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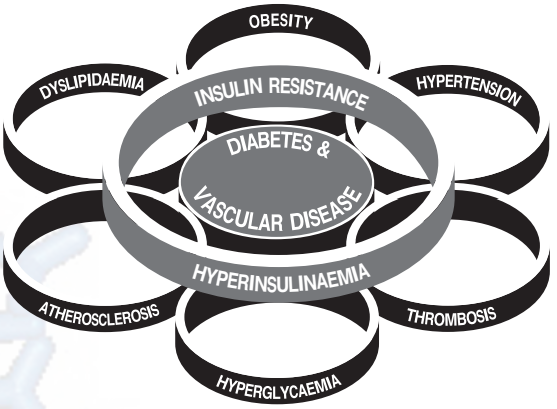

DTN-UK Best Practice Guide

Using diabetes technology in pregnancy

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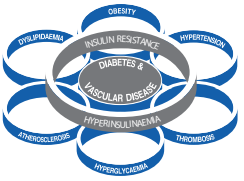

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DTN-UK Best Practice Guides

The Diabetes Technology Network-UK is part of the Association of British Clinical Diabetologists, and exists to support UK health care professionals in using diabetes technology to improve the lives of people living with diabetes. The Best Practice Guides have resulted from detailed conversations between experts in the field, bringing together the latest evidence with tips and tricks from experienced colleagues. We do believe these Best Practice Guides help share best practice from around the country and will act as a guiding document for local teams, as well as help reduce variation in care and outcomes across the country

We hope that you find these guides useful in your day to day clinical practice.

Prof Pratik Choudhary

Chair - ABCD DTN-UK

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Using diabetes technology in pregnancy

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CONTENT

FOREWORD

Antenatal care for women with diabetes has and continues to be a cornerstone of all diabetes services around the NHS. The St Vincent's declaration in 1989 was testament to the desire of all relevant healthcare professionals to try and ensure outcomes for those with diabetes were at par with those who didn't.

Yet in spite of many years of efforts, work and development of antenatal services, neonatal death, stillbirth, congenital anomaly, large and small for dates babies and neonatal unit admission remain high by comparison with pregnancies in women without diabetes and are of considerable concern.

Some system-wide changes which may help could be:

- Targeted and improved patient education and support around contraception and pregnancy preparation with a focus on identifying those at highest risk.
- Greater empowerment of women to make routine diabetes self-management decisions.
- Increased awareness and training for all healthcare professionals.
- Development and implementation of new pathways for identification, referral and treatment.

One of the roles of NHS England is to look at emerging research and work towards getting this to the population at pace, to help translate the benefits shown in clinical trials to a wider patient population. The CONCEPTT trial led by Professor Helen Murphy and involving several members of the working group for this guide showed the benefit of using continuous glucose monitoring (CGM) in pregnant women with type 1 diabetes, with impressive outcomes from a neonatal perspective. As part of the drive to increase access to relevant technology and improve neonatal outcomes, the NHS Long Term Plan 2020 committed to all relevant patients having access to CGM.

As part of the implementation of this, NHS England has been working closely with the Diabetes Technology Network to tackle the issue of education in an effort to minimise variation in the delivery of this ambitious plan. It has been a delight to see this guide being produced, which hopefully will help in informing colleagues about the use of technology in the setting of pregnancy in diabetes.

My thanks to all the authors and collaborators and especially to Drs Kate Hunt and Peter Hammond who led in delivering this excellent piece of work, which hopefully will go a long way to improving pregnancy outcomes in women with type 1 diabetes across the NHS.

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OBJECTIVE

This document aims to provide healthcare professionals with UK expert consensus on the best practice for starting, managing and optimising insulin pump therapy (continuous subcutaneous insulin infusion (CSII)) and glucose sensors (real-time continuous glucose monitoring (RT-CGM) and flash glucose monitoring) in pregnancy.

INTRODUCTION

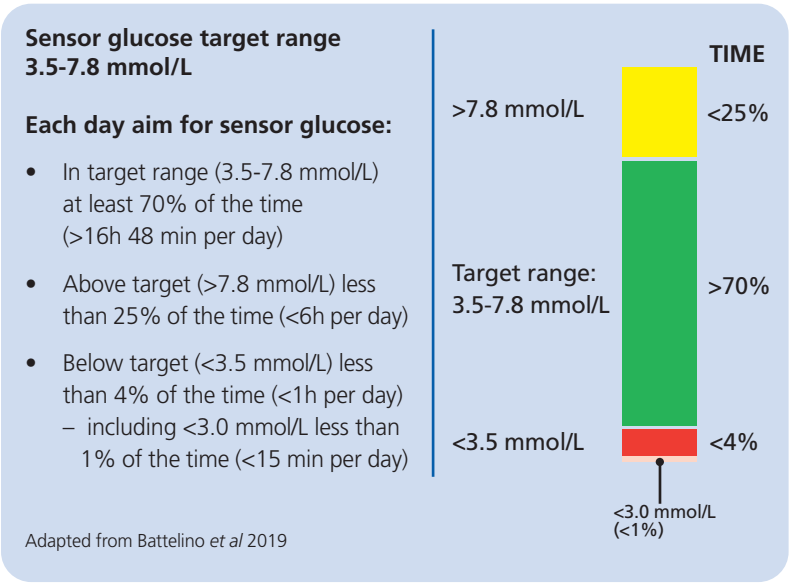
Pre-pregnancy diabetes is associated with increased risk of a range of adverse pregnancy outcomes.[1] Excellent glycaemic control throughout pregnancy is associated with reduced risk of these adverse outcomes,[1] but this is very difficult to achieve. Current recommended targets are:

- Fingerstick capillary blood glucose (CBG) targets:[1]
  - Fasting CBG <5.3 mmol/L
  - 1 hour after meals CBG <7.8 mmol/L
  - 2 hours after meals CBG <6.4 mmol/L
  - And to maintain CBG >4 mmol/L
- Continuous glucose monitoring (CGM) targets (Figure 1):[2]
  - Sensor glucose 3.5–7.8 mmol/L at least 70% of the time (>16 h 48 min per day)
  - Sensor glucose >7.8 mmol/L less than 25% of the time (<6 h per day)
  - Sensor glucose <3.5 mmol/L less than 4% of the time (<1 h per day)
    - including sensor glucose <3.0 mmol/L less than 1% of the time (<15 min per day)

Diabetes technology may help improve glycaemic control. Diabetes technology currently refers to insulin pump therapy (continuous subcutaneous insulin infusion (CSII)), glucose sensors (real-time continuous glucose monitoring (RT-CGM) and flash glucose monitoring) and the interaction between them. Closed-loop insulin delivery is not included in this guide as this is not routinely available for clinical use in pregnancy. More detailed information for evidence outside pregnancy is provided in the parallel DTN-UK Best Practice Guides (https://abcd.care/dtn-uk-best-practice-guides). There is evidence that RT-CGM versus usual care in pregnancy improves neonatal outcomes.[3]

NICE guidelines recommend that CSII and/or CGM can be considered in pregnancy (CGM advice is currently under review) (https://www.nice.org.uk/ guidance/ng3).[1] The NHS Long Term Plan (www. longtermplan.nhs.uk/) launched in January 2019 states:

Figure 1. Sensor glucose targets for pregnant women with type 1 diabetes



'The NHS will ensure that, in line with clinical guidelines, patients with type 1 diabetes benefit from life changing flash glucose monitors from April 2019, ending the variation patients in some parts of the country are facing.
In addition, by 2020/21, all pregnant women with type 1 diabetes will be offered continuous glucose monitoring, helping to improve neonatal outcomes'

For current diabetes technology to be used effectively and safely in pregnancy, it is important that both women and their diabetes health professionals have a practical understanding of its strengths and limitations. Many of the principles are the same as using diabetes technology outside of pregnancy. However, there are several challenges particular to pregnancy, where the risk of hypoglycaemia in the mother has to be balanced against the risks of hyperglycaemia to the fetus.

- Glycaemic targets are tighter than outside pregnancy.
- Time is critical as hyperglycaemia during early pregnancy is associated with increased risk for congenital anomaly while hyperglycaemia in the second and third trimesters is associated with fetal growth acceleration, preterm birth and neonatal complications.
- Postprandial glucose is targeted with the aim of minimising postprandial hyperglycaemia.
- Minimising postprandial hyperglycaemia carries a risk of delayed postprandial hypoglycaemia due to the tail of the meal bolus, particularly before 20 weeks of gestation.

- Insulin absorption is increasingly delayed and with more day to day variability in late pregnancy.[4]
- Insulin requirements change markedly through pregnancy and after birth.
- Increased risk of hypoglycaemia, particularly in the late first and early second trimester and after birth. Approximately 10% of pregnant women with type 1 diabetes have at least one hospital admission due to hypoglycaemia.[5]
- Increased risk of diabetic ketoacidosis (DKA), as pregnancy is a ketogenic state. 2.7% of pregnant women with type 1 diabetes have at least one admission with DKA.[5] DKA in pregnancy carries a risk of fetal death (16–27% or higher).[6,7]
- Pregnant women with diabetes are usually highly motivated. However, the psychological impact and time commitment required for women with diabetes to achieve and sustain their best possible glycaemic control when preparing for pregnancy, throughout pregnancy and birth and then adjusting after birth should not be underestimated.

A recurrent theme which limits access to diabetes technology is health professional time and training.[8] This guide has been developed with the aim of sharing best practice from across the UK to inform those who support women with diabetes using diabetes technology in pregnancy, or who would like to provide this service. A multidisciplinary team of health professionals and women with diabetes provided input into this guide. It is our hope that, by providing clear clinical and service pathways, this document will support staff to deliver safe, effective and high-quality care. In parallel with this guide, the Diabetes Technology Network is supporting the development of a series of online modules on use of glucose sensors in pregnancy, available at https://abcd.care/dtn/education

INSULIN PUMP THERAPY (CSII) BEFORE AND DURING PREGNANCY

Insulin pump therapy (continuous subcutaneous insulin infusion, CSII) employs a battery operated, portable, programmable pump to continuously deliver rapid-acting insulin via an infusion set inserted subcutaneously.[9] The basal insulin infusion rate can be varied and programmed in advance. Bolus doses are given via the pump for meals or corrections and most pumps incorporate bolus calculators.

Evidence for insulin pump therapy (CSII) before and during pregnancy

Insulin pump therapy is more effective than multiple daily injection (MDI) therapy in lowering HbA_{1c} in non-pregnant individuals and with a lower risk of hypoglycaemia.[9,10]

There are no randomised controlled trials (RCTs) comparing modern CSII and MDI therapies in pre-pregnancy or established pregnancy.[11] The four RCTs were small and all conducted before 1990.[11] Evidence is mainly derived from observational studies with the associated limitations, including that glycaemic control may have influenced choice of CSII or MDI.[11] Meta-analysis of observational studies reported lower first trimester HbA_{1c} in women who started CSII prior to pregnancy compared with those on MDI.[11] Meta-analyses of mostly observational studies also reported lower HbA_{1c} in the second trimester in women using CSII, with no significant difference in the third trimester HbA_{1c}, and higher gestational weight gain.[11] There is evidence that second and third trimester insulin dose adjustment is not sufficiently aggressive to keep pace with rising insulin resistance among insulin pump users.[12] The meta-analysis reported no significant difference in the percentage of women who had severe hypoglycaemia.[11]

Image used with permission: Medtronic

The meta-analysis of mostly observational studies reported a higher incidence of miscarriage (which may be related to women on CSII booking for pregnancy care earlier, resulting in better recording of miscarriage) and large for gestational age babies in women using CSII versus MDI, but no difference in any other maternal, fetal or neonatal outcome.[11]

There is some evidence that use of insulin pump therapy in pregnancy is associated with less blood glucose variability than MDI.[13]

In the experience of the authors, pump therapy may be of benefit in pregnant women with severe hyperemesis gravidarum, both in improving the ability to control blood glucose levels and alleviate some of the symptoms of hyperemesis.

Indications for insulin pump therapy (CSII) before and during pregnancy

NICE has published clear guidance on indications for CSII for adults with diabetes, and these apply to women planning pregnancy.[14] NICE does not make specific recommendations on indications for CSII in women planning pregnancy and does not set different HbA_{1c} thresholds, although does recommend further research in this area.[1] A reasonable approach is to consider CSII in women with type 1 diabetes planning pregnancy where HbA_{1c} has remained at or above 53 mmol/mol (7.0%) on MDI therapy despite a high level of care, as described by NICE.[9,14]

Table 1 Calculations for insulin pump settings for starting in pregnancy

Starting pump total daily dose (TDD) calculation: pre-pump TDDx(0.85±0.15)		
Consider lower starting pump TDD if problematic hypoglycaemia or if total daily bolus >60% of pre-pump TDD Consider higher starting pump TDD if HbA_{1c} ≥64 mmol/mol		
Starting pump settings		
Basal rate Total basal=pump TDDx0.5	Insulin:carbohydrate ratio (I:C ratio) (1 unit of insulin for X grams of carbohydrate)	Insulin sensitivity factor (ISF) (1 unit of insulin reduces glucose by Y mmol/L) Glucose target Insulin active time
Option 1: flat basal rate at total basal/ 24 units per hour Option 2: variable basal rate (see Table 2)	Before 20 weeks gestation* Breakfast: 300/pump TDD Other meals: 400/pump TDD *(use existing I:C ratios if working)*	Before 20 weeks gestation* ISF 130/pumpTDD *(use existing ISF if working)* Target: 5 mmol/L Insulin active time: 4 hours
Pump setting adjustment		
Basal rates	Insulin:carbohydrate ratio (I:C ratio)	ISF
Adjust 12 hours before Adjust by 10–20% (Avoid formal basal rate testing involving fasting in pregnancy)	Adjust by 20% (see Table 3)	Correction should bring glucose back to target range within 2–3 hours without causing hypoglycaemia Adjust by 10–20% (see Table 4)

*see text if starting pump after 20 weeks gestation

NICE recommends that pregnant women with insulin-treated diabetes should be offered CSII during pregnancy if adequate blood glucose control is not obtained by optimised MDI without significant disabling hypoglycaemia.[1]

Starting insulin pump therapy (CSII) in pregnancy

When initiating insulin pump therapy outside of pregnancy, including pre-pregnancy, it is usual to start with a total daily dose (TDD) of insulin via the pump which amounts to 75% of the pre-pump TDD on subcutaneous insulin injections.[9] The DTN Best Practice Guide on CSII details starting regimens including basal rate options and bolus settings.[9]

In pregnancy, maintaining good glycaemic control during switch from MDI to pump is essential. There is no evidence that glycaemic control deteriorates when women are converted from injections to pump therapy so, when the switch to pump therapy is indicated, this should be done as soon as this can be safely organised. However, after starting insulin pump therapy in pregnancy, daily contact is essential so that initial settings can be adjusted every 1–2 days until optimised.

Table 2 Modified basal rate profile (King's College Hospital)

Time of day	Basal rate = total pump basal/24 units per hour
Bedtime to 3 hours before waking	80–100%
3 hours before waking to waking up	100–120%
Waking to lunch	80–100%
Lunch to evening meal	80–100%
Evening meal to bedtime	100–120%

In pregnancy, the recommended starting pump TDD is 85±15% of the injection TDD (Table 1). Consider using a lower starting pump TDD (eg, 70% of the injection TDD) if the woman has problematic hypoglycaemia or if the total daily bolus is more than 60% of pre-pump TDD. Consider using a higher starting pump TDD (eg, 95% of the injection TDD) if HbA_{1c} >64 mmol/mol (8.0%), bearing in mind that HbA_{1c} may reflect time before the woman knew of her pregnancy and her diabetes management may have changed.

Having decided the starting pump TDD, 50% of this should be set as the basal infusion rate. There are two options for the basal insulin profile: either a flat rate over 24 hours (pump TDD x 0.5/24 units per hour) or using a modified basal rate profile with 4–6 blocks which reflects the diurnal variation (Table 2).

Women should continue to use their existing insulin:carbohydrate ratio (I:C ratio) and insulin sensitivity factor (ISF) if these appear effective. Alternatively, if starting before 20 weeks of gestation, the starting bolus ratios can be calculated using 300/pumpTDD for breakfast and 400/pumpTDD for other meals and the ISF using 130/pumpTDD. These may need to be adjusted if starting insulin pump therapy after 20 weeks of gestation (see next section). We recommend setting all glucose targets (high, low and single) at 5 mmol/L, as this means the target is independent of the pump system used.

When starting insulin pumps in pregnancy it is particularly important that women understand that the pump only contains rapid-acting insulin and that, if the infusion set or pump fails, ketosis/ketoacidosis can develop within hours. They should know the rules for the management of unexplained hyperglycaemia (see

below), have back-up insulin pens (rapid-acting and long-acting) and should be advised not to change the set in the evening.

Using insulin pump therapy (CSII) in pregnancy

Insulin requirements may reduce in the first trimester and then increase from 16–20 weeks of gestation and pump settings will need to be adjusted to reflect this. Bolus insulin requirements increase to a considerably greater extent than basal insulin during pregnancy, with a 3–4 fold change in insulin:carbohydrate ratios from early to late pregnancy (greatest with breakfast), compared to a 1.25–1.5 fold increase in basal insulin requirements over the same time period. This translates into a change in basal:bolus ratio from 50:50 in early pregnancy to approximately between 35:65 and 25:75 in later pregnancy.

Pump settings should be reviewed frequently and adjusted using data from glucose profiles.

Basal rate adjustment

Basal rates should be adjusted at least 1–2 hours before the inflection point on a CGM trace. Generally, aim for no more than six basal time blocks per 24 hours and avoid short (less than 1–2 hour) blocks unless there is a clear requirement. Short time blocks are not usually needed, and multiple short time blocks makes it more difficult to see patterns and make further adjustments. Basal rates should be adjusted by 10–20%.

We don't advise formal basal rate testing with fasting in pregnancy because daytime basal rates are often lower than physiological requirements due to large bolus doses and the likelihood of ketosis with consequent nausea is higher.

Bolus calculator setting adjustment

Bolus settings should be reviewed frequently and adjusted using data from glucose profiles. It may also be useful to sense check the settings.

Basal:bolus ratio sense check

- Up to 20 weeks of gestation: 50:50 to 35:65.
- Beyond 20 weeks of gestation: 35:65 to 25:75.

