 11/22 attended screening; [5] 'Almost all' had 6 weeks, 'most' had first year, 'few' had second year tests.

ADAPT: Avoiding Diabetes After Pregnancy Trial; CASP: Critical Appraisal Skills Programme checklist; DIP: diabetes in pregnancy; FPG: fasting plasma glucose; (h)GD: (history of) gestational diabetes; HVMA: Harvard Vanguard Medical Associates; MCHN: maternal and child health nurse centres; NDSS: National Diabetes Service Scheme; OGTT: oral glucose tolerance test; T1D: type 1 diabetes.

Appendix 8: GRADE-CERQual qualitative evidence profile of recommendations for promoting attendance at diabetes screening after gestational diabetes.

Objective: To systematically synthesise the literature focussing on the views of women with a history of GD on attendance at postpartum glucose testing							
Perspective: Views, experiences and ideas of any women who have had GD during any previous pregnancy							
Included studies: Studies that examine women's postpartum experiences following GD relating to attendance at postpartum glucose testing							
Review recommendation	**Studies directly contributing to the recommendation**	**Assessment of methodological limitations**	**Assessment of relevance**	**Assessment of coherence**	**Assessment of adequacy**	**Overall CERQual confidence assessment**	**Explanation of CERQual assessment**
Relationship with healthcare							
1. Educate clinicians to, and how to, promote screening throughout GD and subsequent care	Abraham, Campbell, Kilgour, Lie, Morrison, Nielsen, Paez, Rafii a, Sterne, Svensson, Zulfiqar	Minor concerns: the highest quality studies contributed most to informing this recommendation	Minor concerns: these findings addressed attitudes towards screening (rather than general healthcare seeking, which was also sometimes considered)	Minor concerns: for many participants, clinicians played the key part in forming views toward screening	Minor concerns: several studies discussed in detail how women interpreted (lack of) information and others more briefly mentioned this idea	**High confidence**	Lack of information (during pregnancy and postpartum) and seemingly conflicting advice about postpartum screening from clinicians were clearly reported, while the opposite encouraged screening
2. Implement recall systems for postpartum testing from general practice or obstetric care, and send reminders to non-responders/for	Kilgour, Lie, Nielsen, Paez, Pennington, Rafii a, Rafii b, Sterne, Zulfiqar	Minor concerns: the highest quality studies contributed most to informing this recommendation	No or very minor concerns: these findings clearly addressed attitudes towards arranging the screening test (rather than general healthcare seeking, which was	Minor concerns: invitations from clinicians were reported positively; participants wanted reminders; many took control of arranging	Minor concerns: several studies discussed arranging tests: the majority discussed difficulties when they didn't receive support but some discussed	**High confidence**	Benefits or anticipated benefits of invitations and reminders were reported in many studies

missed appointments			also sometimes considered)	tests but reported this negatively	invitations and reminders helping		
3. Establish standard protocols for communicating gestational diabetes history within the healthcare system	Bennett, Bernstein, Campbell, Kilgour, Nielsen, Svensson	Minor concerns: four high and two good quality studies contributed to this recommendation; two studies considered the researcher-participant relationship so this may have influenced the discussion about the healthcare system in the others	Minor concerns: these findings were relevant to postpartum follow-up including screening	Moderate concerns: six studies clearly discussed fragmented care and women as information brokers, which lead to postpartum abandonment and getting lost between specialities; one explained how this discouraged screening attendance	Moderate concerns: data regarding women's discussion of continuity of care were rich but explanations on the consequences for screening were sparse	**Moderate confidence**	There was a clear need to ensure sharing of patient history within the healthcare system, which would improve follow-up care; one benefit may be improved screening uptake
4. Promote patient-centred approaches to care in order to facilitate building relationships and opportunities to ask questions	Links to healthcare provision in general; specifically Abraham, Bennett, Campbell, Kilgour, Nielsen	No or very minor concerns: the studies that directly contributed to this recommendation were the highest quality	Minor concerns: these findings were relevant to postpartum follow-up including screening	Moderate concerns: it is clear and logical that patient-centred care improves healthcare experience but less clear from these studies that screening attendance would increase as a result	Moderate concerns: few studies contributed directly to this recommendation, however, all of the studies that discuss the healthcare system inform patient-centred care in some way	**Moderate confidence**	Improving experience of care would make it more pleasant and may improve screening attendance (directly or indirectly)
The appointment and test							
5. Make clinics more child and nursing-friendly, and encourage mothers to bring children to appointments	Bennett, Kilgour, Paez, Rafii a, Sterne	Moderate concerns: four studies were very high quality but Sterne contributed most to this theme and had many methodological limitations	Minor concerns: these findings were relevant to postpartum follow-up and screening appointments	Moderate concerns: it was clear that many women did not consider taking the baby to the appointment so struggled to go if they couldn't find childcare; some participants suggested	Moderate concerns: data about the need for childcare were rich, but there were fewer data about changing clinic environments and bringing children	**Moderate confidence**	It is clear that clinics/long appointments are not considered suitable places to bring children but how to improve this was