Insulin:carbohydrate (I:C) ratio (1 unit of insulin for X grams of carbohydrate)

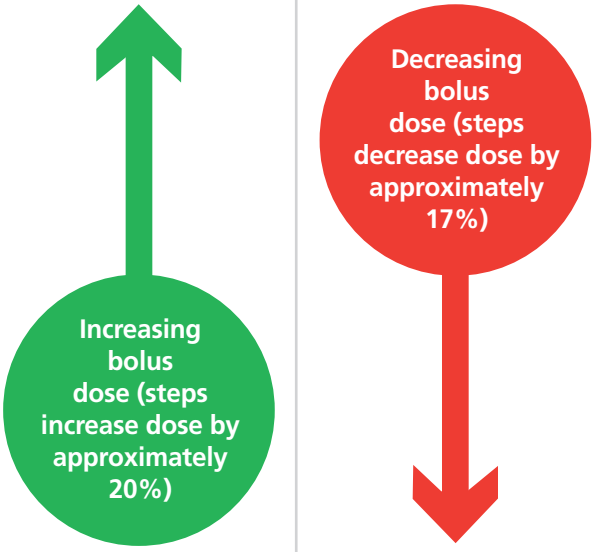
- Usually adjust by 20% (see Table 3).
- To sense check.
  - Up to 20 weeks of gestation: breakfast 300/TDD, other meals 400/TDD
  - Beyond 20 weeks of gestation: breakfast 200/TDD, other meals 300/TDD

Insulin sensitivity factor (ISF) (1 unit of insulin reduces glucose by Y mmol/l)

- Correction should bring glucose back into target range within 2–3 hours, without causing hypoglycaemia (outside pregnancy this is 4–5 hours).[9] (ABCD-DTN-UK 2018).
- Usually adjust by 10–20% (see Table 4) (although it makes sense to adjust the ISF when a ratio is adjusted, in pregnancy

Table 3 Adjusting insulin:carbohydrate ratios in the bolus calculator.

Ratios are usually adjusted by about 20%
In this table each step increases insulin dose by approximately 20% (or reduces insulin dose by approximately 17%)



1 unit of insulin for X grams of carbohydrate	Units of insulin per 10g carbohydrate portion
1.4 g	7.4 units
1.6 g	6.2 units
1.9 g	5.2 units
2.3 g	4.3 units
2.8 g	3.6 units
3.3 g	3.0 units
4.0 g	2.5 units
4.8 g	2.1 units
5.8 g	1.7 units
6.9 g	1.44 units
8.3 g	1.20 units
10 g	1 unit
12 g	0.83 units
14 g	0.69 units
17 g	0.58 units
21 g	0.48 units
25 g	0.40 units

Table 4 Adjusting insulin sensitivity factor (ISF) in the bolus calculator.

ISF is usually adjusted by 10-20% In this table each step increases corrective dose by approximately 10% (or reduces corrective dose by approximately 9%)	ISF: 1 unit of insulin reduces glucose by
Increasing corrective dose (steps increase dose by approximately 10%)	1.0 mmol/L
	1.1 mmol/L
	1.2 mmol/L
	1.3 mmol/L
	1.4 mmol/L
	1.5 mmol/L
	1.7 mmol/L
	1.9 mmol/L
	2.1 mmol/L
	2.3 mmol/L
	2.5 mmol/L
	2.7 mmol/L
	3.0 mmol/L
	3.3 mmol/L
	3.6 mmol/L
	4.0 mmol/L
	4.4 mmol/L
	4.8 mmol/L
	5.3 mmol/L
Decreasing corrective dose (steps decrease dose by approximately 9%)	5.8 mmol/L

the ISF does not change strictly in proportion to the I:C ratio).

- To sense check.
  - Up to 20 weeks of gestation 130/TDD
  - Beyond 20 weeks of gestation consider 100/TDD, particularly if women are using RT-CGM with alerts.

Targets: set target glucose levels (high, low or single) to 5.0 mmol/LI. If the woman has problematic hypoglycaemia, consider setting glucose target at 5.5 mmol/IL.

Other considerations when using insulin pump therapy in pregnancy

- Management of unexplained hyperglycaemia and sick day rules are slightly different in pregnancy (see below).
- In case of set/pump failure, insulin pump users must carry a rapid-acting insulin pen with them at all times, should have access to long-acting insulin pens and should document their pump settings regularly.
- Change infusion sets regularly, at least every 2–3 days, to minimise ketosis risk and optimise insulin absorption.
- Reinforce to perform set changes early in the day, not in the evening. Pump users should check glucose 2–4 hours after a set change to make sure the new set is working. Avoid going to sleep within 2 hours of a set change (or set an alarm after 2 hours to wake up and check glucose).
- Site selection: cannula placement may be difficult as the abdominal skin tautens as pregnancy progresses and sites may irritate more easily. Consider using alternative sites such as flanks, buttocks and thighs and different cannulas, including metal.
- Reservoir volume: daily insulin requirements may exceed 100 units so consider using a pump with a 300 unit reservoir if initiating pump therapy during pregnancy.
- Beyond 20 weeks of gestation, insulin absorption is delayed.[4] Where possible, bolus doses should be given:
  - Up to 20 weeks of gestation: 15±10 min pre-meals
  - Beyond 20 weeks of gestation: extend towards 45±15 min pre-meals
- Consider the use of a basal to bolus switch (or 'Super Bolus') (Box 1) to cover postprandial peaks, particularly breakfast, if increasing the bolus ratio results in late postprandial hypoglycaemia.

Management of unexplained hyperglycaemia for insulin pump (CSII) users in pregnancy

Set or pump failure can occur and, if not detected and managed, can potentially result in the development of ketosis/ketoacidosis within hours.[9] All insulin pump users should be aware of the potential for set failure and how to manage this. The guidance for management of unexplained hyperglycaemia is very similar to outside pregnancy.[9] The differences are that the glucose threshold at which action is recommended is lower (10 mmol/L rather than 13 mmol/L), checking for ketones is earlier and the ketone threshold for action is lower. This is because pregnancy is a ketogenic

Box 1: Using a basal to bolus switch ('Super Bolus') – worked example

30 year old woman, 28 weeks gestation struggling with post-breakfast hyperglycaemia:
- **Glucose peak 9–10 mmol/l (about one hour after breakfast).**
- **I:C ratio of 1:4 (1 unit for 4 g carbohydrate).**
- **Basal insulin infusion rate 08.00-13.00 = 1.3 units/hour.**

She is already limiting her breakfast carbohydrate and giving her bolus 30 min before eating (see table 10). She tried adjusting the breakfast I:C ratio from 1:4 g to 1:3.3 g. She found that, using the recommended pre-breakfast bolus at 08.00 am, the peak glucose (at about 1 hour) was <7.8 mmol/L but she will be hypoglycaemic around 10:00-11.00 am.

Option A: 'Super Bolus'

The simplest version of a 'Super Bolus' is to calculate basal insulin delivered over 2 (or 3) hours, add this to the recommended meal bolus, and set a 0% temporary basal rate for 2 (or 3) hours, eg:
- **Breakfast at ~ 08.30 contains 20 g carbohydrate.**
- **Recommended meal bolus 5 units. Basal insulin delivered over 2 hours is 2.6 units**
- **Adjust recommended bolus from 5 units to 7.6 units (given at 08.00 am)**
- **Set 0% temporary basal rate for 2 hours starting at 08.00 am.**

✔ **Advantage: adjustment of meal bolus and setting temporary basal are linked, so unlikely to do one without the other**
✖ **Disadvantages: doing the calculation, several steps**

Option B:

Adjust I:C ratio settings. Plan to set a 0% temporary basal rate for 2 (or 3) hours after giving meal bolus, eg:
- **Change breakfast I:C ratio by at least 20% (from 1:4 g to 1:3.3 g)**
- **Breakfast at ~ 08.30 contains 20 g carbohydrate.**
- **Give recommended bolus (6.1 units)**
- **Set a 0 % temporary basal rate for 2 (or 3) hours**

✔ **Advantage: no calculation, single step**
✖ **Disadvantage: if the person forgets to set the temporary basal rate they are highly likely to have hypoglycaemia at 2–4 hours post bolus**

state. Pregnant women with type 1 diabetes require blood ketone testing equipment. Rules for managing unexplained hyperglycaemia for CSII users in pregnancy are given in Figure 2.

Insulin pump users should be encouraged to explore the reasons why the high glucose has occurred.[9]

Pump users must have back-up insulin pens (rapid-acting and long-acting) and should document their pump settings regularly. This is particularly important in pregnancy as pump settings are changed frequently. In the event of pump failure, the emergency basal insulin would be the same as the total daily basal insulin on the pump and the I:C ratio and ISF would be the same as on the pump.

Pump users should routinely check glucose 2–4 hours after a set change to make sure the new set is working. Avoid going to sleep within 2 hours of a set change (or set an alarm after 2 hours to wake up and check glucose). If pump users need to give a correction dose using a pen/syringe and then continue using insulin pump therapy (usually after changing the infusion set and reservoir), they should check glucose at 2 and 4 hours and wait at least 4 hours before sleeping. This is because, if the set/pump is not working, glucose may only start to rise once the effect of the rapid-acting insulin given by pen/syringe is wearing off (3–4 hours).

Sick day rules for insulin pump (CSII) users in pregnancy

Pregnancy is a ketogenic state. Women with diabetes are at higher risk of developing diabetic ketoacidosis (DKA) when they are pregnant. The NPID Audit reported 2.7% of pregnant women with type 1 diabetes have at least one admission with diabetic ketoacidosis.[5] Diabetic ketoacidosis in pregnancy carries a risk of fetal death (16–27% or higher).[6,7] Women using CSII are at higher risk of ketosis than those using MDI, as any interruption in insulin delivery can result in hyperglycaemia and ketosis as the insulin pump only contains rapid-acting insulin. Prompt detection of ketones is key to early treatment.

The sick day rules for pregnant women using CSII are given in Figure 3. Fingerstick glucose checks (rather than sensor glucose) should be used during illness. The general principles of sick day rules are similar to outside pregnancy.[9] However, there are some differences. Pregnant women with type 1 diabetes require blood ketone testing equipment and should not be expected to manage using urine ketone testing. In pregnancy blood ketone levels of above 1.0 mmol/L are considered significant requiring increased insulin and monitoring, which is lower than the threshold of 1.5 mmol/L outside of pregnancy. In pregnancy the threshold for attending hospital as an emergency is lower: straight away if ketones are above 3 mmol/L and if no improvement after 2 hours if ketones 1.1–3 mmol/L. Women should continue to follow the sick day rules until they are assessed and alternative treatment instituted if needed. We recommend early set change with bolus using pen/syringe. We encourage women to maintain carbohydrate intake with bolus insulin (using their normal I:C ratio) as this will help suppress ketogenesis.

Pregnant women with diabetes who are unwell with vomiting, abdominal pain or ketones MUST be assessed for DKA even if glucose levels are normal. DKA can occur in pregnancy in a woman with known diabetes with a normal blood glucose.[15] Guidance on management of diabetic ketoacidosis in pregnancy is given by JBDS-IP.[15] Women who are not in DKA, but have ketone levels above 1.0 mmol/L which are not quickly resolved using sick day rules, will require variable rate intravenous insulin (VRII) and appropriate fluid replacement. Women may continue to use insulin pump therapy as well as VRII to allow basal rates to continue if she is able to manage the pump herself.

Figure 2. Rules for managing unexplained hyperglycaemia in pregnancy for insulin pump users

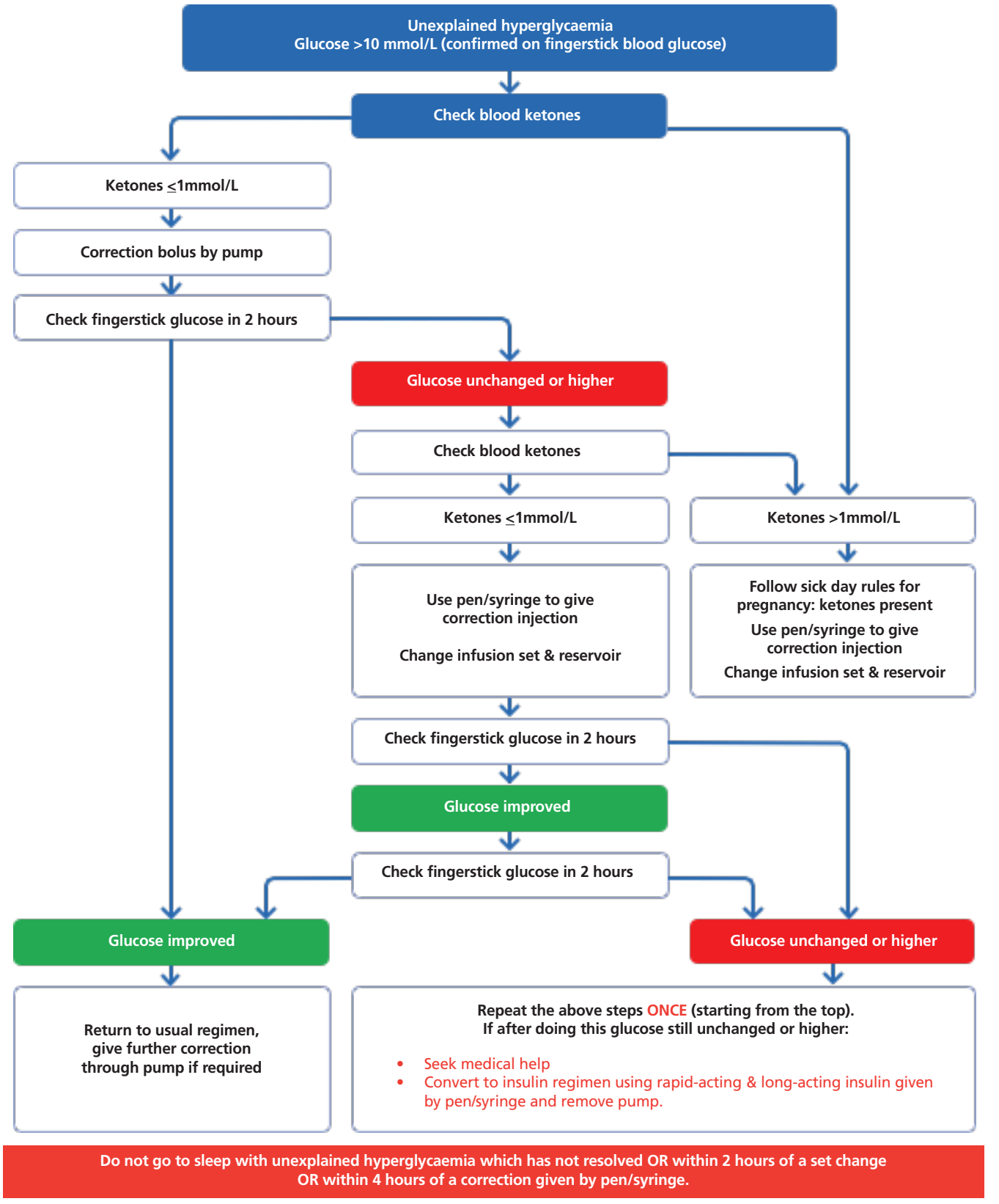
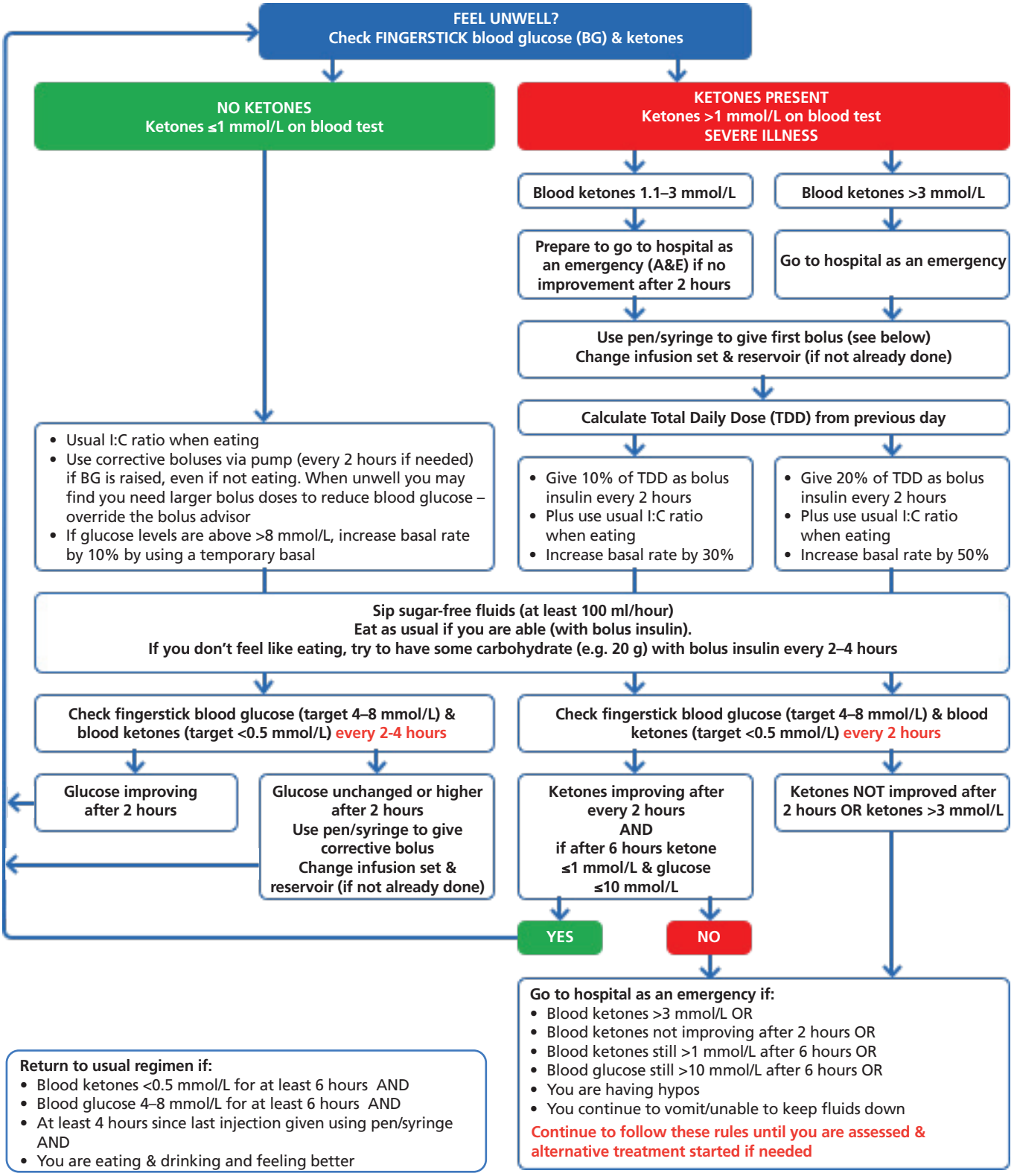


Figure 3. Sick day rules in pregnancy for insulin pump users.



Whilst on intravenous insulin infusion for ketosis or DKA, CBG checks (not sensor glucose) are required every hour. If pump therapy has been discontinued during the ketosis event, then once resolved an overlap of 1 hour between restarting CSII and stopping intravenous insulin is required.

USING GLUCOSE SENSORS BEFORE AND DURING PREGNANCY

Glucose sensors measure glucose in the interstitial fluid just below the skin. Changes in interstitial glucose, and therefore sensor glucose, lag about 5–10 min behind changes in blood glucose. It is generally accepted that the sensor accuracy is not affected by the physiology of pregnancy.[16]

Real-time continuous glucose monitoring (RT-CGM) provides continuous information about sensor glucose (updated every 5 min) with the facility to set glucose alarms. Of the current RT-CGM systems, we have extensive experience of supporting pregnant women using the Dexcom G6 and the Medtronic Guardian Sensor 3. Dexcom G6 has a CE markspecifically for use in pregnancy (meaning it complies with European Union health, safety and environmental standards). Medtronic Guardian Sensor 3 has a CE mark that does not exclude use in pregnancy. The Dexcom G6 sensor data is viewed using the Dexcom G6 App on a mobile phone, the Dexcom receiver or used with the Tandem t:slim insulin pump. The Medtronic Guardian Sensor 3 data is viewed using the Guardian Connect App on a mobile phone or used with the MiniMed 640G or 670G insulin pump systems. Note the MiniMed 670G Auto Mode feature (hybrid closed loop system) is not suitable for use in pregnancy because the target is too high for pregnancy. Other RT-CGM systems are available.

Flash glucose monitoring only provides a glucose reading when the user 'scans' the device and, currently, it does not have alarms. Currently, the FreeStyle Libre is the only flash glucose monitoring system available and has a CE mark for use in pregnancy (meaning it complies with European Union health, safety and environmental standards).

Evidence for RT-CGM before and during pregnancy

The CONCEPTT trial provided evidence that, in women with type 1 diabetes, RT-CGM started in the first trimester versus capillary glucose monitoring improves glycaemic control and improves neonatal outcomes, including reduction in large for gestational age (number needed to treat to prevent 1 case (NNT) 6), neonatal hypoglycaemia (NNT 8), neonatal intensive care admission (NNT 6) and length of hospital stay.[3]

In CONCEPTT, at 34 weeks of gestation the sensor glucose time in target range 3.5–7.8 mmol/L was 68%±13% in the RT-CGM arm and 61%±15% in the usual care arm, an increase of 1.7 hours per day in target range. In CONCEPTT, most women only achieved the recommended 70% time in target range (Figure 1) in the last 3–4 weeks of pregnancy.[2] For optimal neonatal outcomes, women should be supported to reach 70% time in target range as early as possible during pregnancy and then maintain this.

In CONCEPTT, the benefit of RT-CGM was seen both in women using pumps and women using multiple daily injections, suggesting that women do not need to be familiar with diabetes technology or be using pumps to benefit from RT-CGM. Furthermore, the RT-CGM treatment effect was comparable in women with baseline HbA_{1c} levels above and below 58 mmol/mol (7.5%). Our experience is that women with low numeracy and/or literacy can also benefit from RT-CGM with individualised advice and support.
CONCEPTT also included a group of women planning pregnancy.[3] There was no clear evidence of benefit on glycaemic control at confirmed pregnancy or after 24 weeks study period in women who did not conceive, possibly due to the small sample size.

Image used with with permission: instagram.com/diabetesia

However, as the authors noted, women may be uncomfortable changing monitoring modality during early pregnancy and it may be logistically easier for services to plan RT-CGM starts during pregnancy planning. The evidence for RT-CGM outside pregnancy will be covered in the ABCD-DTN- UK Best Practice Guide for RT-CGM.

Indications for RT-CGM before and during pregnancy

Women preparing for pregnancy may be assessed for RT-CGM using the usual criteria for adults with diabetes.

For women who are pregnant, current NICE guidelines,[1] published before CONCEPTT was published, are given in Box 2. NICE are currently undertaking a partial update focused on CGM in women with type 1 diabetes who are planning to become pregnant or are already pregnant (https://www.nice.org.uk/guidance/ng3).

The NHS Long Term Plan launched in January 2019 states

> ***'…by 2020/21 all pregnant women with type 1 diabetes will be offered continuous glucose monitoring, helping to improve neonatal outcomes.'***
>
> ***(section 3.80, (www.longtermplan.nhs.uk/)***

Box 2: NICE guidance on continuous glucose monitoring in pregnancy[1] – note this is under review (see text)

- **Do not offer continuous glucose monitoring routinely to pregnant women with diabetes**
- **Consider continuous glucose monitoring for pregnant women on insulin therapy:**
  - **who have problematic severe hypoglycaemia (with or without impaired awareness of hypoglycaemia) or**
  - **who have unstable blood glucose levels (to minimise variability) or**
  - **to gain information about variability in blood glucose levels**

At the time of writing, NHS England are working to implement this plan, in Scotland availability of RT-CGM for all pregnant women with type 1 diabetes is subject to a Scottish health technology assessment as well as assessment in an updated SIGN guideline, and in Wales RT-CGM is recommended for pregnant women with type 1 diabetes.[17]

Information provided by RT-CGM

For people to use RT-CGM effectively and safely, the sensor settings should be appropriate and both they and their diabetes health professionals need to understand the information the RT-CGM is providing and how to use that information. It is important to recognise that the extra information provided by RT-CGM can be overwhelming and the psychological impact of seeing 'out of range' sensor glucose readings can be difficult to cope with and may result in over-reaction. This is particularly important in pregnancy as women are understandably very keen to keep sensor glucose in the target range.

Sensor glucose

RT-CGM measures glucose in the interstitial fluid just below the skin (whereas a fingerstick test measures CBG). The displayed sensor glucose value is updated every 5 min. Changes in interstitial glucose usually lag 5–10 min behind changes in blood glucose. For example, if blood glucose has dropped steadily from 10 mmol/L to 3 mmol/L over the last hour, the fingerstick glucose will be around 3 mmol/L but the sensor glucose will still be around 4 mmol/L.

Even when blood and interstitial glucose are stable, RT-CGM devices may give different results from fingerstick CBG readings.

For these reasons there is often a difference between fingerstick CBG and sensor glucose. If there is a difference, the fingerstick CBG should be considered the more accurate.

Direction of change arrows

The arrows show how fast and in which direction sensor glucose has changed over the past 20 min (Table 5).

Graphs

The graphs shown on the RT-CGM display show sensor glucose over the preceding 3 hours, 6 hours, 12 hours or 24 hours.

RT-CGM set up in pregnancy

Issues to cover for women starting RT-CGM during pregnancy are listed in Box 3 and tips for established users of RT-CGM who are newly pregnant in Box 4.

Calibration

Calibration requirements vary between RT-CGM systems and some do not need to be calibrated at all. At the time of writing, Dexcom G6 does not require calibration, whereas Medtronic Guardian Sensor 3 does require calibration (within the first 2 hours and then at least every 12 hours).

For systems requiring calibration, it is very important to get the calibration process right otherwise the RT-CGM will be inaccurate.

Table 5 What RT-CGM/flash glucose monitoring arrows mean

Dexcom G6	Medtronic Guardian Sensor 3	FreeStyle Libre	Over past 20 min sensor glucose has been:	Approximate* rate of change	If trend continues, approximately*:	
					How long to change by 1 mmol/L?	How much will sensor glucose change in 30 min?
↑ ↑	↑↑↑	↑	Rising very quickly	>0.2 mmol/L/min	< 5 min	>5 mmol/L
↑	↑↑		Rising quickly	0.1–0.2 mmol/L/min	Average 7 min	3-5 mmol/L
↗	↑	↗	Rising	0.06–0.1mmol/L/min	Average 15 min	2-3 mmol/L
→	No arrow	→	Stable or changing slowly	<0.06 mmol/L/min	>20 min	<2 mmol/L
↘	↓	↘	Falling	0.06–0.1mmol/L/min	Average 15 min	2–3 mmol/L
↓	↓↓	↓	Falling quickly	0.1–0.2 mmol/L/min	Average 7 min	3–5 mmol/L
↓ ↓	↓↓↓		Falling very quickly	>0.2 mmol/L/min	< 5 min	>5 mmol/L

*Approximate figures given for practical purposes and for harmonisation across devices.

It is important to minimise the risk of inaccurate fingerstick CBG readings and calibrate when there is the least likelihood of a difference between CBG and interstitial glucose.

- To maximise the likelihood of accurate CBG reading:
  - Clean hands
  - Don't use sites other than fingers
- Calibrate when glucose levels are stable.
  - Before meal bolus or before bed (if >3 hours after eating)
  - Sensor showing glucose stable (no up or down arrows)
  - NOT after hypoglycaemia, exercise or within 3 hours after a bolus (correction/meal)
- Calibrate when fingerstick and sensor glucose similar (within 3 mmol/L).
  - This may sound counter-intuitive, but if the sensor and fingerstick readings are very different it is likely that blood glucose is changing quite rapidly or there is an aberrant sensor or CBG reading and using this will introduce error
- For systems needing calibration at least 12 hourly (eg, Medtronic Guardian Sensor 3), if no calibration is performed within 12 hours the sensor will alert and if the user does not calibrate it will stop providing a sensor glucose reading. Therefore:
  - For every fingerstick CBG performed, think whether the above criteria are met and calibrate every time they are. This is because it can be very difficult, particularly in pregnancy, to find enough times suitable for calibration
  - Do a calibration in the evening. This is because otherwise the calibration alert will disturb sleep and if the user then does not calibrate the sensor will not provide readings for the rest of the night

Alerts

RT-CGM systems have many possible glucose alerts (Table 6). However, many of the negative comments from RT-CGM users are about alerts/alarms. People may stop using the RT-CGM altogether because of alerts or may develop 'alert fatigue' where they ignore all the alerts including the more important ones. The general rule is only turn on an alert if it is something the user can safely, and should, do something about at that time.

High glucose alerts

- The useful high alert is the high glucose alert which, provided the threshold is set at a suitable level, is something the user can and should do something about. It alerts when the sensor glucose reaches the high glucose threshold.
- High alert glucose thresholds are usually set at a level that may indicate system failure (eg, set/pump failure or missed bolus). High alert glucose threshold should be set at:
  - Usual waking hours: 12–15 mmol/L
  - Usual sleeping hours: 8–10 mmol/L
- Setting the thresholds lower than this will usually result in multiple alerts, with the risk of alert fatigue, and may encourage inappropriate corrections with subsequent hypoglycaemia. It is important to explain this to pregnant women otherwise many will be keen to set the threshold much lower.
- For new RT-CGM users the high alert thresholds should usually be set at the top of the range (ie, waking hours at 15 mmol/L, sleeping hours at 10 mmol/L). These can be brought down to the lower end of the range as they become more familiar with the system and glycaemic control improves.
- Some more advanced RT-CGM users may choose to set the high alert glucose threshold lower than these ranges. In such cases the risk of alert fatigue and/or inappropriate corrections should be discussed.
- The high repeat (Dexcom G6) or high snooze (Medtronic Guardian Sensor 3 used with MiniMed 640G or 670G systems) should be set at 2 hours as this is the recommended minimum time between repeated corrective doses.

Table 6 RT-CGM glucose alerts and alarms

	Alerts	Set up	Use/comment
Predictive high glucose alert	A set number of minutes before the sensor glucose is predicted to reach the high glucose threshold	Off	Rarely used: may trigger frequently (eg, after meals or hypo treatment) and generally should not be acted on. Does not add much to high glucose alert.
High glucose alert	When the sensor glucose reaches the high glucose threshold	On	To alert if sensor glucose is high at a level which can and should be acted on.
Rate of rise alert	When the sensor glucose is rising rapidly	Off	Rarely used: will trigger frequently (eg, after meals or hypo treatment) and generally should not be acted on. Sometimes used as a 'missed bolus' alert.
Predictive low glucose alert	A set number of minutes (usually 20–30 min) before the sensor glucose is predicted to reach a low glucose threshold	On	To avoid hypoglycaemia.
Low glucose alert	When the sensor glucose reaches a low glucose threshold	On or off	To alert the user to hypoglycaemia or near- hypoglycaemia. Some systems (eg, Dexcom G6) can have 2 separate low thresholds.
Rate of fall alert	When the sensor glucose is falling rapidly	Off	Rarely used: rapidly falling glucose is only important if approaching hypoglycaemia (which will trigger predictive low glucose alert).

Low glucose alerts

RT-CGM systems have slightly different low glucose alert functionalities and need to be set up slightly differently. Probably the most useful alert is the predictive low glucose alert as this is something the user can and should do something about in order to avoid hypoglycaemia. It alerts a set number of min (usually 20–30 min) before the sensor glucose is predicted to reach a low glucose threshold.

- Dexcom G6:
  - 'Urgent Low Soon Alert': alerts 20 min before sensor glucose predicted to reach 3.1 mmol/L (the threshold of 3.1 mmol/L cannot be changed
  - 'Urgent Low Alarm': alarms when sensor glucose reaches 3.1 mmol/L (the threshold of 3.1 mmol/L cannot be changed). This alarm cannot be turned off.
  - 'Low Glucose Alert': alerts when the sensor glucose reaches the individualised low glucose threshold. The purpose is to alert the user when sensor glucose is low but is not falling quickly enough to trigger the 'Urgent Low Soon Alert'. Users may wish to keep this alert on as the urgent low threshold of 3.1 mmol/L is quite low. The threshold is usually set at 3.4–4.0 mmol/L depending on hypoglycaemia awareness and personal preference. For example, if the woman has reduced hypoglycaemia unawareness, the threshold is set at the higher end of this range. For those who want to minimise alerts, a threshold at the lower end of the range may be used. Some women will choose to set the threshold at the higher end of this range, accepting that this will result in lots of alerts and some of the time the appropriate action will be to watch and wait.
- Medtronic Guardian Sensor 3 used with MiniMed 640G or 670G systems or the Guardian Connect App:
  - 'Alert Before Low': alerts 30 min before sensor glucose predicted to reach the individualised low glucose threshold. This is usually set at 3.4–3.6 mmol/L. If the woman has reduced hypoglycaemia awareness or severe hypoglycaemia, consider setting the low glucose alert threshold at 3.8–4 mmol/L.
  - 'Alert On Low': alerts when the sensor glucose reaches the individualised low glucose threshold. This may be kept off to limit the number of alerts, as the person should already be responding to the Alert Before Low
  - The Guardian Connect App (but not the MiniMed 640G or 670G) has an 'Urgent Low' alarm set at 3.1 mmol/L which cannot be turned off.

The repeat (Dexcom G6) or low snooze (Medtronic Guardian Sensor 3) (time after an alert before another alert if the alert condition still exists) should be set at 30 min. Treatment or avoidance of hypoglycaemia should usually be complete within 30 min and the system will then warn of a further episode. Setting the repeat at a shorter time may result in the alerts sounding when the woman is still treating the hypoglycaemia (which can be annoying) or when the hypoglycaemia has been successfully treated/avoided but the sensor is lagging behind (which can encourage overtreatment of hypoglycaemia).

Using RT-CGM in pregnancy

Issues to cover for women starting RT-CGM during pregnancy are listed in Box 3 and tips for established users of RT-CGM who are newly pregnant in Box 4.

When to check fingerstick CBG

There may be a difference between fingerstick CBG and sensor glucose due to sensor lag or inaccuracy. If there is a difference the fingerstick CBG should be considered the more accurate.

Situations to ALWAYS check fingerstick CBG

RT-CGM users should be advised to ALWAYS check fingerstick CBG (rather than using sensor glucose) in the following situations (this is the same as outside pregnancy)

- To confirm hypoglycaemia AND monitor recovery from hypoglycaemia. (Those with good hypoglycaemia awareness may not need to repeat fingerstick to confirm recovery from hypoglycaemia if their symptoms have improved. However, due to sensor lag, sensor glucose should not be used to guide the requirement for further 15 g of quick acting carbohydrate).
- If symptoms do not match sensor glucose (eg, if symptoms of hypoglycaemia and sensor glucose normal).
- If sensor reading seems unlikely in the circumstances.
- If sensor reading unreliable (eg, no reading, or no arrow (in the Dexcom G6 system)).
- If required for calibration.
- During and after exercise.
- When following 'sick day rules' or 'rules for management of unexplained hyperglycaemia'.
- When in hospital, RT-CGM SHOULD NOT be used to adjust variable rate intravenous insulin infusions (VRII).

Note the Medtronic Guardian Sensor 3 may give falsely high glucose readings after paracetamol. Dexcom G6 is not affected by paracetamol (unlike earlier Dexcom systems).

Situations when it is ADVISED to check fingerstick CBG in pregnancy

In pregnancy, RT-CGM users should be advised to also check fingerstick CBG in the following situations:

- Before using a glucose value to calculate meal bolus (the glucose is used to calculate the correction part of the meal bolus).
- Before taking action to avoid hypoglycaemia (eg, when responding to the predictive low glucose alert).
- Before taking action to correct hyperglycaemia.

In pregnancy we advise this for all RT-CGM systems, including those licensed to be used instead of fingerstick CBG testing for treatment decisions (termed non-adjunctive systems). This advice is different from outside pregnancy because the glucose targets in pregnancy are very tight and time spent outside range is particularly important in pregnancy, so discrepancy between sensor glucose and fingerstick CBG is important. A sensor that is giving readings that are slightly out will impact for the lifetime of that sensor, a duration that may be important in pregnancy. However,

experienced RT-CGM users may reasonably choose not to check fingerstick glucose in these three situations if they are using a non-adjunctive system and are confident the sensor is working well (eg, smooth graph, no gaps, sensor glucose has been close to fingerstick glucose, and sensor glucose as expected in the circumstances). However, we recommend testing fingerstick glucose an absolute minimum of once per day, usually first thing in the morning, to monitor accuracy of that particular sensor.

Routine monitoring of fingerstick CBG at 1–2 hours post-meal is generally not required in women using RT-CGM in pregnancy, provided none of the above apply.

Pregnant women using RT-CGM will generally require at least four CBG test strips per day.

When to look at RT-CGM readings

As a minimum, pregnant women should look at their RT-CGM display on getting up in the morning, pre-meals, 1 hour post-meals (for reflection in real-time), 2 hours post-meals (for reflection in real-time and possible corrective action), pre-bed and if they wake in the night.

Responding to high sensor glucose

It is very important to remind RT-CGM users of the action profile of rapid-acting insulin and to emphasise that a corrective dose of rapid-acting insulin will not reduce sensor glucose immediately, that a rising glucose may continue to rise for 30–60 min after a correction, and to leave at least 2 hours between corrective doses. Giving too large or multiple corrective doses will not reduce glucose more quickly but will cause hypos.