				improving clinic environments			rarely discussed in the studies
6. Seek innovative, personalised options to make it easier for hard-to-reach women to attend testing (eg. drop-ins, alternative locations)	Bennett, Bernstein, Campbell, Paez, Rafii a, Rafii b, Sterne	Minor concerns: several high quality studies contributed most to informing this recommendation	Minor concerns: these findings were relevant to postpartum follow-up and screening appointments	Moderate concerns: how easy/convenient it was to attend the test affected uptake, highlighting this as an area for improvement; one study suggesting home testing	Moderate concerns: data about the inconvenience of testing were rich but how to improve it was rarely reported	**Moderate confidence**	Too inconvenient appointments discouraged testing but the studies did not clearly suggest alternatives
7. Utilise more pleasant, less time-consuming testing procedures and protocols	Bernstein, Paez, Pennington, Rafii a, Sterne	Moderate/minor concerns: two of the five studies contributing to this theme were low quality but this is not expected to have a large impact on this recommendation	No or very minor concerns: these findings clearly addressed attitudes towards arranging the screening test	Moderate concerns: the need to fast, drink a glucose drink and wait were clear barriers to the OGTT and alternative tests were suggested, but no studies showed increased attendance using alternative tests	Minor concerns: the data provide a clear understanding of how OGTTs discourage attendance	**Moderate confidence**	OGTTs discourage screening; a shorter test without fasting or a glucose drink is desired and may increase uptake
Family-related practicalities							
8. Schedule postpartum glucose testing to coincide with other postpartum check-ups (both mothers' and children's appointments)	Links to inconvenience of appointments and motivation in general; specifically Bennett, Nielsen, Rafii a, Rafii b	No or very minor concerns: the studies that directly contributed to this recommendation were the highest quality	No or very minor concerns: these findings clearly addressed attitudes towards screening and arranging the test	Moderate concerns: participants attended appointments for other reasons (eg. for vaccinations or to discuss contraception) and Rafii b describes 'accidental screening', therefore we only assume that combined appointments are more convenient and worth attending	Major concerns: only a few studies contributed to this theme, plus general inconvenience of appointments and motivation to attend	**Low confidence**	Glucose tests were difficult to attend; it is assumed that combing them with appointments that women are more motivated to attend would facilitate attendance

Concern about diabetes							
9. Educate women about the purpose of screening and how the procedure works	Abraham, Bennett, Bernstein, Campbell, Kilgour, Lie, Nielsen, Paez, Rafii a, Rafii b, Sterne, Zulfiqar	Minor concerns: mostly high quality studies contributed to this recommendation	Minor concerns: these findings showed that apathy and fear of diagnosis acted as a barrier to screening and understanding the need for screening as a facilitator to screening attendance specifically	Minor concerns: findings show that knowledge about the purpose of screening increased attendance and so it is clear and logical that education of women on the purpose of screening should increase attendance	Minor concerns: several studies discuss the themes contributing to this recommendation in detail	**High confidence**	Often knowledge of the purpose of screening increased attendance; apathy and fear of diagnosis were barriers but could be reduced through education
10. Educate women that postpartum self-testing, behaviour compliance or one negative test result is not sufficient to rule out T2D in the long term	Bennett, Bernstein, Kilgour, Lie, Nielsen, Paez, Rafii a, Rafii b	Minor concerns: mostly high quality studies contributed to this recommendation	Minor concerns: these findings were relevant predominantly to postpartum screening, but did include other aspects of post-partum behaviour such as diet	Minor concerns: use of glucometer postpartum consistently discouraged screening attendance in these studies	Moderate concerns: four of the studies discuss the impact of self-testing on screening attendance whilst remaining have sparse findings addressing role of reassurance of postpartum readings and test results generally	**Moderate confidence**	Many studies explored how postpartum self-testing influenced concern about diabetes; education that this is not sufficient to rule out diabetes could increase screening attendance