Hyperglycaemia after meals

Generally pregnant women should be advised NOT to correct postprandial hyperglycaemia because this will often cause subsequent hypoglycaemia. Seeing postprandial hyperglycaemia should trigger 'real-time' reflection on the cause and possible solutions for the future (see below). However, prolonged hyperglycaemia should be acted on. A practical approach is, if sensor glucose is high at 1 hour post-meal, check sensor glucose again at 2 hours post-meal. If sensor glucose remains above target AND sensor glucose is either stable or increasing (upward arrow(s)), then it is reasonable to give a corrective dose. CSII users should use the bolus advisor (which takes account of the insulin on board). MDI users should use half the dose calculated using their individualised ISF or may use an App to calculate the corrective bolus taking account of the insulin on board. Women should not correct if sensor glucose is falling (downward arrows). Alternatively, if sensor glucose is high at 1 hour post-meal, exercise, such as a walk round the block, can be used to reduce glucose if practical.

Hyperglycaemia after hypoglycaemia

Generally pregnant women using RT-CGM should be advised NOT to correct hyperglycaemia after hypoglycaemia as this will often cause further hypoglycaemia. However, prolonged hyperglycaemia should be acted on. In pregnancy, a practical approach is if sensor glucose is high 2 hours after treating hypoglycaemia and the sensor glucose is either stable or increasing (upward arrow(s)), then it is reasonable to give a corrective dose (if CSII using the bolus advisor OR if MDI using individualised ISF). Women should not correct if sensor glucose is falling (downward arrows).

Hyperglycaemia at other times

Hyperglycaemia pre-meals or more than 3 hours after a meal bolus can be corrected as usual using individualised ISF (see next section).

Unexplained marked hyperglycaemia (eg, >10 mmol/L) should trigger consideration of the cause such as system failure (eg, set failure for CSII users or missed insulin) or illness, and the appropriate response to this. It is essential that CSII users know the rules for the management of unexplained hyperglycaemia (see section on Management of unexplained hyperglycaemia for CSII users in pregnancy and Figure 2) which might be due to set/pump failure and can potentially result in the development of ketosis/ketoacidosis within hours. It is also essential that pregnant women with type 1 diabetes (whether CSII or MDI users) know the sick day rules for pregnancy as the risk of ketosis is higher in pregnancy (see section on Sick day rules for CSII users in pregnancy and Figure 3).

Responding to predictive low glucose alerts and low glucose alerts

The predictive low glucose alert is activated a set number of minutes before the sensor glucose is predicted (if the sensor glucose keeps falling at the same rate) to reach the low glucose threshold. Due to the sensor lag and/or the glucose threshold set, the CBG may already be <3.5 mmol/L when the predictive low glucose alert is triggered. The person should respond promptly to a predictive low glucose alert. The low glucose alert/alarm is activated when the sensor glucose reaches a low glucose threshold. However, there may be a difference between CBG and sensor glucose. Therefore, the woman should check fingerstick CBG immediately if they have hypoglycaemia symptoms (even if sensor glucose normal), if the sensor is reading <3.5 mmol/L, if the low glucose alert is triggered or if the predictive low glucose alert is triggered. If there is a difference, the fingerstick CBG should be considered accurate.

Guidance for avoiding and treating hypoglycaemia is shown in Figure 4. Hypoglycaemia avoidance (fingerstick CBG ≥3.5 mmol/L) is managed by consuming 10 g quick acting carbohydrate (Table 7) and reviewing sensor glucose/arrows. Hypoglycaemia (fingerstick CBG <3.5 mmol/L) is treated by consuming 15 g quick acting carbohydrate (Table 7) and using fingerstick (NOT sensor) glucose to monitor recovery from hypoglycaemia. This is because the sensor glucose lags 5–10 min behind blood glucose and so sensor glucose will continue to fall for 5–10 min even if blood glucose is rising after effective hypoglycaemia treatment. Using sensor glucose to monitor recovery from hypoglycaemia usually results in

Figure 4. Guidance for avoiding and treating hypoglycaemia

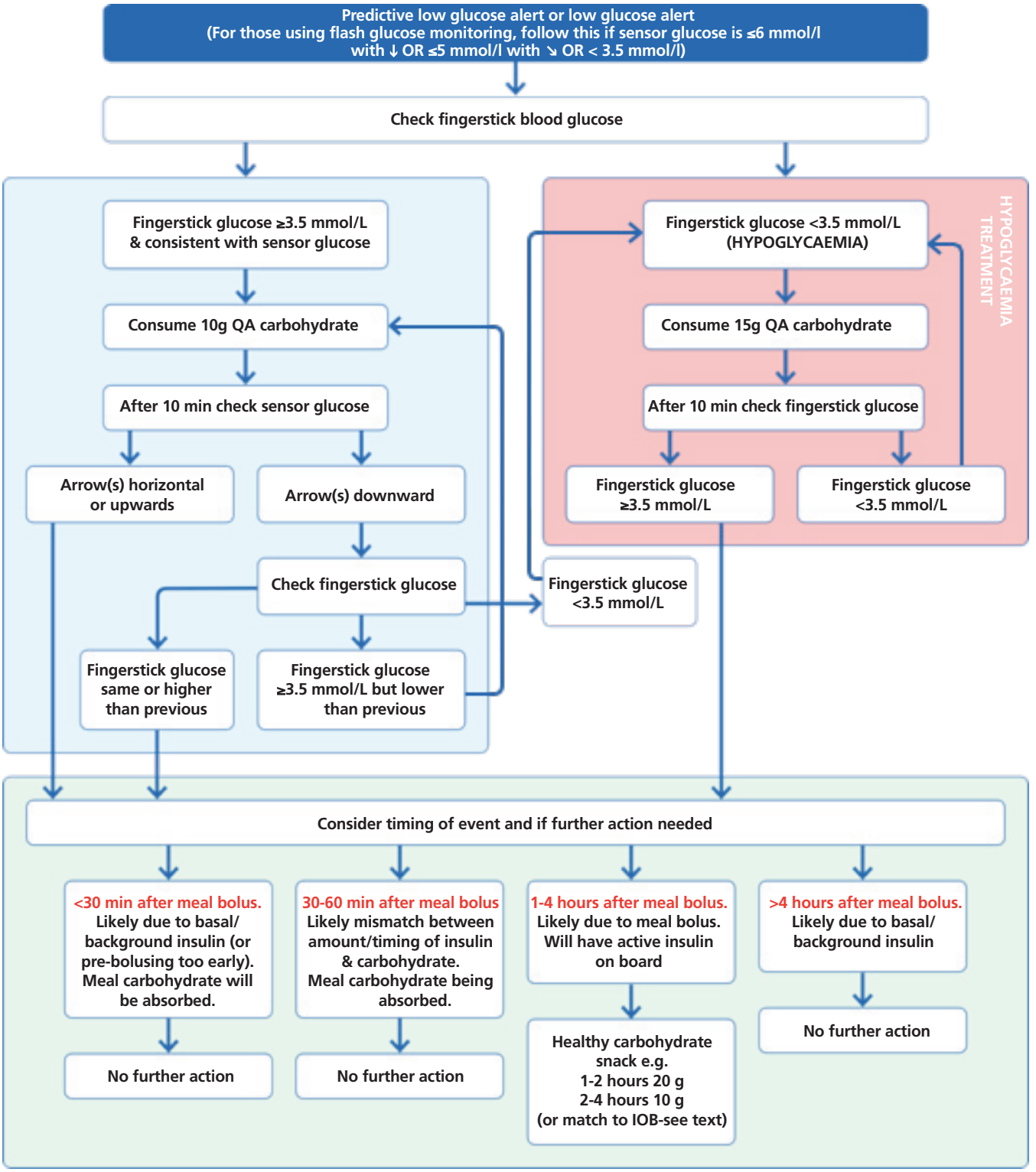


Table 7 Some quick acting (QA) carbohydrate suggestions for avoiding and treating hypoglycaemia

	Hypoglycaemia avoidance. 5 g quick acting carbohydrate	Hypoglycaemia avoidance. 10 g quick acting carbohydrate	Hypoglycaemia treatment 15 g quick acting carbohydrate
Lift Shot (previously Glucojuice)	1/3rd of a bottle	2/3rds of a bottle	1 bottle
Smooth orange juice	50 mL	100 mL	150 mL
Lucozade energy	60 mL	120 mL	180 mL
Lucozade sport	75 mL	150 mL	225 mL
Lift glucose tablets	1	2	4
Glucose tablets	2	3	5
Jelly babies	1	2	3

overtreatment of hypoglycaemia. A practical tip is to advise RT-CGM users to avoid looking at the RT-CGM display until fingerstick CBG shows recovery, as it is very difficult to ignore a falling sensor glucose.

Hypoglycaemia (or predicted hypoglycaemia) 1.5–4 hours after meal bolus is common during pregnancy due to 'tail' of the large meal boluses. At this time, most of the meal carbohydrate has been absorbed but there will be insulin on board/active insulin from the meal bolus and there is a risk of further hypoglycaemia. After taking steps to avoid hypoglycaemia using quick acting carbohydrate (Figure 4), consuming a healthy carbohydrate snack to match the insulin on board should help avoid further hypoglycaemia.

- A practical approach is to have a healthy snack containing 20 g carbohydrate if 1–-2 hours after meal bolus or 10 g carbohydrate if 2–4 hours after meal bolus (Table 8). This assumes the preceding meal was 40–60 g. If the preceding meal had a much higher carbohydrate content and bolus insulin was matched to this, then insulin on board will be higher and a larger amount of carbohydrate may be needed. If the preceding meal had a much lower carbohydrate content, then insulin on board will be lower and a smaller amount of carbohydrate may be needed.
- Some women may wish to

Table 8 Healthier snack choices containing carbohydrate

	Carbohydrate content
Fruit • Very small banana (weight in skin 75 g) • Small apple (weight 85 g) • Pear (weight 90 g) • Peach (weight 140 g) • Nectarine (weight 110 g) • Orange (weight 160 g) • 2 clementine/tangerine/satsuma (total weight 160 g) • 2 Kiwi (total weight 100 g) • 2 apricot/plum (total weight 110 g) • Blueberries (total weight 100 g) • Blackberries (total weight 180 g) • Strawberries (total weight 140 g) • Raspberries (total weight 200 g) • 10 grapes (total weight 70 g) • 12 cherries total weight 120 g	Each about 10 g
Oat cakes x 2	12 g
Ryvita x 2	12–13 g
Wholewheat/wholegrain cracker or crispbread x1	4–8 g (see nutritional table on pack)
1 small slice wholemeal bread sandwich (filled lean meat/tinned fish/cheese/salad/egg)	10 g
1 medium slice wholemeal bread sandwich (filled lean meat/tinned fish/cheese/salad/egg)	15 g
1 small wholemeal roll (filled lean meat/tinned fish/cheese/salad/egg)	20 g
Small pot Icelandic yogurt (150 g)	11.5 g
Small pot diet yogurt (120 g)	12 g
Small pot full fat yogurt (120 g)	15 g
Weight Watchers Chocolate mousse	16 g
20g Popcorn (salted or natural)	9 g
70% cocoa solids chocolate 30 g weight, eg • 3 large squares eg Tesco • 9 small squares eg Green & Blacks • 2 extra dark Lindor chocolate balls	10 g
Graze Peanut Butter & Chocolate Protein Oat bite x 130 g	12 g
Nakd peanut delight bars x 135 g	15 g
Nature Valley Protein Peanut & Chocolate bars x 140 g	10 g

match the carbohydrate snack to the insulin on board/active insulin (the same approach can be used after a corrective dose).

– Check or estimate 'insulin on board/active insulin'
  - CSII: check 'insulin on board/active insulin'
  - MDI: either use an App that estimates insulin on board/active insulin or estimate by assuming insulin on board/active insulin reduces by 25% per hour (ie, at 1 hour 75%, at 2 hours 50%, at 3 hours 25%, at 4 hours 0%).
– Consume healthy snack containing carbohydrate to match the insulin on board/active insulin MINUS 10 g (to take some account of that already consumed as quick acting carbohydrate in avoiding/treating hypoglycaemia)
  - The easiest approach is to work out in advance the amount of carbohydrate per 1 unit insulin on board/active insulin using the median of the mealtime ratios. Note: as insulin resistance changes through pregnancy the ratios and therefore the amount of carbohydrate required per unit of insulin on board/active insulin will change:
    Example 1*: if ratios are breakfast 1:8 g, lunch 1:12 g, evening meal 1:9 g the median ratio is 1:9 g. If IOB 3 units, the woman would have a healthy snack containing (3x9) – 10 = 17 g carbohydrate*
    Example 2*: if ratios are breakfast 1:4 g, lunch 1:7 g, evening meal 1:6 g the median ratio is 1:6 g. If IOB 3 units, the woman would have a healthy snack containing (3x6) – 10 = 8 g carbohydrate*
    Example 3*: if ratios are breakfast 1:4 g, lunch 1:7 g, evening meal 1:6 g the median ratio is 1:6 g. If IOB 1 unit, the woman would not need a snack ((1x6) – 10 = –4 g)*
  - Some women will choose to work this out in real-time each time it occurs using the ratio in place at that time of day

All these options are starting points, and may need adjusting according to individual response.

Predictive low glucose alert when there is no bolus insulin on board (ie, > 4 hours after a meal or other bolus) is due to basal insulin. CSII users may choose to suspend the basal for 1 hour rather than consume quick acting carbohydrate.

Using insulin suspend features in pregnancy

Some RT-CGM systems, when used with an appropriate insulin pump, have the facility for the sensor glucose to trigger suspension and resumption of insulin delivery. Insulin suspension can be triggered when either the sensor glucose is predicted to reach a low threshold if the sensor glucose keeps falling at the same rate (predictive low glucose suspend) or when the sensor glucose reaches a low threshold. The currently available systems are the Medtronic Guardian Sensor 3 used in the MiniMed 640G or 670G systems (SmartGuard) and the Dexcom G6 with the Tandem t:slim pump (Basal-IQ). The aim of such systems is to avoid, or limit the duration of, hypoglycaemia.

Insulin suspension must not be used to treat hypoglycaemia because it does not work quickly enough.

Insulin suspension may not be sufficient to avoid hypoglycaemia, particularly if there is insulin on board from a bolus. In pregnancy, during waking hours most episodes of hypoglycaemia occur 1.5–4 hours after mealtime bolus when there is insulin on board, due to the large pre-meal boluses required to limit the post-meal glucose peak. In this situation, predictive suspend may not be sufficient to avoid hypoglycaemia, and the person needs to consume quick-acting carbohydrate. During sleeping hours, episodes of hypoglycaemia are usually due to basal insulin and the predictive suspends work well to avoid hypoglycaemia.

After insulin suspension there is a risk of subsequent rebound hyperglycaemia, which is particularly important in pregnancy. Rebound hyperglycaemia is even more likely if the person consumes quick-acting carbohydrate AND the basal is suspended (sometimes called 'double treatment' of hypoglycaemia). To avoid 'double treatment', if the person treats/avoids hypoglycaemia with quick-acting carbohydrate, they should restart the basal as soon as hypoglycaemia is treated/averted and if the predictive suspend feature is ON, the predictive alert (which will usually prompt the person to consume quick-acting carbohydrate) should usually be OFF and vice versa.

Using the MiniMed 640G or 670G systems insulin suspend features in pregnancy

MiniMed 640G or 670G systems insulin suspend features

The MiniMed 640G and 670G systems have both predictive low glucose suspend and low glucose suspend features. Both can be programmed to be on or off at different times and the low threshold can be adjusted.

The predictive low glucose suspend feature ('suspend before low') is triggered when sensor glucose is predicted to reach or fall below a level that is 1.1 mmol/L above the low glucose threshold within 30 min AND sensor glucose is ≤3.9 mmol/L above the low glucose threshold. After a minimum 30 min suspend time, basal insulin delivery is automatically restarted if sensor glucose is at least 1.1 mmol/L above the low limit AND sensor glucose is predicted to be more than 2.2 mmol/L above the low threshold within 30 min. The maximum duration of insulin suspension is 2 hours. The user can manually resume basalinsulin delivery at any time. After a suspend before low event, this feature is unavailable for a period of time (30 min to 4 hours depending on the user response). Note: in the MiniMed 640G or 670G systems, if both alert before low and suspend before low are on, the alert is triggered when insulin delivery is suspended (rather than 30 min before the low glucose threshold).

The low glucose suspend feature ('suspend on low') stops all insulin delivery when the sensor glucose reaches or falls below the low glucose threshold. In earlier MiniMed systems (Paradigm Veo), insulin remained suspended for 2 hours unless manually restarted. In the MiniMed 640G or 670G systems, basal insulin delivery is resumed automatically after a suspend on low event using the same criteria as for resuming after suspend before low. After a suspend on low event, the automatic suspend functionality is unavailable for a period of time (30 min to 4 hours depending on the response).

In the MiniMed 640G or 670G systems, if either suspend before low or suspend on low feature is enabled, the alert on low is automatically turned on. If the pump is suspended and the user does not respond to the low glucose alert within 10 min, a siren sounds and an emergency message appears.

Use in pregnancy
If the low glucose suspend is triggered, the low glucose alert will sound automatically. The person should manage as in Figure 4 (note insulin suspension should not be used to treat hypoglycaemia as it does not work quickly enough) and then restart the basal as soon as hypoglycaemia has resolved.

As discussed above, in pregnancy insulin suspend features may not be enough to avoid hypoglycaemia during the day and 'double treatment' of hypoglycaemia may result in hyperglycaemia.

One practical starting approach in pregnancy for the MiniMed 640G or 670G systems is:
- During usual waking hours.
  - Low threshold set at 3.4–3.6 mmol/L
  - Predictive low glucose alert ON (manage as Figure 4)
  - Predictive low glucose suspend OFF
  - Low glucose suspend ON (as a safety net – should not be needed if the person responds to the predictive low glucose alert appropriately). If the low glucose suspend is triggered, the person should manage as Figure 4 and then restart the basal as soon as hypoglycaemia has resolved
- During usual sleeping hours.
  - Low threshold set at 3.4–3.6 mmol/L
  - Predictive low glucose alert OFF
  - Predictive low glucose suspend ON
  - Low glucose alarm ON automatically. If this is triggered, the person should manage as Figure 4 and then restart the basal as soon as hypoglycaemia has resolved

Using the Dexcom G6/Tandem t:slim insulin suspend features (Basal-IQ) in pregnancy

Basal-IQ system insulin suspend features
The Basal-IQ system has a combined predictive low glucose suspend and low glucose suspend feature. Unlike the MiniMed system, both are either ON or OFF (cannot be programmed to be on or off at different times) and the low threshold is fixed. The Basal-IQ suspends basal insulin when sensor glucose is predicted to reach or fall below 4.4 mmol/L or the actual sensor glucose is ≤3.9 mmol/L. These values cannot be adjusted. If insulin is suspended, an active standard bolus will complete but an extended bolus will be cancelled. Basal insulin delivery is resumed when either the sensor value increases from the lowest point, if the prediction of going below 4.4 mmol/L is no longer valid or if insulin delivery has been stopped for a cumulative 2 hours in the preceding 2.5 hours. These criteria are different from the MiniMed systems and would be expected to restart insulin earlier.