Recommendations frequently result from findings within multiple themes but have been presented under the primary contributing theme. Only studies directly contributing to the recommendation have been cited.

Appendix 9: Characteristics of the studies included in the qualitative synthesis of healthy lifestyle after gestational diabetes.

Study (first author and year)	Sample size	Setting (country)	Study aim(s) relevant to this analysis	Recruitment method	Participant inclusion criteria	Method of data collection	Time of data collection[1]	CASP rating (/10)
Graco 2009 (282)	10	Australia	Explore perceptions of PA among women with previous GD, in context of T2D prevention	Purposive sampling (adverts at maternal and child health centres)	hGD, English-speaking, ≥18 years old, resident in selected area, not pregnant or since developed T2D	Interviews (not specified)	NR	8.0
Doran 2010 (277)	11	Tonga	Explore how GD diagnosis influenced change in diet and PA, influencing factors and support of sustained change	Purposive sampling (hospital records)	hGD within 1 year, delivered baby at the recruiting hospital	Interviews (face-to-face)	Within 1 year	7.0
Evans 2010 (283)	16	Canada	Determine perceived health status and experiences in establishing and maintaining healthy lifestyle changes	Purposive sampling (GD clinic)	hGD, English-speaking, in the final trimester of pregnancy, telephone access	Interviews (not specified)	At 6 weeks, 3 and 6 months, and 1 year	8.5
Lindmark 2010 (284)	10	Sweden	Investigate perceptions about lifestyle	Recruited from outpatient endocrinology hospital clinic by mailout	hGD within 1 year, Swedish-speaking, 30–40 years old, no other known diseases	Interviews (face-to-face)	At 1 year	8.5
Razee 2010 (285)	57	Australia	Explore beliefs, attitudes, social support, environmental influences etc. on diabetes risk behaviours; preferred forms of program deliv-ery to inform health promotion	Purposive sampling (GD hospital clinic databases via letter)	hGD within 6–36 months, Cantonese-, Mandarin-, Arabic- or English-speaking, not pregnant or since developed T2D	Interviews (telephone)	Between 6 months and 3 years	8.0
Bandyopad-hyay 2011 (278)	17	Australia	Explore understanding of T2D risk, risk reduction, management strategies, and attitudes and behaviour	Immigrant South Asian women recruited from GD clinic after diagnosis	hGD, ≥18 years old, Hindi-, Bengali- or English-speaking	Interviews (face-to-face)	At 6 weeks[2]	8.0

Nicklas 2011 (279)	25	US	Identify barriers and facilitators to healthy lifestyle changes, and approaches to facilitate participation in interventions	Recruited through flyers and internet postings	hGD within 7 years, 18–50 years old, English-speaking, not since developed T2D	Interviews (telephone) and focus groups	Within 7 years	8.5
Gaudreau 2012 (280)	7	Canada	Understand cultural factors contributing to maintenance of health behaviours encouraged during GD pregnancy	Recruited by general informants contacts	hGD within 2–10 years, ≥18 years old, Algonquin peoples, GD/health care in Algonquin community, not breastfeeding or pregnant	Ethnography (observations and interviews)	Between 2 and 10 years	8.5
Hjelm 2012 (286)	14	Sweden	Explore beliefs about health, illness and healthcare and study their influence on self-care and care seeking	Consecutive sampling (women born in the Midd-le East living in Sweden recruited by staff at hosp-ital-based specialist clinic)	hGD, ≥16 years old	Interviews (face-to-face)	At 3 and 14 months[2]	9.5
Jones 2012 (287)	17	US	Describe knowledge, perceptions and self-efficacy beliefs related to preventing cardiometabolic disease	Purposeful and snowball sampling (through fliers distributed by tribal health system care staff)	hGD, self-identify as American Indian, 19–45 years old, not pregnant or within 6 weeks postpartum (including 3 with T2D)	Interviews (not specified)	NR	8.0
Dasgupta 2013 (281)	29	Canada	Identify factors that could enhance participation and engagement in a T2D prevention program	Recruited from GD clinic via letter from physician (structured recruitment strategy)	hGD, English- or French-speaking, not pregnant or since developed T2D	Focus groups	Within 5 years	9.0
Lie 2013 (256)	35	UK	Explore views on postnatal lifestyle change to prevent T2D to inform development of intervention approaches	Purposive then theoretical sampling (diabetes obstetric service contacted by clinic staff while attending appointments or from hospital records)	hGD within 2 years, English-speaking, ≥16 years old, successful pregnancy outcome, received antenatal care at specified sites, able to consent	Interviews (face-to-face)	Within 2 years then between 12 and 18 months later	8.5

Abraham 2014 (257)	10	US	Explore lived experiences of women in rural communities with GD	Purposive sampling and a snowball approach via obstetric and healthcare-provider offices	hGD within 5 years, ≥18 years, reside in a county eligible for rural community grants, not since developed T2D	Interviews (face-to-face and telephone)	Between 2 and 5 years	8.0
Morrison 2014 (252)	393	Australia	Describe reflections on the experience of GD-pregnancy	Australian women recruit-ed from the NDSS databa-se for cross sectional survey by mailout	hGD within 3 years, ≥18 years old at time of registration, not residing in a Queensland postcode[3]	Open-ended survey	At 3 years	7.0
Jones 2015 (288)	26	US	Elicit women's perspectives on cardiometabolic risk reduction behaviours to inform the development of a postpartum lifestyle modification intervention	Contact study team after advertising study through fliers and business card distribution at the CNDH	hGD within 10 years, self-identify as American Indian, 19–45 years old, health care through CNDH	Interviews (face-to-face and telephone) and focus groups	Within 10 years (1 or 2 interviews)	8.5
O'Dea 2015 (289)	17	Ireland	Evaluate a lifestyle intervention programme (give context to quantitative findings)	Women identified from the Atlantic DIP research data-base and Galway Universi-ty Hospital Group pregna-ncy service contacted by letters and telephone	hGD within 1–3 years, English-speaking, not pregnant or since developed T2D (randomised to the trial intervention arm)	Interviews (face-to-face)	Between 1 and 3 years	7.5
Tang 2014 (290)	23	US	Explore T2D risk perception and motivators and barriers to preventive health behaviours, to inform intervention approaches	Purposive sampling (Afric-an American, Hispanic, non-Hispanic White wom-en recruited from hospital-affiliated academic clinics via telephone call from researcher or response to flyer)	hGD within 1 year, English- or Spanish-speaking, no pre-existing diabetes or since developed T2D	Interviews (face-to-face)	Within 1 year	8.5

Lim 2017 (291)	165	Australia	Explore the acceptability of a diabetes prevention program and compare the characteristics associated with program engagement	Women enrolled in the MAGDA trial	hGD in most recent pregnancy, English-speaking, not pregnant, with pre-existing T2D or other severe illness	Interviews (face-to-face and telephone)	NR (1 or 2 interviews)	8.5
Pennington 2017 (263)	16	Australia	Investigate factors influencing engagement with diabetes preventative care (barriers and enablers), the GP's role in care	Purposive sampling (approached or advertise-ments at general practices and MCHN centres)	hGD	Interviews (face-to-face and telephone)	NR	8.5
Svensson 2017 (264)	5	Denmark	Examine the experience of transition from a GD-affected pregnancy to postpartum	Random sampling (sent invitation letters via the hospital patient registry and telephoned)	hGD, recently delivered at the hospital	Interviews (face-to-face)	Between 3 and 5 months	8.0
Zulfiqar 2017 (265)	23	Australia	Explore barriers and facilitators to following long-term healthy lifestyle recommendations, and whether there were differences between overseas-born- and Australian-born-women	Women managed by a hospital DIP Service who attended a GD-related health education programme	hGD, English-speaking, live singleton delivery, not pregnant or since developed T2D	Interviews (face-to-face)	More than 3 years	8.5

[1] In reference to/since gestational diabetes-affected pregnancy; studies collected data once postpartum unless otherwise specified; [2] Plus 1 during pregnancy; [3] Due to a concurrent study.