Use in pregnancy
The Tandem t:slim pump became available in the UK in 2018, so we have limited experience of the Basal-IQ system in pregnancy.

As discussed above, in pregnancy insulin suspend features may not be enough to avoid hypoglycaemia during the day and 'double treatment' of hypoglycaemia may result in hyperglycaemia. The approaches suggested for the MiniMed systems cannot be easily used with the Basal-IQ system because the Basal-IQ system cannot be programmed to be on or off at different times and the low threshold is fixed. However, it is possible that the insulin restart criteria of the Basal-IQ system will restart insulin earlier and therefore MAY be less likely to result in rebound hyperglycaemia.

A possible starting approach for those who choose to use the Basal-IQ system is:

- Basal-IQ system ON.
- Set the following alerts and manage as Figure 4 if any are triggered. The basal will be restarted automatically once glucose starts to rise.
- During usual waking hours:
  - 'Urgent Low Soon Alert': ON (alerts 20 min before sensor glucose predicted to reach 3.1 mmol/L)
  - 'Urgent Low Alarm': ON (cannot be turned off) (alarms when sensor glucose reaches 3.1 mmol/L)
  - 'Low Glucose Alert': ON (at 3.4–4.0 mmol/L)
- During usual sleeping hours:
  - 'Urgent Low Soon Alert': OFF
  - 'Urgent Low Alarm': ON (cannot be turned off)
  - 'Low Glucose Alert': OFF or ON (at 3.4–4.0 mmol/L)

Reviewing insulin suspend features in pregnancy

It is important to review how the insulin suspend functions are working for the person.
- If the suspends are happening at the same time of day or night, then the insulin settings should be adjusted.
- If hypoglycaemia is occurring despite alerts/suspends:
  - review how the woman is responding to the alerts
  - consider increasing the threshold, if applicable
- If there is marked rebound hyperglycaemia:
  - check if the person is 'double treating'
  - if the predictive low glucose suspend is on:

  - for those with reduced hypoglycaemia awareness or severe hypoglycaemia, consider the risks/benefits before changing the threshold or turning off suspend features
  - for the MiniMed 640G or 670G system:
    - consider reducing the low threshold
    - consider turning the predictive low glucose suspend off (in which case increase the threshold back up (to 3.4–3.6 mmol/L) and turn on the predictive low glucose alert, and the low glucose suspend and/or low glucose alarm)
  - for the Basal-IQ system:
  - consider turning Basal-IQ off (in which case turn on the 'Urgent Low Soon Alert' and the 'Low Glucose Alert' (at 3.4–4.0 mmol/L))
  - for those where the rebound hyperglycaemia is mainly during the day, consider manually turning the Basal-IQ off when getting up every morning and back on when going to bed at night
- What to do if sensor not used or not working. Consider reducing the overnight basal by 10%, particularly if impaired hypoglycaemia awareness, history of severe hypoglycaemia, sleeps alone, or one or more overnight predictive low glucose/low glucose alerts/suspends per week.

Using sensor arrows

Using sensor arrows to modify the pre-meal bolus doses

There is some debate about whether and how to use the RT-CGM arrows to modify pre-meal insulin boluses. This may be introduced once users have become familiar with the RT-CGM and some women may not use it at all. There are several approaches to adjusting pre-meal boluses based on arrows. We usually use the ISF rule or the 10/20% rule (Table 9).

- ISF (insulin sensitivity factor)-based insulin rule: add or subtract a fixed amount of insulin from the calculated dose based on the arrows. This is fairly straightforward. However, the amount of insulin will need to be adjusted as insulin sensitivity changes through pregnancy.
- 10%/20% insulin rule: increase or decrease calculated bolus by 10% or 20% based on the arrows. This has the advantage that it automatically takes account of insulin sensitivity changes through pregnancy. However, it does involve more arithmetic. It does vary with varying meal carbohydrate content (which may or may not be an advantage). In practice it generally gives similar results to the ISF rule, particularly in pregnancy where meal carbohydrate content is usually 30–60 g.

Using sensor arrows to guide healthy snacking

Eating 10–20 g healthy carbohydrate snack at 60–90 min post-meal can 'absorb' the insulin action tail of the meal- time insulin to avoid a low glucose later. This can be fine-tuned using information from the sensor. For example, if at 1–2 hours post-meal the sensor glucose is in target with up arrows, the snack may not be needed (see Table 12). Healthy snacking is discussed in the section 'Using sensor data to improve glycaemic control in pregnancy: diet, activity and insulin considerations'.

Using sensor arrows to guide corrective insulin doses

The sensor arrows can be used to decide whether or not to give a corrective dose. For example, we usually advise not to give a corrective dose if arrows show glucose is falling (Table 12).

A note on hybrid closed loop systems in pregnancy

Three hybrid closed loop systems are either currently licensed for use in the UK or likely to become available in the near future.

Table 9 Using arrows to modify pre-meal boluses

Dexcom G6	Medtronic Guardian Sensor 3	FreeStyle Libre	Over past 20 min sensor glucose has been:	Option A (ISF rule)	Option B (10%/20% rule)
				Calculate bolus (for food and any corrective) and:	
↑ ↑ or ↑	↑↑↑ or ↑↑	↑	Rising quickly	• Add 0.5 units (if TDD <25) • **Add 1 unit (if TDD 25-60)** • Add 2 units (if TDD >60)	increase by 20%
↗	↑	↗	Rising	• Add 0.2 units (if TDD <25) • **Add 0.5 unit (if TDD 25-60)** • Add 1 unit (if TDD >60)	increase by 10%
→	No arrow	→	Stable or changing slowly	No adjustment	No adjustment
↘	↓	↘	Falling	• Subtract 0.2 units (if TDD <25) • **Subtract 0.5 unit (if TDD 25-60)** • Subtract 1 unit (if TDD >60)	reduce by 10%
↓ or ↓ ↓	↓↓ or ↓↓↓	↓	Falling quickly	• Subtract 0.5 units (if TDD <25) • **Subtract 1 unit (if TDD 25-60)** • Subtract 2 units (if TDD >60)	reduce by 20%

Box 3: Starting RT-CGM or flash glucose monitoring during pregnancy

Sensor start visit: key issues to cover
Many of the key issues are directed at avoiding over-reaction to sensor glucose readings.

- **Prepare for the psychological impact of seeing 'out of range' sensor glucose readings. This is particularly important for women starting glucose sensors in pregnancy**
- **When sensor use will be stopped (usually at 3 months after birth, unless the woman fulfils criteria for RT-CGM or flash glucose monitoring outside of pregnancy)**
- **Sensor glucose may be different from CBG (due to sensor lag and sensor accuracy). If different, the fingerstick CBG should be considered accurate**
- **Tips for calibration, if the system requires it**
- **When to check fingerstick glucose**
- **When to check sensor glucose**
- **What the arrows mean**
- **Set up low glucose alerts but usually keep all other alarms off**
  - **Dexcom G6: Urgent Low Soon, Urgent Low, Low Glucose alerts**
  - **Medtronic Guardian Sensor 3: Alert Before Low**
- **Avoiding & treating hypoglycaemia (Figure 4).**
  - **RT-CGM: responding to alerts; flash glucose monitoring: if sensor glucose is either ≤6 mmol/L with ↓ OR ≤5 mmol/L with ↘ , or <3.5 mmol/L**
  - **Do not use sensor glucose to monitor recovery from hypoglycaemia**
  - **Hypoglycaemia at 1.5–4 hours post-meal is common in pregnancy. Emphasise the need for a healthy carbohydrate snack after avoiding/treating hypoglycaemia at this time**
- **Avoid correcting post-meal hyperglycaemia and hyperglycaemia after hypoglycaemia. If sensor glucose still above target range at 2 hours with sensor glucose either stable or increasing (upward arrow(s)), then it is reasonable to give a corrective dose**
- **Set up on the appropriate system for viewing and sharing sensor data**

Issues to cover at subsequent visits

- **Setting up the high glucose alerts**
- **Using arrows to guide post-meal healthy snacking**
- **Using arrows to modify pre-meal boluses (some women, with their diabetes healthcare professionals, may decide not to use this)**
- **Setting up insulin suspend functions (if applicable) (for those with hypoglycaemia unawareness/severe hypos this may need to be set up at sensor start)**
- **Support and encourage 'reflection in real-time'. Users will often have started to do this themselves.**
- **Interpreting RT-GCM downloads**
- **Target range is 3.5–7.8 mmol/L. Every 5% increase in time in target range improves outcomes. Aiming for sensor glucose:**
  - **In target range (3.5–7.8 mmol/L) at least 70% of the time (>16h 48 min per day)**
  - **Above target (>7.8 mmol/L) less than 25% of the time (<6 h per day)**
  - **Below target (<3.5 mmol/L) less than 4% of the time (<1 h per day)**
    - **including < 3.0 mmol/L less than 1% of the time (<15 min per day)**
- **What to do if sensor not used or not working for RT-CGM (with alerts) users**

The MiniMed 670G system has a hybrid closed loop feature (Auto Mode) and is available in the UK at the time of writing. This is not suitable for use in pregnancy because the glucose target of 6.7 mmol/L is set too high for pregnancy and cannot be changed.
The Control-IQ system (using the Dexcom G6 sensor and Tandem t:slim pump) is not available in the UK at the time of writing. The target glucose for the Control-IQ system is set at 6.7 mmol/L, which is too high for pregnancy. However, it has a 'sleep mode' feature which uses a lower glucose target of 6.1 mmol/L. During pregnancy, the 'sleep mode' feature could be applied 24 hours a day (set from midnight to 23.59 hours) although the target of 6.1 mmol/L may still be too high for pregnancy.

The Cambridge Artificial Pancreas system (Cam APS FX) (using the Cambridge algorithm, Dexcom G6 sensor and Dana pump) received a CE mark for use in pregnancy in 2020. It is currently used in research clinic settings (http:// www.uea.ac.uk/aidapt/home) and may be available in selected NHS clinics (https://camdiab.com). In addition to automated basal insulin delivery, it also allows the user to increase or decrease basal insulin delivery (using the 'boost' or 'ease-off' functions). The glucose target can be set by the user, with current recommendations to aim for 5.5 mmol/L in early pregnancy, lowering to 5.0 mmol/L after 16–20 weeks.

Evidence for flash glucose monitoring before and during pregnancy

Flash glucose monitoring, like RT-CGM, measures interstitial glucose. It generates a glucose value every 15 min and stores the data. However, unlike RT-CGM, it only displays the glucose data when the user scans the device and, currently, it does not have alerts/alarms. The FreeStyle Libre is the only flash glucose monitoring system currently available.

FreeStyle Libre readings have been compared against fingerstick CBG measurements in pregnancy,[18] and the FreeStyle Libre device has a CE mark for use in pregnancy. However, there are no randomised controlled trials of flash glucose monitoring versus fingerstick monitoring or versus RT-CGM in pregnancy or outside pregnancy. An observational study of women with type 1 diabetes using RT-CGM or flash glucose monitoring in pregnancy showed that women using flash glucose monitoring spent more time with sensor glucose below 3.5 mmol/L at all gestational ages.[19] It is not

Box 4: Tips for established users of RT-CGM or flash glucose monitoring who are newly pregnant

Key issues that should be emphasised at the first pregnancy visit (and in pre-pregnancy clinic) include things that are different in pregnancy and problems that are more likely to occur in pregnancy due to the tight glucose targets.

- **Sensor should be worn as much as possible (aiming for at least 90–100% of the time)**
- **Target range is 3.5–7.8 mmol/L. Every 5% increase in time in target range improves outcomes. Aiming for sensor glucose:**
  - **In target range (3.5–7.8 mmol/L) at least 70% of the time (>16h 48 min per day)**
  - **Above target (>7.8 mmol/L) less than 25% of the time (<6 h per day)**
  - **Below target (<3.5 mmol/L) less than 4% of the time (<1 h per day)**
    - **including < 3.0 mmol/L less than 1% of the time (<15 min per day)**
- **There will be many 'out of range' sensor glucose readings and it is important to avoid over-reacting to these**
- **When to check fingerstick glucose. In addition to the 'always' list, which is the same as outside pregnancy, in pregnancy advise women to check fingerstick glucose pre-meals, before taking action to avoid hypoglycaemia, or correct hyperglycaemia**
- **When to check sensor glucose**
- **Discourage setting too many alerts/alarms. Particularly discourage setting the high glucose alert too low.**
- **Avoiding and treating hypoglycaemia (Figure 4)**
  - **RT-CGM: responding to alerts; flash glucose monitoring: if sensor glucose is either ≤6 mmol/l with ↓ OR ≤5 mmol/L with ↘ , <3.5 mmol/L)**
  - **Do not use sensor glucose to monitor recovery from hypoglycaemia**
  - **Hypoglycaemia at 1.5–4 hours post-meal is common in pregnancy. Emphasise the need for a healthy carbohydrate snack after avoiding/treating hypoglycaemia at this time**
- **If the RT-CGM system supports insulin suspend functions, review strategies for avoiding rebound hyperglycaemia**
- **Avoid correcting post-meal hyperglycaemia and hyperglycaemia after hypoglycaemia. If sensor glucose still above target range at 2 hours with sensor glucose either stable or increasing (upward arrow(s)), then it is reasonable to give a corrective dose**
- **Using arrows to guide post-meal healthy snacking**
- **Using arrows to modify pre-meal boluses (some women, with their diabetes healthcare professionals, may decide not to use this). For those already using the 'ISF' rule, advise this will need to be adjusted as insulin sensitivity changes through pregnancy**
- **What to do if sensor not used or not working for RT-CGM (with alerts) users. Consider reducing the overnight basal by 10%, particularly if impaired hypoglycaemia awareness, history of severe hypoglycaemia, sleeps alone, or 1 or more overnight predictive low glucose/low glucose alerts/suspends per week**
- **Make sure set up on the appropriate system for viewing and sharing sensor data**

clear whether this relates to baseline differences between women using RT-CGM or flash glucose monitoring, differences in diabetes self-management behaviours (for example, women using RT-CGM might take more action to avoid hypoglycaemia), or to differences in sensor accuracy at lower glucose concentrations.[16] However, it reinforces the advice that women using glucose sensors should check fingerstick glucose before taking action to treat or avoid hypoglycaemia (Figure 4).

Indications for flash glucose monitoring before and during pregnancy

Women preparing for pregnancy may be assessed for flash glucose monitoring using the usual criteria for adults with diabetes.[20-22]

Flash glucose monitoring is not covered in the current NICE guidelines.[1] However, at the time of writing, NHS England will reimburse CCGs for the cost of flash glucose sensors for pregnant women with type 1 diabetes for 12 months in total inclusive of the postpartum period.[22] In Northern Ireland, Scotland and Wales, pregnant women with type 1 diabetes would meet criteria for flash glucose monitoring due to the frequency of glucose checking required.[20,21]

Information provided by flash glucose monitoring

Like RT-CGM, flash glucose monitoring displays sensor glucose, direction of change arrows (Table 5) and graphs. Unlike RT-CGM, current information is only provided when the user scans the device.

Flash glucose monitoring set-up in pregnancy

The FreeStyle Libre does not require calibration and, at the time of writing, does not have alerts/alarms. As it does not have alerts, the glucose target range on the Libre reader/App should be set at 3.9–7.8 mmol/L (the Libre reader/App will not allow the lower limit to be set below 3.9 mmol/L). (Note the target range for reports can be adjusted to 3.5–7.8 mmol/L when viewing downloads in LibreView; see section 'An approach to the consultation and looking at downloads…').

Image used with permission: Abbott

Using flash glucose monitoring in pregnancy

Most of the advice for using flash glucose monitoring in pregnancy is the same as for RT-CGM. The key difference is that flash glucose monitoring does not have alerts for predicted or actual hypoglycaemia or for hyperglycaemia. This means it is important to scan the device regularly and understand what combination of sensor glucose and arrows might suggest risk of hypoglycaemia.

When to check fingerstick CBG

Women should be advised to test fingerstick CBG as for RT-CGM.

When to look at flash glucose monitoring readings

As for RT-CGM, pregnant women should look at flash glucose readings ('scan') on getting up in the morning, pre-meals, 1 hour post-meals (for reflection in real-time), 2 hours post-meals (for reflection in real-time and possible corrective action), pre-bed and if they wake in the night. It is particularly important that this is done in women using flash glucose monitoring as there are no alerts/alarms. This means that glucose may be out of range for a prolonged period without being noticed, particularly overnight. Women might consider setting an alarm or planning to wake up once in the night to check sensor glucose and take action if out of target range.

Using flash glucose monitoring information to try to avoid hypoglycaemia

Flash glucose monitoring does not have a predictive low glucose alert or a low glucose alert. A practical approach is to assume that, if sensor glucose is either ≤6 mmol/L with ↓ OR ≤5 mmol/L with ↘, hypoglycaemia is likely within the next 15–30 min. In these situations, or if sensor glucose is <3.5 mmol/L, the person should manage this as for response to predictive low glucose alert/low glucose alert (see Figure 4).

The following are managed in the same way as for RT-GCM: hypoglycaemia detection, treatment and monitoring recovery; responding to high sensor glucose; using arrows to modify pre-meal bolus doses; and reflection and downloads.

USING SENSOR DATA TO IMPROVE GLYCAEMIC CONTROL IN PREGNANCY: DIET, ACTIVITY AND INSULIN CONSIDERATIONS

One of the ways RT-CGM works is to allow the user to see the effect of different foods, activity and insulin (dose and timing) on their glucose levels both in real-time and on downloads. Users should be encouraged to reflect in real-time to modify future behaviour. For example:

- my peak post-meal sensor glucose was at target, I think that is because …, next time I will do the same thing!
- my peak post-meal sensor glucose was above target, I think that is because …, next time I will … (think food, activity, insulin).

Pregnant women using RT-CGM should be encouraged to look at their RT-CGM downloads at least twice per week.

The following guidance is based on experience gained from supporting women with diabetes optimising their glucose levels during pregnancy. It is important to acknowledge that individual women's experience will vary and advice should be tailored. Some women will need to make more dietary changes than others and attention should be given to ensure their diet meets the additional nutritional requirements for pregnancy and food safety recommendations (women can be directed to NHS Choices for further information).