CASP: Critical Appraisal Skills Programme checklist (score out of 10); CNDH: Chickasaw Nation Department of Health; DIP: diabetes in pregnancy; (h)GD: (history of) gestational diabetes; MAGDA: Mothers After Gestational Diabetes in Australia; MHCN: maternal and child health nurse centres; NDSS: National Diabetes Service Scheme; NR: not reported; PA: physical activity.

Appendix 10: GRADE-CERQual qualitative evidence profile of recommendations for promoting healthy lifestyles after gestational diabetes.

Objective: To systematically synthesise the literature focussing on the views of women with a history of GD on reducing their risk of developing T2D postpartum

Perspective: Views, experiences and ideas of any women who have had GD during any previous pregnancy

Included studies: Studies that examine women's postpartum experiences following GD relating to lifestyle/behaviour, views on T2D risk management and/or experience of a T2D prevention programme

Review recommendation	Studies directly contributing to the recommendation	Assessment of methodological limitations	Assessment of relevance	Assessment of coherence	Assessment of adequacy	Overall CERQual confidence assessment	Explanation of CERQual assessment
Role as mother and priorities							
1. Highlight the benefits to the family of the mother being healthier and role modelling healthy lifestyle to children as the incentive for change, alongside preventing T2D	Dasgupta, Gaudreau, Hjelm, Jones 2015, O'Dea, Svensson, Tang, Razee	Minor concerns: the role of the researcher was poorly considered and implementation of ethical processes was unclear but this was expected to have little impact on answers to this question	No or very minor concerns: many of these studies are directly relevant	Moderate concerns: women in some studies explicitly reported that their children were their motivation for healthy behaviour, while others reported prioritising their children's health; it is unclear whether this should be encouraged and in all women	Minor concerns: women in some studies explicitly reported that their children were their motivation for healthy behaviour, while others reported prioritising their children's health more generally	**Moderate confidence**	Women directly or indirectly reported that their children were their incentive for change; whether it is appropriate for all should be considered
2. Include the option of childcare in face-to-face interventions if children are not part of the sessions	Dasgupta, Graco, Lim, O'Dea	Minor concerns: some studies had methodological issues but this was expected to have little impact on answers to this question	No or very minor concerns: these studies are directly relevant	No or very minor concerns: offering childcare is recommended by women in multiple studies; this is also supported by a general concern for children and about childcare	Moderate concerns: relatively few studies contribute to this recommendation and it is not reported in large detail	**Moderate confidence**	Few studies contributed to this recommendation but some directly suggested it and it is supported by general concern about children/ childcare

Support from family and friends							
3. Promote healthier lifestyles in the wider family (and friends)	Abraham, Dasgupta, Gaudreau, Jones 2015, Lie, Nicklas, Svensson, Zulfiqar	No or very minor concerns: high quality studies contributed to this recommendation	No or very minor concerns: these studies are directly relevant	Moderate concerns: the studies all report that family must eat the same healthier diets (particularly partners) but exercise and the family was less clearly discussed	Moderate concerns: the link between family and diet is well explained but has been extrapolated to include friends and physical activity	**Moderate confidence**	It is clear that women need support for a healthy diet but few studies clearly discussed family and friends exercising
4. Encourage the wider family (and friends) to promote healthy lifestyles in mothers and support them practically (such as relieving housework burdens)	Abraham, Dasgupta, Gaudreau, Graco, Jones 2015, Lim, Nicklas, O'Dea, Razee, Svensson, Zulfiqar	Minor concerns: none clearly considered the role of the researcher or implementation of ethics but this was expected to have little impact on answers to this question	No or very minor concerns: many of these studies are directly relevant	No or very minor concerns: these studies specifically reported the crucial role of family and friends in behaviour and none of the studies contradicted the others	No or very minor concerns: studies reported that women directly suggested involving partner; benefited from support; struggled because they lacked support; or said that prioritising their partner prevented healthy behaviour	**High confidence**	Many studies explained the benefits of or need for support for lifestyle change
5. Include the family in interventions (eg. information or modules for partners and children)	Abraham, Dasgupta, Nicklas, Zulfiqar	No or very minor concerns: high quality studies contributed to this recommendation	No or very minor concerns: these studies are directly relevant	No or very minor concerns: two studies suggested including family in interventions and the other linked lack of partner attendance at educational sessions (during pregnancy) with lack of postpartum support	Major concerns: only a few studies reported this recommendation, suggesting it as a way of increasing partner support	**Moderate confidence**	Inadequate data reduced our confidence that this recommendation would be useful to postpartum women

6. Encourage and facilitate women to exercise with others/a buddy	Dasgupta, Gaudreau, Graco, Nicklas	Minor concerns: high quality studies contributed to this recommendation, although the role of the researcher was poorly considered	No or very minor concerns: these studies are directly relevant	Moderate concerns: some directly suggested having help to find exercise buddies and others reported benefits of socialising while exercising; in addition to the general need for support	Moderate concerns: the studies that directly contributed to this theme did not report the recommendation in much detail	**Moderate confidence**	This recommendation was developed from the general need for support, plus a few studies that specifically addressed it
Demands of life							
7. Provide guidance about how to buy and prepare healthy, tasty food efficiently	Dasgupta, Evans, Gaudreau, Jones 2012, Jones 2015, Lie, Nicklas, Razee, Zulfiqar	Minor concerns: the role of the researcher was poorly considered and implementation of ethical processes was unclear but this was expected to have little impact on answers to this question	Minor concerns: these studies were generally relevant to the review question	Minor concerns: difficulties in meal planning and preparation were frequently reported, and many said they would like more help and information (eg. suggested recipe books)	Minor concerns: this idea was common across studies although the specifics of implementing this were less clear	**High confidence**	Many women reported the lack of and need for more guidance for having a healthy diet
8. Provide guidance about how to exercise around the house and as part of regular daily routines	Abraham, Bandyopadhyay, Dasgupta, Graco, Jones 2015, Lie, Nicklas, Tang, Zulfiqar	Minor concerns: the role of the researcher was poorly considered and implementation of ethical processes was unclear but this was expected to have little impact on answers to this question; there was agreement between	Minor concerns: these studies were generally relevant to the review question	Moderate concerns: this recommendation was made because time restraints, exhaustion and lack of information were reported to prevent exercise while many reported doing simple exercise in their normal routine; yet others wanted per-	Minor concerns: reasoning behind women's views was well reported and by several studies	**Moderate confidence**	It is clear, and stated, that women need help to increase exercise; however, there is some contradictory suggestions about the best form(s) of exercise to promote and how

		higher and lower-quality studies		sonal trainers or facilities. Some differences may have been due to definitions of exercise			
Personal preferences and experiences							
9. Support women to maintain healthy behaviour/diet in challenging situations – eg. social gatherings, breastfeeding, at work (particularly for vulnerable groups)	Bandyopadhyay, Hjelm, Jones 2012, Nicklas, Razee, Zulfiqar	Moderate concerns: the role of the researcher was poorly considered in these studies, which may have had a small effect on women reporting personally challenging situations	Minor concerns: most of these studies were relevant to this review question; both native and migrant populations were studied	Moderate concerns: it is clear that women struggle to maintain healthy diets in challenging situations but none suggested how to help this	Moderate concerns: although this is reported in several studies, this it is relatively vague and broad	**Low confidence**	Certain situations affect women's ability to maintain healthy diets; the best way to address this is unclear
10. Highlight the wider benefits of healthier lifestyle (such as reducing stress and weight as well as T2D risk)	Bandyopadhyay, Doran, Gaudreau, Graco, Jones 2012, Jones 2015, Morrison, O'Dea, Razee, Svensson, Tang, Zulfiqar	Minor concerns: these studies had variable quality, particularly around the role of the researcher and implementation of ethical processes, but this was expected to have had a small impact on this recommendation	No or very minor concerns: most of these studies are directly relevant	Minor concerns: many studies reported motivation for healthier lifestyle as T2D prevention or weight loss/body image/ enjoyment, and serval reported both	Minor concerns: this was discussed in some detail by many studies	**High confidence**	Women had identified many benefits of adopting healthier lifestyles that helped them to maintain them (perhaps after their awareness of T2D declined over time)
Diabetes risk perception and information							
11. Make information, resources and training easily accessible and make interventions	Abraham, Dasgupta, Doran, Evans, Gaudreau, Graco, Hjelm, Jones 2015, Lie, Morrison,	Minor concerns: there was a range of methodological limitations in these studies, but there is	No or very minor concerns: most of these studies are directly relevant	Minor concerns: many reported lacking knowledge about postpartum behaviour; most of	Minor concerns: this recommendation	**High confidence**	This recommendation resulted from many studies that were in agreement,