There are no specific UK recommendations for weight gain in pregnancy. International guidelines recommend women with pre-pregnancy BMI 18.5–24.9 kg/m^2 gain 11–16 kg over their pregnancy, with those underweight recommended to gain more weight and those overweight or obese recommended to gain less weight.[23] For women who are obese, there is no evidence that a stable weight or minimal weight loss (<5 kg) is associated with adverse pregnancy outcomes. However, weight loss resulting in the presence of ketones should be avoided. The UK guidance discourages 'eating for two' and advises that an additional 200 kcal/day are required only in the last trimester in pregnancy. Women should avoid excessive weight gain as this will lead to greater insulin resistance and make achieving glucose levels within pregnancy targets more challenging.

Sensor data are useful to identify glucose excursions and facilitate conversations. There is something powerful about seeing the data that helps focus the mind with curiosity rather than judgement and makes it easier to identify habitual behaviours that might not ordinarily come to light during a consultation. It can be helpful to consider potential changes for diet, activity and insulin.

Options for managing post-meal glucose excursions

In pregnancy the post-meal glucose targets are:

- peak (which usually occurs about 1 hour) after meals <7.8 mmol/L
- 2 hours after meals <6.4 mmol/L

Postprandial glucose tends to swing up faster and higher during pregnancy. The amount of bolus insulin required to limit this peak to below 7.8 mmol/L may cause a glucose below target at 1.5–4 hours because of the duration of action of rapid-acting insulin. Broadly speaking, the peak (1 hour) postprandial glucose is predominantly influenced by meal carbohydrate content, type of food (glycaemic index), activity and the timing of insulin in relation to the meal. The 2-hour postprandial glucose is predominantly influenced by the type of food (high fat or protein meals result in prolonged hyperglycaemia), activity and amount of insulin in relation to carbohydrate.

The following guidance provides a range of strategies to limit the post-meal rise and reduce the risk of a later low glucose and is

Table 10 Options for managing post-meal glucose excursions

	Peak=above target AND 2-4h=within target	Peak=above target AND 2-4h=below target	Peak=within target AND 2-4h=below target	Peak (1hr)=above target AND 2-4 h=above target
Adjust diet				
Carbohydrate quantity at each meal (restrict to 15–60 g/meal)	✔	✔	✔	✔
Carbohydrate type (switch to lower GI)	✔	✔	✔	✖
Increase lean protein or healthy fats	✔	✔	✔	✖
Healthy snack containing 10–20 g carbohydrate at 60–90 min post-meal	✖	✔	✔	✖
Split the meal	✔	✔	✖	✖
Adjust activity				
Activity (15 min) at <1 hour post-meal	✔*	✔*	✖	✔
Adjust insulin				
Pre-bolus: increase time between bolus and meal by 5–10 min	✔	✔	✔*	✖
Insulin:carbohydrate ratio: adjust by 20% to give more insulin (see Table 3)	✔ (with other options)	✔ (with other options)	✖	✔
'Basal to bolus switch' ('superbolus') (for CSII users) (see Box 1)	✔	✔	✔*	✖

*May need to reduce insulin:CHO ratio if choose this option.

summarised in Table 10. Different women are likely to find different options practically useful.

Dietary considerations for managing post-meal glucose excursions

- Total carbohydrate intake 150–180 g/day achieves the best glucose levels for most women. Those who eat more than 200 g carbohydrate per day tend to see more glucose out of target. In pregnancy, we recommend a minimum of 120 g carbohydrate per day and advise pregnant women not to restrict their carbohydrate intake below this. This is important as people with diabetes may follow lower carbohydrate diets for glycaemic control outside of pregnancy. Women who eat less than 120 g carbohydrate per day tend to see more ketone production and their diets tend to be less nutritionally balanced.
- Limit the carbohydrate load at each occasion by spreading carbohydrate intake over three meals with between-meal healthy snacks. The following carbohydrate loads work well for most:
  - Breakfast 15–20 g
  - Mid-morning healthy snack 10–20 g
  - Lunch 40–60 g
  - Mid-afternoon healthy snack 10–20 g
  - Evening meal 40–60 g
  - (post evening meal carbohydrate-containing snack is usually not needed as evening meal tends to be higher in protein/fat and activity levels lower)
- Accurate carbohydrate counting. People with type 1 diabetes should have access to a type 1 diabetes education programme.[24] However, pregnant women may not have completed such a programme, or may need a refresher, and should be offered additional education on carbohydrate counting as needed. Miscalculating carbohydrate by 10 g can make a 2–3 mmol/L difference in glucose. Although it is not possible to be 100% accurate, women should be encouraged to weigh foods where possible and use the tools available such as carbohydrate counting lists, Apps (eg, my fitness pal/Carbs & Cals) and food labels. In pregnancy, women may choose to avoid foods where estimating carbohydrate content is more difficult – for example – avoiding mixed sources such as risotto, pasta bakes and limiting meals out.
- Carbohydrate type: Choosing carbohydrates that are slowly digested and absorbed (low glycaemic index (GI)) can help limit postprandial peaks and level out glucoses between meals (see Appendix 1). Women should be counselled on how to reduce the post-meal rise by actions such as: freezing bread;

cooling rice/pasta/potato and then reheating or eating cold; eating more vegetables, including pulse vegetables with carbohydrates.

- Breakfast suggestions to optimise glucose levels: Breakfast time is when insulin resistance is greatest and therefore carbohydrate is least tolerated. Women should be given examples of good low GI breakfast that are ≤20 g carbohydrate such as one slice of wholegrain or rye bread/toast with non-carbohydrate topping (egg/mushrooms/tomato/avocado/cream cheese) or non-sweetened plain yogurt (eg, Greek style or natural yoghurt) with a portion of fruit topped with nuts/seeds.
- Keeping a food diary: Seeing how glucose rises after meals may be unsettling for many women. Women should be supported to see this information as useful, helping them to identify which meals/carbohydrate choices are working well and which may be best avoided or need additional management strategies. Keeping a food diary helps to use post-meal sensor data reflectively.
- Protein: Increasing protein quantities at meals can help aid satiety, meet the additional 6 g daily requirement for pregnancy, help level out glucose levels between meals and avoid the post-meal dip (delayed conversion protein to glucose).
- Fat: There may be benefit to adding healthy fat (eg, eggs, olive oil, nuts, cream cheese) with meals to limit immediate post-meal glucose rise and extend glucose tail. This should be used with caution for women who are overweight or obese.
- Eating carbohydrate-containing healthy snacks between meals: Eating 10–20g carbohydrate at 60–90 min post-meal can 'absorb' the insulin action tail of the meal-time insulin to avoid a low glucose later. For example, if there is a pattern of peak glucose at target with subsequent predicted or actual hypoglycaemia, introducing a 10–20 g carbohydrate healthy snack at 60–90 min post-meal can avoid hypoglycaemia. This can be fine-tuned using information from the sensor. For example, if at 1–2 hours post-meal the sensor glucose is in target with up arrows, the snack may not be needed (see Table 12).
- Dietary data from CONCEPTT showed that 44% of daily carbohydrate intake came from non-recommended sources (eg, confectionery, biscuits and pastries).[25] Women should be counselled on making healthy snack choices (Table 8). For women who do not require additional carbohydrate between meals, lists of carbohydrate-free healthy snacks should be made available (Table 11).
- Splitting the meal: If peak (1 hour) above target and 2 hour predicted/actual hypoglycaemia, consider 'splitting the meal'. For example, if the meal is a sandwich (40 g carbohydrate) and a piece of fruit (15 g carbohydrate), bolus for 55 g carbohydrate, eat the sandwich and delay eating the fruit for about 60–90 min).
- Hydration: Staying well hydrated will ensure optimal insulin circulation and aid glucose management. There are no specific UK recommendations for pregnancy but 1.2–1.6 L/day is likely to meet requirements for most.

Table 11 Healthier snack choices with minimal carbohydrate

The following snack suggestions will have little or no effect on blood glucose levels so are good choices if you are feeling hungry between meals

- Vegetable stick (eg, cucumber, carrot, celery)
- Dips: hummus, salsa, cream cheese, cottage cheese, guacamole, peanut butter
- Cherry tomatoes
- Cubes of cheese with pickled onion or gherkin
- Natural nuts/seeds
- Boiled egg
- Olives
- Sun blush/sun dried tomatoes
- Mini stuffed peppers
- Lettuce roll-ups – fill with chopped egg, tuna and mayonnaise, cream cheese, cottage cheese, grated cheese, cooked meat (leftovers from roast or bolognaise sauce), well cooked prawns
- Sugar-free jelly
- Frozen sugar-free squash ice lollies
- Vegetable cup a soup
- Lean ham rolled with cream cheese

Activity considerations for managing post-meal glucose excursions

- Activity post-meal is a great tool for limiting the post-meal glucose rise and can make up to a 2 mmol difference. Women should try to be active for 15 min after meals and be encouraged to consider their day to make space and time to enable this to happen. The type of activity can be walking, cycling, being active around the house, stairs. Women who have pelvic pain may consider seated activity.

Insulin considerations for managing post-meal glucose excursions

- Pre-bolusing: Outside pregnancy, if rapid-acting insulin is injected just before a meal, the average rise in glucose can be 8–10 mmol/L whereas, if rapid-acting insulin is injected 15–20 min pre-meal, the average rise in glucose is 3–5 mmol/L. In late pregnancy time to peak insulin is delayed.[4] Where possible, bolus doses should be given:
  - Up to 20 weeks of gestation: 15±10 min pre-meals
  - Beyond 20 weeks of gestation: extend towards 45±15 min pre-meals
- If the sensor glucose is rising and/or above target pre-meal, some women may find it helpful to give the bolus (for the meal and any correction) and then wait until the sensor glucose graph flattens out or glucose starts to fall before eating
- Increasing the I:C ratio will reduce glucose levels at 1 and 2 hours post-meals (Table 3)
- Basal to bolus switch ('Super Bolus') (Box 1) is an option for some women using insulin pumps.
- For CSII users, insulin should usually be given as a normal bolus, as insulin is needed upfront to limit the post-meal rise. Occasionally, women may find that particular meals (high fat (>40 g) and/or high protein (>25 g)) result in glucose in target at 1 hour but above target at 2 hours and beyond. One option

Table 12 Using sensor glucose, sensor arrows and time in relation to meal to decide on action

Sensor arrow			Sensor glucose									
Dexcom G6	Medtronic Guardian Sensor 3	Libre	Pre-meal (target 4–5.3 mM)			1 h post-meal (target 4–7.8 mM)			2–4 h post-meal (target 4–6.4 mM)			No active insulin (target 4–5.3 mM)		
			Predicted low/low	In target	Above target	Predicted low/low	In target	Above target	Predicted low/low	In target	Above target	Predicted low/low	In target	Above target
↑ ↑↑ or ↑	↑↑↑ or ↑↑	↑		Calculate bolus** & add 1 unit (if TDD 25–60)***			Reflect, check again 1 h	Reflect, DON'T correct, check again 1 h		Reflect check again 1 h	Reflect, consider corrective dose		Check again 1 h	Calculate corrective & add 1 unit (if TDD 25–60)***
↗	↑	↗		Calculate bolus** & add 0.5 unit (if TDD 25–60)***			Reflect, check again 1 h	Reflect, DON'T correct, check again 1 h		Reflect check again 1 h	Reflect, consider corrective dose		Check again 1 h	Calculate corrective & add 0.5 unit (if TDD 25–60)***
→	No arrow	→	Treat/ avoid hypo* then bolus	Calculate bolus**, no adjustment		Treat/ avoid hypo*, then 20g CHO HS	Reflect, check again 1 h	Reflect, DON'T correct, check again 1 h	Treat/ avoid hypo*, then 10 g CHO HS	Reflect	Reflect, consider corrective dose	Treat/ avoid hypo*	No action	Calculate corrective
↘	↓	↘	Treat/ avoid hypo* then bolus	Provided NOT predicted low, calculate bolus** & subtract 0.5 unit (if TDD 25–60)***		Treat/ avoid hypo*, then 20g CHO HS	Provided NOT predicted low, 15–20 g CHO HS	Reflect, check again 0.5–1 h	Treat/ avoid hypo*, then 10 g CHO HS	Provided NOT predicted low, consider 10–15 g CHO HS	Reflect, check again 0.5–1 h	Treat/ avoid hypo*	Provided NOT predicted low, consider 10 g CHO HS	Check again 0.5–1 h
↓ or ↓↓ ↓	↓↓ or ↓↓↓	↓	Treat/ avoid hypo* then bolus	Provided NOT predicted low, calculate bolus** & subtract 1 unit (if TDD 25–60)***		Treat/ avoid hypo*, then 20g CHO HS	Provided NOT predicted low, 15–20 g CHO HS	Reflect, check again 15–30 min	Treat/ avoid hypo*, then 10 g CHO HS	Provided NOT predicted low, consider 10–15 g CHO HS	Reflect, check again 15–30 min	Treat/ avoid hypo*	Treat/avoid hypo*	Reflect, check again 15–30 min

* For hypoglycaemia treatment/avoidance see Figure 4.
** Calculate bolus for food and any corrective.
*** If TDD < 25 units OR > 60 units the amount of insulin is different, see Table 9.

CHO=carbohydrate, HS=healthy snack, TDD=total daily dose.

is to avoid such meals in pregnancy. An alternative is to increase the total bolus and use a dual wave bolus. A reasonable starting point in pregnancy is to increase the bolus calculated from the I:C ratio by 30% and use a dual wave (combination) bolus with 70% given initially and the remainder over 3 (2–6) hours, depending on the individual's experience.[9]

- Morning sickness: If women are vomiting they may feel nervous about giving their insulin early. Women should be advised that they will still see a rise in glucose after a meal even when they have vomited. A useful strategy is to give third to half their bolus insulin before eating and the rest when they are confident they will keep it down.

Options for managing overnight glucose

Dietary considerations for managing overnight glucose

- Eat evening meal before 19:30 hours (or at least 3 hours before going to bed).
- Apply above guidance to ensure post evening meal glucose in target.
- Any snacks taken in the evening should be carbohydrate-free (Table 11).

Insulin considerations for managing overnight glucose

- Basal rates should be adjusted at least 1–2 hours before the inflection point on a CGM trace. Generally, aim for no more than six basal time blocks per 24 hours and avoid short (less than 1–2 hour) blocks unless there is a clear requirement. Short time blocks are not usually needed, and multiple short time blocks make it more difficult to see patterns and make further adjustments.
- Basal rates should be adjusted by 10–20%.

AN APPROACH TO THE CONSULTATION AND LOOKING AT DOWNLOADS WITH PREGNANT WOMEN USING DIABETES TECHNOLOGY

Before consultation, refer to Language Matters.[26] This guide provides practical examples of language that will encourage positive interactions with people living with diabetes and subsequently positive outcomes.

The first consultation in pregnancy

- Consider congratulating the woman on her pregnancy.
- Ask how she is finding her pregnancy, without reference to diabetes.
- Acknowledge that being pregnant can be a hard experience for many women who don't have diabetes. As a person who has diabetes it can be harder still.
- Explore what support the women has which may help her managing her diabetes in pregnancy. For example, can her partner, family or friend support her? Does she have access to online groups for pregnant women with diabetes, or face to face groups?
- Signpost to further information about pregnancy in women with type 1 diabetes (eg, JDRF pregnancy toolkit).
- Contact details for the diabetes pregnancy team (routine and emergency).
- Share the outcomes for pregnant women with diabetes compared to the general population. The majority of pregnant women with type 1 diabetes leave hospital after birth with a healthy baby. However, the risks of adverse pregnancy outcomes are higher than in the general maternity population. Some women will wish to know the statistics.[5] Sharing this data with women right at the beginning of their pregnancy demystifies the risks that they face. These risks can be reduced, although not completely eliminated, by optimising glucose levels.
- Review expected care during pregnancy (frequency of appointments, scans, etc).[1]
- Review 'non-glycaemic' risk factors (blood pressure, smoking, medications), presence of diabetes complications (retinopathy, nephropathy, neuropathy, etc) and other interventions (offer folic acid 5 mg if not already taking, and consider aspirin to reduce the risk of pre-eclampsia).[1] Further discussion of these issues is outside the remit of this guide.
- Review hypoglycaemia awareness, any episodes of severe hypoglycaemia, hypoglycaemia treatment. Ensure she has glucagon at home and in date and partner/family/friends know how to use it. Review DVLA rules.
- Ensure she has a blood ketone meter with in-date strips. Review sick day rules for pregnancy and that she should use fingerstick glucose when following sick day rules.
- Discuss the glucose targets in pregnancy that are associated with improved neonatal outcomes (reduced risk of large for gestational age, neonatal hypoglycaemia and NICU admission). For women already using glucose sensors, discuss aiming for at least 70% of time in range 3.5–7.8 mmol/L. Keep in mind that for many women these targets seem unachievable. Emphasise that every 5% increase in time in range 3.5–7.8 mmol/L improves outcomes.
- Discuss expected changes in insulin requirements in pregnancy. At the first visit discuss particularly that insulin requirements are likely to reduce in the first trimester.
- Document pre-pregnancy insulin doses/settings.
- For CSII users:
  - Rules for the management of unexplained hyperglycaemia in pregnancy. Should use fingerstick glucose when managing unexplained hyperglycaemia
  - Must carry a rapid-acting insulin pen with them at all times in case of set/pump failure. Should have access to long-acting insulin pens
  - Document their pump settings regularly (in case of pump failure)
  - Reinforce need to perform set changes early in the day, not in the evening
- Offer RT-CGM or flash glucose monitoring according to guidelines. Discuss when sensor use will be stopped (usually at 3 months postpartum, unless the woman fulfils criteria for RT-CGM or flash glucose monitoring outside of pregnancy).
- For established sensor users, see tips in Box 4.

Issues to actively review periodically in pregnancy

There are some issues that should be actively reviewed periodically, perhaps at 12, 20 and 28 weeks of gestation.

- Ascertain if there is additional support that she needs – for example, from psychological services. People with diabetes are more than twice as likely to be diagnosed with depression.[27]
- Review expected care during pregnancy (appointments, scans, etc).[1]
- Review 'non-glycaemic' risk factors and diabetes complications.[1] Further discussion of these issues is outside the remit of this guide.
- Discuss expected changes in insulin requirements in the upcoming weeks.
- Review hypoglycaemia awareness, severe hypoglycaemia, hypoglycaemia treatment, glucagon, DVLA rules.
- Ensure she has a blood ketone meter with in-date strips. Review sick day rules for pregnancy and that she should use fingerstick glucose when following sick day rules.
- Nutritional value of snacks. Encourage healthy snacks (see section 'Using sensor data to improve glycaemic control in pregnancy:…').
- For CSII users:
  - Rules for the management of unexplained hyperglycaemia in pregnancy. Should use fingerstick glucose when managing unexplained hyperglycaemia
  - Must carry a rapid-acting insulin pen with them at all times in case of set/pump failure. Should have access to long-acting insulin pens
  - Document their pump settings (in case of pump failure)
  - Reinforce need to perform set changes early in the day, not in the evening

- For sensor users:
  - What to do if sensor not used or not working for RT-CGM (with alerts) users. Consider reducing the overnight basal by 10%, particularly if impaired hypoglycaemia awareness, history of severe hypoglycaemia, sleeps alone, or 1 or more overnight predictive low glucose/low glucose alerts/ suspends per week
  - When in hospital, RT-CGM or flash glucose monitoring SHOULD NOT be used to adjust variable rate intravenous insulin (VRII)

Looking at the download

Data from glucose sensors have changed how we consider glycaemic control, particularly looking at the peak post-meal glucose (rather than certain time points) and the time in, above and below target range. However, there is a lot of information and it may be useful to have a structured approach.

- Make sure to point out all the positives. Both pregnant woman and health professionals tend to focus on what is 'wrong' so it can be improved and may forget to acknowledge positives.
- Ask the woman what they think needs to be addressed: they live with their diabetes every day.
- Ask the woman when changes were last made and what they were. They may have made changes (to diet, activity, insulin pump settings or MDI doses) and it is helpful to know this when looking at the download.
- Support real-time reflection and reflection on downloads and changes made.
- Make small achievable goals and reassure women that every 5% extra time in range (3.5–7.8 mmol/L) is associated with improved neonatal outcomes.

Review of settings and structure on the download

It is helpful to sense check the settings and structure of carbohydrate intake, insulin delivery and RT-CGM because it can help to generate ideas about what might need to be adjusted. These ideas can be checked with the woman and using the daily graphs and changes made if needed.

Carbohydrate intake

- Total carbohydrate: recommended 150–180 g/day, minimum 120 g/day. Remember the total carbohydrate reported only includes what is entered: a considerable amount of carbohydrate may be consumed as snacks without bolus.
- Carbohydrate per meal: in pregnancy usually recommended breakfast 15–20 g, lunch and evening meal 40–60 g.

Insulin delivery

- Set change every 2–3 days.
- Over-riding the bolus calculator. The reason for over-riding should be sought. Remember some of this may be over-riding the bolus advice to account for arrows.
- Basal:bolus split:
  - Up to 20 weeks of gestation 50:50 to 35:65
  - Beyond 20 weeks of gestation 35:65 to 25:75
- Insulin:carbohydrate ratios (1 unit of insulin for X grams of carbohydrate):
  - Up to 20 weeks of gestation: breakfast 300/TDD, other meals 400/TDD
  - Beyond 20 weeks of gestation: breakfast 200/TDD, other meals 300/TDD
- Bolus calculator target: 5 mmol/L (5.5 mmol/L if problematic hypoglycaemia).
- Insulin sensitivity factor (ISF) (1 unit of insulin reduces glucose by Y mmol/L):
  - Up to 20 weeks of gestation 130/TDD
  - Beyond 20 weeks of gestation consider 100/TDD, particularly if women are using RT-CGM (with alerts)
  - If more insulin resistant at certain points in the day, is ISF in keeping with this?

RT-CGM / flash glucose monitoring

- Check the % of sensor use. Expect at least 90% sensor use with modern systems.
- For Libre users, check number of scans aiming for at least 8 per day.
- Time in target glucose range.
  Current recommended CGM targets[2] are sensor glucose:
  - In target range (3.5–7.8 mmol/L) at least 70% of the time (>16h 48 min per day)
  - Above target range (>7.8 mmol/L) less than 25% of the time (<6 h per day)
  - Below target range (<3.5 mmol/L) less than 4% of the time (<1 h per day)
    - including <3.0 mmol/L less than 1% of the time (<15 min per day).

  The aim is to achieve these targets as early as possible in pregnancy and then maintain them. To display time in this range on the download:
    - Dexcom G6: in the Clarity system for each person go to 'Interactive Report', 'Settings' tab and adjust the thresholds to 3.5–7.8 mmol/L. The information for the adjusted time in range is given in the 'AGP' tab
    - Medtronic Guardian Sensor 3. The MiniMed 640G system does not provide information on time in range for RT-CGM. For those using MiniMed 670G, in the CareLink system go to 'My Profile', 'My Report Settings', 'Glucose Settings' and adjust the thresholds to 3.5–7.8 mmol/L. The information for the adjusted time in range is given in 'Assessment and Progress' report. This will change the report settings throughout
    - Libre: in LibreView for each person go to 'Glucose History', 'Glucose Reports', 'Report Settings' and adjust the report settings to 3.5–7.8 mmol/L. For Libre users, focus on the time above range aiming for <25% time >7.8 mmol/L
  - Compare with previous time in range. If time in range is decreasing, reasons for this should be sought.
  - Emphasise the amount of time spent in range and remember that every 5% increase is important (many women will focus on the out of target readings and will get disheartened)

- For Libre users, focus on the mean glucose and time above range aiming for <25% time >7.8 mmol/L, again remembering that every 5% less time above range is associated with improved neonatal outcomes.
- Target mean glucose 6.0 mmol/L. Compare with previous mean glucose.
- Check the low alert settings (depends on the system).
- Check the insulin suspend system settings (depends on the system).
- High alert settings:
  - Alert on high
    - During usual waking hours 12–15 mmol/L
    - During usual sleeping hours 8–10 mmol/L
  - Generally no other high alerts.
- Number of alerts (for RT-CGM):
  - No more than 6–8 glucose alerts per 24 hours. More than this risks 'alert fatigue' and suggests something needs to be changed (which might be the insulin delivery 'settings', pre-emptive action to avoid the alert, the response to the alert or the alert settings).

Review the daily graphs and agree changes

- Generally look at the download since changes were last made which may be only a few days ago. In pregnancy there is little point in looking at the summary data over the preceding month because insulin requirements may have changed and it is likely that multiple changes have been made.
- Check potential issues generated by review of settings and structure of carbohydrate intake, insulin delivery and RT-CGM/flash glucose monitoring. If confirmed on review of the trace, suggest changes. Note: if not confirmed on review of the trace, changes may not be required.
- Focus on the overnight (sleeping hours) trace:
  - Are there too many alarms/suspends?
  - Is the glucose in target going to bed? If not:
    - Eat evening meal before 19:30 hours (or at least 3 hours before going to bed)
    - Apply above guidance to ensure post evening meal glucose in target
    - Any snacks taken in the evening should ideally be carbohydrate-free
  - Is the trace in target overnight? The overnight targets are 4–5.3 mmol/L. Remember a trace that is flat at 6–7.8 mmol/L will look good on the daily graphs at first sight, but is a prolonged period above target. However, given variation in insulin requirements night-to-night, it is very difficult to achieve glucose 4–5.3 mmol/L every night with current diabetes technology
    - Adjust basal rate at least 1–2 hours before the graph inflection. Generally, aim for no more than six basal time blocks per 24 hours and avoid short (less than 1–2 hour) blocks unless there is a clear requirement.
    - Basal rates should be adjusted by 10–20%
    - Reflect on total basal before and after changes. This is particularly important for women using CSII where it is easy to make very small adjustments
- Focus on postprandial glucose profile:
  - Targets, if achievable without causing problematic hypoglycaemia,[1] are:
    - Peak (which is usually about 1 hour) after meals <7.8 mmol/L
    - 2 hours after meals <6.4 mmol/L
  - Strategies for managing postprandial glucose excursions are given in Table 10 and section 'Using sensor data to improve glycaemic control in pregnancy: diet, activity and insulin considerations.'
  - Are there too many post-meal predictive low glucose alerts? Aim for no more than 1–2 per day. If occurring after the same meal, consider:
    - Introducing a healthy carbohydrate snack 30 min before usual time of predictive low glucose alert
    - Basal to bolus switch ('Super Bolus') (Box 1)
- Is the action in response to the predictive low glucose alert working (ie, are hypos being avoided without causing rebound hyperglycaemia)?
- Check for overtreatment of hypoglycaemia. This may be too much carbohydrate, using long-acting rather than quick-acting carbohydrate, 'double treatment' (quick-acting carbohydrate AND basal suspend), using the sensor to monitor recovery from hypos.
- Are corrections for hyperglycaemia being used appropriately (look specifically for use of post-meal corrections, post-hypoglycaemia corrections, multiple corrections and correcting when glucose is falling).
- Look at the basal requirement during the day
  - In pregnancy, this is often lower than true basal requirements (because of the high bolus doses). For this reason, basal rate testing (missing a meal or zero carbohydrate meal) is generally not used in pregnancy Furthermore, pregnancy is a ketogenic state.
  - Adjust basal rate at least 1–2 hours before the graph inflection. Generally, aim for no more than six basal time blocks per 24 hours and avoid short (less than 1–2 hour) blocks unless there is a clear requirement.
  - Basal rates should be adjusted by 10–20%.

USING DIABETES TECHNOLOGY IN PARTICULAR CIRCUMSTANCES IN PREGNANCY

Using diabetes technology in hospital

Women using insulin pump therapy (CSII) are usually safest remaining on CSII if admitted to hospital, unless incapacitated.[28] Women using RT-CGM or flash glucose monitoring can continue to use it as they would outside hospital provided they are confident the sensor is working well (eg, smooth graph, no gaps, sensor glucose has been close to fingerstick glucose, and sensor glucose as expected in the circumstances).

RT-CGM or flash glucose monitoring SHOULD NOT be used to adjust intravenous variable rate insulin infusions.

Managing steroid-induced hyperglycaemia using CSII

Corticosteroids may be given to promote fetal lung maturation. All women between 24 and 34 weeks of gestation who are at risk of pre-term birth within the next 7 days should be given antenatal corticosteroids.[29] In women between 34 and 36 weeks of gestation at risk of pre-term birth, antenatal corticosteroids should be discussed. In those women who are having a planned prelabour caesarean section up to 38+6 weeks of gestation, corticosteroids should be considered. In this situation, 1–4 doses of steroid (betamethasone or dexamethasone) are usually administered. This steroid treatment can significantly elevate blood glucose levels and women are usually admitted for 24–48 hours (depending on the steroid regimen and impact on glucose levels) for intensive monitoring and intravenous insulin treatment. However, in most cases women on insulin pump therapy can use this to effectively manage the elevation in blood glucose. Such women should still be admitted, because they may need to be started on intravenous insulin therapy if glucose remains above target despite best efforts using insulin pump. However, they can be considered for early discharge potentially reducing overnight stays.

The response to steroids is unpredictable with increases in insulin requirements potentially ranging from 20% to 100%. The effect on glucose levels usually persists for about 24 hours after the last steroid dose. The key to successfully managing blood glucose levels over this period is frequent monitoring: at least hourly during the day, and two hourly overnight. This is greatly facilitated by use of RT-CGM or flash glucose monitoring.

We recommend:

- The obstetric team should inform the diabetes team before (or as soon as possible after) steroids are started. The diabetes team will:
  - discuss with the woman whether she wishes to try to manage steroid-induced hyperglycaemia using her own pump
  - provide guidance (outlined below)
  - prescribe a VRII (without glucose) to be added if glucose remains above target despite best efforts using insulin pump. The VRII should be individualised, taking into account the woman's usual insulin requirements and that she is continuing on CSII.
- If the woman chooses to manage the steroid-induced hyperglycaemia using her own pump, she will be responsible for the management of her glucose testing and pump.
- Check glucose hourly (2-hourly overnight). Target 3.5–7.8 mmol/L. Glucose can be monitored using the sensor, but women should check a fingerstick glucose at least every 4 hours.
- At 4–6 hours after first steroid dose, start a 50% temporary basal rate increase (150% of usual basal insulin infusion rate). This may need to be adjusted.
- At 4–6 hours after first steroid dose, increase mealtime bolus doses by 50%. This is best achieved by using the bolus calculator as normal (which calculates the insulin dose for the meal and any correction required), then adding 50% to the recommended dose and overriding.
- Additional corrective doses should be given using the woman's usual ISF (we do not routinely change ISF) and target (usually 5 mmol/L). Corrective doses may be given every hour if needed. The woman may use the bolus calculator to work out the corrective dose, but may need to override the recommended dose (as this will take into account the insulin on board).
- VRII (without glucose) should be added:
  - If glucose levels are not within target after two correction boluses (assessed 1 hour after 2nd correction)
  - If blood ketones ≥0.5 mmol/L (blood ketones should be checked if glucose >10 mmol/L)
- If VRII (without glucose) is required:
  - CSII should be continued, including boluses for food, but not corrective doses
  - The VRII should be individualised, taking into account the woman's usual insulin requirements and that she is continuing on CSII. The VRII should ideally be written in advance.
  - Fingerstick glucose (NOT sensor glucose) should be used to adjust VRII. Midwives are responsible for ensuring fingerstick glucose is checked hourly and for adjusting VRII. The woman continues to be responsible for managing her CSII.
- The woman's standard insulin regimen can usually be reinstated 24 hours after the last steroid dose, but occasionally the increased doses need continuing for up to 72 hours if blood glucose levels remain elevated.

Using diabetes technology before and during birth

Women should usually continue their recommended glucose monitoring and insulin delivery regimen until in established labour or fasting prior to caesarean section.

Women on CSII may be converted to VRII plus glucose for labour or in preparation for a caesarean birth (traditional management). Women who choose to may continue to use their CSII during labour or fasting prior to a caesarean and birth, provided their glucose levels are within an acceptable range (see Figure 5) and the woman/ birth partner is able and willing to manage her CSII.

The safety of using insulin pump therapy through delivery is well established, with evidence that continuing insulin pump therapy is at least as good in maintaining glycaemic control as switching to intravenous insulin.[30] Furthermore, the ability to switch to a pre-programmed basal rate after birth means that women continuing on their pump are less likely to experience the marked variability in glucose levels often seen postpartum in those who have been on an intravenous insulin infusion. Pump manufacturers do not recommend the use of insulin pumps in the operating theatre, but in our experience there is no problem with continuing insulin pump therapy through a caesarean section. However, if

there are concerns, the long insulin action time in late gestation means that the insulin pump can be disconnected immediately before knife-to-skin contact, provided the pump is reconnected IMMEDIATELY postpartum and is disconnected for an ABSOLUTE MAXIMUM of 60 min, thus avoiding the need for intravenous VRII.

Continuous glucose monitoring (CGM) has been shown to be accurate during delivery.[31] Women continuing CSII (or MDI) during labour or leading up to a caesarean birth who are using either RT-CGM or flash glucose monitoring can continue to use this during delivery, ensuring that a glucose level is recorded at least hourly. However, if the sensor glucose is out of target range 4–7 mmol/L, a CBG level should be checked before action is taken. In addition, CBG should be checked at least 4-hourly. If a VRII plus glucose is started, CBG should be checked hourly (RT-CGM or flash glucose monitoring SHOULD NOT be used to adjust intravenous variable rate insulin infusions).

Planning for management of glycaemic control during labour or prior to a caesarean birth

We recommend a discussion at a 34–36 week clinic appointment to plan for birth. This should include:

- Prescribing individualised VRII (plus glucose).
- For CSII users, decision about whether the woman will plan to continue on CSII through labour or prior to caesarean and birth or convert to VRII (plus glucose).
- For women planning to continue on CSII:
  - educate the woman and her birth partner on using CSII through labour or prior to caesarean birth and provide written information
  - check birth partner is able to set temporary basal rates and give correctives through the pump
  - explain the responsibilities of the woman, her birth partner and staff. Women should understand that most staff on the labour ward will not be familiar with insulin pumps
  - document the insulin sensitivity (correction) factor to be used
- Determine postpartum insulin pump settings/doses (see Box 5) and document in the woman's care plan. For CSII users, the postpartum basal rate can be programmed into the pump in advance as an additional basal profile. For most pumps, all other settings must be programmed after birth. In the future, partial or fully automated insulin delivery systems (closed-loop systems) may be approved for use in pregnancy and consideration should be given regarding appropriate glucose targets for the postpartum period.
- For sensor users, explain:
  - Can continue to use sensor as normal prior to established labour/fasting for caesarean section and after birth. For women continuing CSII (or MDI) through birth, they can continue to use sensor ensuring that a glucose level is recorded at least hourly. However, if the sensor glucose is out of target range 4–7 mmol/L, a CBG level should be checked before action is taken. In addition, CBG should be checked at least 4-hourly
  - If a VRII (plus glucose) is started, CBG should be checked hourly (RT-CGM or flash glucose monitoring SHOULD NOT be used to adjust intravenous variable rate insulin infusions.)
- A checklist of what supplies need to be brought into hospital (Table 13).
- Provide with hospital menu carbohydrate content.
- Diabetes team contact details and diabetes follow up arrangements for after birth.