available to start immediately after pregnancy (or during pregnancy)	Pennington, Razee, Svensson, Zulfiqar	agreement with high quality ones		these suggested or implied that this should be addressed as early as possible (only Lie reported that an intervention should begin at weaning)	arose from many studies		with few exceptions
12. Ensure that interventions are culturally appropriate and recommendations allow maintenance of women's identity	Bandyopadhyay, Dasgupta, Gaudreau, Jones 2012, Razee, Zulfiqar	Minor concerns: no studies clearly considered the role of the researcher, which may have had implications for this question, but is unlikely	No or very minor concerns: these studies include migrant or ethnic minority populations; most of the studies included that include such populations report this theme	No or very minor concerns: lack of culturally-specific information was reported as a barrier, presence was a facilitator and some reported women wanting more information	Minor concerns: data is rich in many of the studies	**High confidence**	It was clear that women wanted culturally-relevant interventions and that they were beneficial to those who received it
13. Ensure that care providers consider women's attitude towards T2D and advise them on their risk appropriately	Abraham, Bandyopadhyay, Evans, Nicklas, Pennington, Jones 2015, Svensson, Tang, Zulfiqar	Minor concerns: the role of the researcher was poorly considered and implementation of ethical processes was unclear but this was expected to have little impact on answers to this question	No or very minor concerns: most of these studies are directly relevant	Major concerns: this recommendation was based on the finding that women have different attitudes towards T2D (eg. fear or apathy) and some engage or behave differently based on their relationship with clinicians	Major concerns: the studies do not clearly discuss this recommendation	**Low confidence**	This recommendation is a step on from women's attitudes towards behaviour change and their clinician
14. Promote a long-term perspective about maintaining healthy	Bandyopadhyay, Evans, Graco, O'Dea, Zulfiqar	Minor concerns: no studies clearly considered the role	No or very minor concerns: many of these studies are	Minor concerns: women reported that it was hard to	Moderate concerns: this was not consid-	**Moderate confidence**	Paucity of data has reduced our

lifestyle, with an 'every little helps' approach, rather than 'all or nothing', and include the importance of both diet and activity		of the researcher, which may have had implications for this question, but is unlikely	directly relevant; some were carried out relatively long after pregnancy	maintain healthy lifestyles, some were daunted by the magnitude of change suggested, and some thought diet was more important than exercise – which should be addressed	ered by many studies or in detail; many women appeared to feel that it was just too hard to try (although this was not always explicitly stated by authors)		confidence in this recommendation
Finances and resources							
15. Provide information about low-cost or money-saving healthy behaviours and resources; interventions should be free	Abraham, Dasgupta, Gaudreau, Hjelm, Nicklas, Svensson, Zulfiqar	Minor concerns: these studies were considered high quality; none clearly considered the role of the researcher or implementation of ethics but this was expected to have little impact on answers to this question	No or very minor concerns: many of these studies are directly relevant	No or very minor concerns: women reported the cost of healthy lifestyle (particularly diet) as a barrier, that they wanted advice on saving money or found that they could save money through healthy lifestyle	Moderate concerns: fewer studies reported this thoroughly but many mentioned the cost of healthy living as a barrier	**High confidence**	There was agreement across studies but this was not reported in detail
Format of intervention and other							
16. Recommend increasing fruit and vegetable intake, reducing sugar and substituting with healthier ingredients or methods to improve diet	Doran, Evans, Gaudreau, Graco, Hjelm, Lie, Razee	Minor concerns: no studies clearly considered the role of the researcher or implementation of ethics but this was expected to have little impact on answers to this question	Moderate concerns: although the studies are quite directly relevant in terms of study population/ setting, the phenomenon of interest is only partially relevant as studies rarely directly asked what	Minor concerns: this finding is descriptive and none of the studies are contradictory, therefore we have little concern about suggesting it as an approach for others	Minor concerns: women described what changes they had made but not why; no studies reported what women recommended	**Moderate confidence**	Several studies briefly reported women being able to makes these changes

			behaviour change occurred				
17. Recommend flexible exercise such as walking and those performed around the home or with the baby to increase physical activity (rather than attending gyms or classes)	Bandyopadhyay, Dasgupta, Gaudreau, Graco, Hjelm, Jones 2015, Nicklas, O'Dea, Razee, Tang, Zulfiqar	Minor concerns: no studies clearly considered the role of the researcher or implementation of ethics but this was expected to have little impact on answers to this question	Moderate concerns: although the studies are quite directly relevant in terms of study population/ setting, the phenomenon of interest is only partially relevant as studies rarely directly asked what behaviour change occurred	Minor concerns: this finding is descriptive and only one woman was reported to be concerned about walking; although women in different setting reported different types of exercise, these were all quite flexible	No or very minor concerns: women described why they found walking/ flexible exercise the most appropriate to do	**High confidence**	Women across several studies reported how and why they did these types of exercises
18. Ensure interventions have web-based components but encourage additional face-to-face contact (they should not depend on women attending sessions)	Dasgupta, Graco, Jones 2015, Lie, Nicklas, O'Dea	Moderate concerns: no studies clearly considered the role of the researcher, which may have had implications when evaluation interventions	No or very minor concerns: evaluating an intervention or studies aiming to inform development of them	Major concerns: many benefits of but barriers to face-to-face contact were reported; there was no agreement in studies regarding the ideal format (online, face-to-face, text messages or telephone call)	Minor concerns: this theme is reported in various levels of richness	**Low confidence**	There was no agreement across studies; this recommendation attempted to consider what women wanted but also what was most practical
19. Deliver and promote interventions from recognised/trusted sources (eg. the healthcare provider or a dietitian)	Abraham, Dasgupta, Doran, Gaudreau, Hjelm, Lie, Lim, Lindmark, Nicklas, O'Dea, Pennington, Svensson, Zulfiqar	Minor concerns: a variety of methodical limitations were included but the findings tend to be consistent with high quality studies	No or very minor concerns: many of these studies are directly relevant	Major concerns: these studies report benefits of support offered by various professionals (and some appear to have	Moderate concerns: the findings that this recommendation is based on are rich, but no studies asked who should deliver the intervention	**Low confidence**	Preferred source of the intervention was not discussed; however women reported benefits from their interactions

				followed incorrect advice)			with various professionals
20. Promote establishment of systems to monitor progress and accountability (through an intervention or ensure the participant establishes this themselves)	Dasgupta, Gaudreau, Jones 2015, Lim, Nicklas, O'Dea, Tang	Minor concerns: no studies clearly considered the role of the researcher or implementation of ethics but this was expected to have little impact on answers to this question	No or very minor concerns: most included studies were to inform or evaluate interventions	Minor concerns: these studies reported on the need for or benefits of someone to motivate them, and mentioned both formal (eg. clinician) and informal (eg. peer) relationships	Minor concerns: serval studies report this but not very richly; it is in agreement with the general theme of support	**High confidence**	Accountability facilitates behaviour change, but the best way to promote this remains uncertain

Recommendations frequently result from findings within multiple themes but have been presented under the primary contributing theme. Only studies directly contributing to the recommendation have been cited.