Table 13 Checklist for labour ward bag for women using diabetes technology

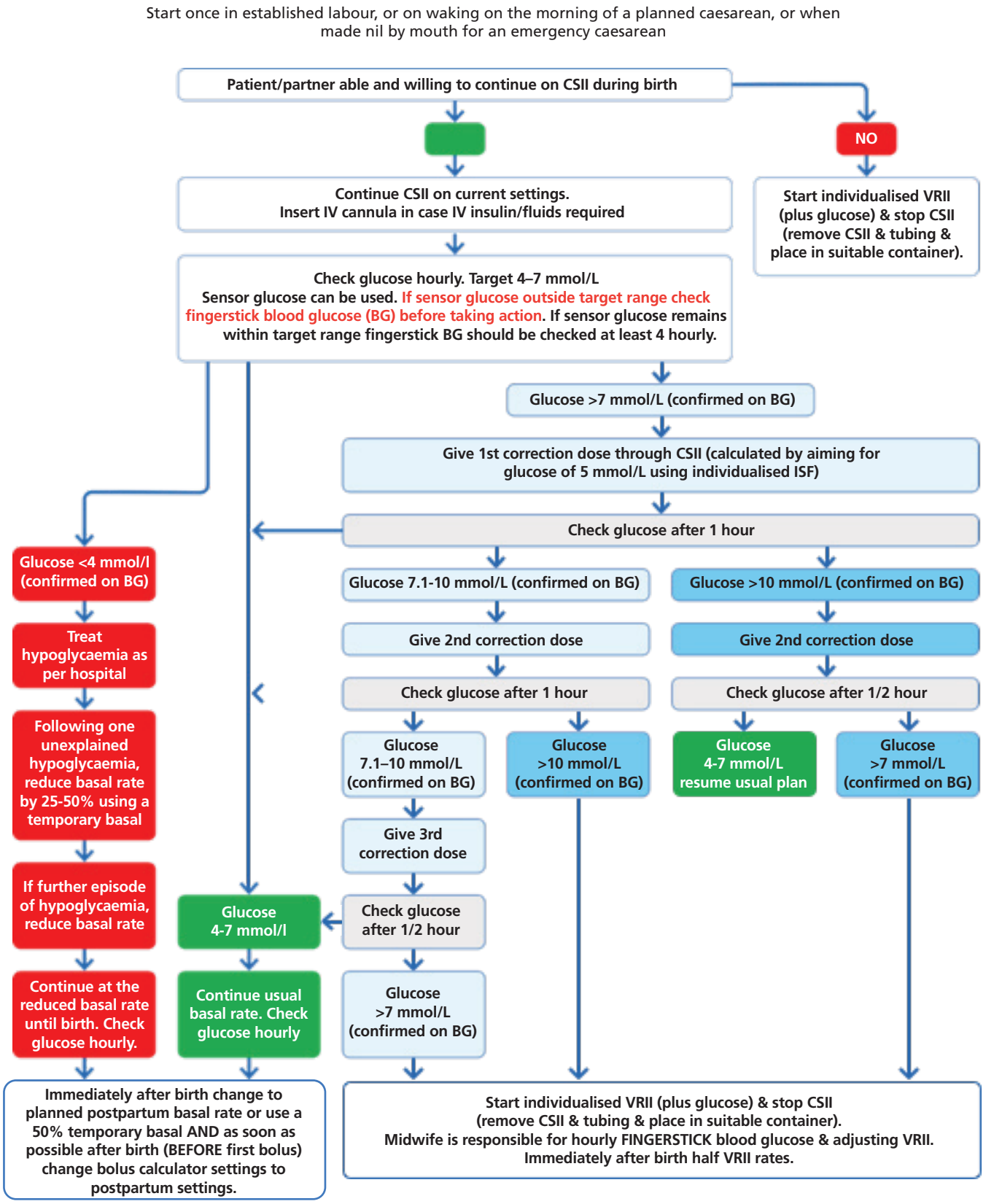
Hypoglycaemia treatment of your choice	
Carbohydrate and non-carbohydrate snacks	
Glucose meter and strips	
Hospital menu carbohydrate content	
Insulin pump users	
Spare sets of batteries x2	
Reservoirs / cartridges x2	
Vial of rapid-acting insulin x1	
Infusion sets (including lines) x5 and inserter device (if using)	
Insulin syringes x10	
Vial of long-acting insulin	
Information about using insulin pump through birth (if applicable)	
Information about post-birth pump settings	
Sensor users	
Spare sensor and inserter device	
Transmitter charger (if applicable)	
Reader/receiver/phone charger	

Managing glucose levels using CSII through labour

A protocol for managing glycaemic control through labour and birth using CSII is shown in Figure 5. This is based on a protocol developed by Peter Hammond, which several UK centres have been using since at least 2013 (a simplified version is presented in the DTN-UK guideline for managing CSII in hospitalised patients[28]).

- The pump cannula and/or sensor should be sited well clear of the potential surgical field in case of emergency or planned caesarean section. The pump is best sited just below the rib cage posteriorly.
- An individualised VRII (plus glucose) should be prescribed in advance in case it is required.

Figure 5. Protocol for managing glucose levels for women continuing on insulin pump therapy during labour and birth or during caesarean birth.



- Women should have a cannula inserted.
- Glucose should be checked and recorded hourly. This can be sensor glucose. However, if the sensor glucose is out of target range 4–7 mmol/L, a CBG level should be checked before action is taken. In addition, CBG should be checked at least 4-hourly.
- The woman should continue her usual basal infusion rates and give correction doses through the pump using individualised ISF and target 5 mmol/L.
- Target glucose range 4–7 mmol/L.
- If glucose remains above 7 mmol/L despite giving correction doses following the protocol, an individualised VRII (plus glucose) should be started and CSII stopped. Remove CSII and tubing and place in a suitable container (there is no need to turn off CSII or to remove the subcutaneous cannula).
- If the woman or birth partner is unable or unwilling to manage CSII, an individualised VRII (plus glucose) should be started and CSII stopped.
- Immediately after birth, basal rates should be reduced to the planned postpartum basal rates, or a 50% temporary basal rate can be used. As soon as possible after birth (and certainly before the first bolus) the woman MUST change the bolus calculator settings to her postpartum settings.
- If the VRII plus glucose is used, insulin rates should be halved at birth. CSII can be restarted once the woman is able to self-manage the pump. All settings should be changed to the planned postpartum settings. The VRII should continue for 60 min after restarting CSII.

Managing glucose levels using CSII through planned caesarean birth

Women who are fasting overnight prior to a planned caesarean birth are advised to check their glucose at 3 am and on waking in the morning and take corrective action if glucose is out of target range 4–7 mmol/L.

Hypoglycaemia should be treated with oral quick-acting carbohydrate and the woman should inform the anaesthetist if this has been necessary. After an episode of hypoglycaemia during fasting, consider reducing the basal rate using a temporary basal rate setting. On the morning of the planned caesarean, the protocol in Figure 5 should be followed from waking.

Responsibilities of staff, the woman and her birth partner for women continuing CSII through birth

The key to successful use of insulin pump therapy during labour or prior to caesarean and birth is to have a clear protocol which all staff on the labour ward are aware of, including not only the obstetric staff but other staff who may be involved, such as anaesthetists. The birth partner should be closely involved in planning for what is going to happen at the time of birth so that they are able to manage the pump, if needed.

While the woman remains on CSII, the woman and her birth partner are responsible for checking and documenting glucose hourly, giving correction via CSII, adjusting basal rates and pump settings as required including after birth. The midwife is responsible for ensuring the woman/birth partner remains able and willing to manage the CSII, that glucose is checked and documented hourly, and that if glucose is persistently (see below) above 7 mmol/L, VRII plus IV glucose is started and the CSII stopped. If the woman is on VRII plus glucose, the midwife is responsible for checking CBG (NOT sensor glucose) hourly and adjusting VRII rates as prescribed.

USING DIABETES TECHNOLOGY AFTER BIRTH

Management immediately after birth until discharge from hospital

Insulin requirements drop immediately after birth and women are at increased risk of hypoglycaemia in the first hours to days after birth. The emphasis should be on avoidance of hypoglycaemia. Several factors may contribute including:

- Continued action of pregnancy insulin doses (due to large insulin doses and longer duration of insulin action in late pregnancy)
- Continuing to use pregnancy insulin doses/pump settings, which may be due to not changing the settings or not believing that the much lower recommended doses are enough
- Continuing to aim for tight glycaemic targets of pregnancy
- Reduced hypo awareness
- Nausea and vomiting
- Breastfeeding

We recommend postpartum insulin pump settings be agreed (see Box 5) and documented in the woman's individual care plan at 34–36 weeks. (The postpartum basal rate can be programmed into the pump in advance as an additional basal profile. For most pumps, all other settings must be programmed after birth).

- For women who continued to use CSII through birth, basal rates should be reduced immediately after birth to the planned postpartum basal rates, or a 50% temporary basal rate can be used. As soon as possible after birth (and certainly before the first bolus) the woman MUST change the pump settings to her postpartum settings.
- If the VRII plus glucose is used for birth, insulin rates should be halved at birth. CSII can be restarted once the woman is able to self-manage the pump. The woman should change all settings to the planned postpartum settings, re-site the pump (perform a set change) and restart the CSII. The VRII should continue for 60 min after restarting CSII.

It is commonly advised to omit the bolus insulin for the first light meal after birth.

Women should be advised that, for the first week or so, postpartum glucose target range should be 6–10 mmol/L15 (to avoid

Box 5: Postpartum insulin pump settings

(Note for the first week or so postpartum glucose target range should be 6–10 mmol/L (to avoid hypoglycaemia) and post-meal glucose excursions up to 12–15 mmol/l are expected and acceptable.)

There are four key changes:

Insulin:carbohydrate ratio (I:C ratio)
- **Pre-pregnancy settings (consider adjusting to give less insulin if tight glycaemic control pre-pregnancy)**
- **OR between 1:10g and 1:15g**

Insulin sensitivity factor (ISF)
- **Pre-pregnancy settings (consider adjusting to give less insulin if tight glycaemic control pre-pregnancy)**
- **OR 1 unit to reduce glucose by between 3 and 4 mmol/L**

Target for bolus calculations
- **Maintain single target at 5 mmol/L (consider increasing (eg, to 6.5 mmol/L) if impaired awareness of hypoglycaemia)**

Basal rate
The basal infusion rate should be reset according to one of the following:
- **pre-pregnancy basal rate profile (consider reducing if tight glycaemic control pre-pregnancy), reduced by 20% if breastfeeding**
- **50% of the basal rate profile in late pregnancy (any time after 34 weeks of gestation), reduced by a further 20% if breastfeeding**
- **A total daily basal of 0.25 units/kg based on the woman's pre-pregnancy weight or 0.2 units/kg if breastfeeding**

hypoglycaemia) and post-meal glucose excursions up to 12–15 mmol/L are expected and acceptable. This can be difficult to get used to after the tight glycaemic targets in pregnancy. Women should be advised to check glucose routinely (by whichever method they are using) when they wake in the morning, pre-meals, (2 hours post-meals for those using sensors), before bed and when getting up in the night. Additional glucose checks may be required around breastfeeding.

Women should be advised that the recommended bolus doses via the bolus calculator will be much lower than they are used to in pregnancy, and to 'believe' the bolus calculator. The diabetes team should offer to review pump settings daily until discharge from hospital.

Management in the postpartum period

For the first few weeks at least, life with a new baby can be unpredictable, with less routine, less sleep and demand feeding. There continues to be a risk of hypoglycaemia. Women will require support in transitioning back to outside of pregnancy targets and practices and managing glycaemic control around breastfeeding, if applicable. Doses of insulin will be lower and this can take some getting used to. Diabetes technology can be extremely useful at this time.

Postpartum glucose monitoring and targets are discussed in the previous section. After the first couple of weeks postpartum, the recommended monitoring and targets are the same as outside of pregnancy.

Hypoglycaemia remains a risk as through the whole of pregnancy. Women should be reminded to:
- Always have hypoglycaemia treatments to hand
- Do fingerstick CBG to confirm hypoglycaemia
- Re-check after 10–15 min if continue to feel symptomatic or if impaired awareness of hypoglycaemia

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- Consider additional 10–15 g long-acting carbohydrate depending on time of day
- Reduced hypoglycaemia awareness can be more common in pregnancy; encouraging women to avoid hypoglycaemia will help restore hypo awareness.

Using insulin pump therapy (CSII): differences after pregnancy

- Meal bolus timing. Outside of pregnancy, meal bolus doses should usually be administered 15–20 min before eating as this is associated with a lower postprandial glucose excursion.[9] However, we recommend advising parents/carers of young babies to bolus immediately prior to eating to reduce the risk of getting distracted between bolus and eating.
- Insulin pump settings (see Box 5).

- Generally, wait at least 48 hours before adjusting settings (unless hypoglycaemia).
- Use temporary basal rates until patterns are more established.
- As in pregnancy, unexplained hyperglycaemia can be a sign of set failure and risk of ketosis. For management outside of pregnancy, see ABCD-DTN-UK 2018.[9]

Using glucose sensors: differences after pregnancy

- Different target glucose range outside pregnancy (3.9–10 mmol/L).[2]
- Less focus on tight post-meal targets. For the first week or so postpartum, post-meal glucose excursions up to 12–15 mmol/L are expected and acceptable.
- When to look at RT-CGM readings/scan flash glucose monitor is different outside pregnancy. Women should be advised to check glucose routinely when they wake in the morning, pre-meals, 2 hours post-meals for those using sensors, before bed and when getting up in the night (at least 8 times per 24 hours).
- When to check fingerstick glucose. For systems with a non-adjunctive licence (eg, Dexcom G6 and FreeStyle Libre), outside of pregnancy it is not necessary to check fingerstick glucose to calculate pre-meal or other bolus dose or to routinely monitor the accuracy of that particular sensor. The 'ALWAYS' list is the same as in pregnancy.
- Low alerts can be even more important postpartum for hypo avoidance. Generally, keep low alerts/predictive low alerts on. Consider raising the low glucose alert thresholds, particularly if impaired awareness of hypoglycaemia. Consider changing predictive low glucose suspend settings (if using) to ON all the time (rather than only during usual sleeping hours)
- High glucose alert thresholds should be increased to avoid alarm fatigue. They should be set at a level that may indicate system failure (eg, pump failure), for example:
  - Usual waking hours at 15–20 mmol/L
  - Usual sleeping hours at 10–13 mmol/L

Breastfeeding/expressing

Breastfeeding and expressing breast milk can cause hypoglycaemia in some women, particularly in the first few days and when milk supplies increase.[32]

- Postpartum CSII settings should reflect this (Box 5). Pump settings will need ongoing adjustment.
- Always keep hypoglycaemia treatment within reach when breastfeeding.
- Women using glucose sensors should be advised to check their sensor glucose before breastfeeding. If sensor glucose below 6 mmol/L, advise to consume 10–15 g carbohydrate before feeding. Some may find it helpful to check their sensor glucose every 30–60 min for 3 hours after the start of a breastfeeding episode to understand their individual pattern.
- As recommended for all women who are breastfeeding/expressing, encourage healthy eating with increased carbohydrate.[15] When breastfeeding is fully established, up to 450 extra calories per day may be needed.[15] This can be consumed as healthy snacks containing 10–15 g carbohydrate with each feed without insulin cover which will additionally help prevent hypoglycaemia.
- A glass of milk is a good option for a 10–15 g carbohydrate snack to help hydration which is also important whilst breastfeeding.
- Reduced temporary basal rates can be considered for longer feeds but generally are too slow to take effect, and the nature of breastfeeding can be smaller more frequent feeds where carbohydrate snacks can be much faster acting.
- When women stop breastfeeding/expressing, pump settings, particularly basal rate settings, may need to be increased.

Postpartum follow-up

Following regular appointments and healthcare professional contact during pregnancy, it can be difficult for women to suddenly have reduced contact, particularly if they are new to technology in pregnancy. Plans should be put in place at the 34–36-week appointment for postpartum arrangements.

- Contact details for diabetes support immediately post discharge.
- 6–12-week postpartum diabetes follow-up appointment:
  - Review ongoing use of diabetes technology (see next section)
  - Review insulin pump settings and/or RT-CGM to ensure in line with usual guidance outside of pregnancy
  - For women who are breastfeeding, discuss that when they stop breastfeeding/expressing, insulin pump settings, particularly basal rate settings, may need to be increased
  - Discuss contraception and future pregnancy planning
  - Refer back to usual diabetes care team

Stopping diabetes technology postpartum

- Some women may have started diabetes technology specifically for pregnancy and provision of ongoing diabetes technology will need to be reviewed postpartum against the indications outside of pregnancy. This should be made clear to women when they start diabetes technology.
- We recommend that diabetes technology started specifically for pregnancy should continue to be offered for 3 months postpartum.
- For those stopping diabetes technology, support should be provided to allow safe transfer. Use of technology may de-skill women in managing their diabetes without diabetes technology. They may perceive their life without the technology much more negatively.[33] These factors should be taken into account when stopping technology to minimise its impact.

SERVICE CONSIDERATIONS FOR SUPPORTING USE OF DIABETES TECHNOLOGY IN PREGNANCY

This section explores the service requirements for supporting women with diabetes using diabetes technology in pregnancy. It is aligned with the ABCD DTN-UK 'Best Practice Guide: CSII – A guide to service requirements'.[24] The requirements for services supporting RT-CGM/flash glucose monitoring alone are slightly different from services supporting both insulin pump therapy AND RT-CGM/flash glucose monitoring. This is because the consequences of inappropriately managed CSII are likely to be more serious.

Workforce requirements

The core multidisciplinary team

We recommend the core multidisciplinary team (MDT) providing support for women using diabetes technology (pumps and/or sensors) in pregnancy should include:

- Consultant Diabetologist, trained in the relevant diabetes technology and its use in pregnancy
- Diabetes Specialist Nurse (DSN), trained in the relevant diabetes technology and its use in pregnancy
- Diabetes Specialist Dietitian, trained in the relevant diabetes technology and its use in pregnancy
- Obstetrician with awareness of the relevant diabetes technology as it relates to their practice
- Midwives with awareness of the relevant diabetes technology as it relates to their practice
- Access to clinical psychology services with interest and experience of diabetes related issues

NICE pump guidance[14] stipulates that the core MDT providing a pump service (outside of pregnancy) should include a pump-trained Consultant Diabetologist, DSN, Diabetes Specialist Dietitian and access to clinical psychology and must be in place (and trained) prior to initiation of a pump service. These staffing requirements apply to services supporting insulin pump use in pregnancy. We recommend that, for services supporting women using insulin pumps in pregnancy, the diabetes healthcare professionals should be trained in using insulin pumps specifically in pregnancy and the core team should also include a consultant obstetrician and midwives with awareness of insulin pumps as it relates to their practice. There is also a requirement for a wider framework of pump-trained or 'pump-aware' diabetes team members, outside the core diabetes and pregnancy MDT, who have training in the management of pump-specific problems such as set failures or pump failures and in support for the use of insulin pumps for inpatients on labour ward or antenatal wards. Ideally, the pump service should provide a 24-hour, 7-day emergency advice service to deal with clinical problems out of hours, which may require working with other local centres.[24] This is particularly important for women using pumps in pregnancy.

For services supporting RT-CGM/flash glucose monitoring alone, we recommend the core MDT includes a Consultant Diabetologist, DSN and Diabetes Dietitian trained in the use of RT-CGM/flash glucose monitoring in pregnancy and an obstetrician and midwives with awareness of RT-CGM/flash glucose monitoring as it relates to their practice. There is no requirement for a wider framework of RT-CGM/flash glucose monitoring trained diabetes team members outside the core diabetes and pregnancy MDT or out of hours support specifically related to the sensors.

Diabetes technicians or healthcare assistants as part of the MDT

A diabetes technician or healthcare assistant is a valuable member of the team, particularly for larger services, as they free up clinician time.

Their role may include:

- Downloading pumps and sensors before the consultation and transferring the report to the electronic patient record so that it is available for the person with diabetes and clinician to view during the consultation.
- Teaching the person with diabetes the 'mechanics' of using a pump or sensor (eg, how to insert a pump cannula or sensor; how to navigate the menus and functions, how to link to Apps).
- Teaching the person with diabetes how to download their data at home, share their data with their clinic and order supplies.

Workforce competencies

Consultant Diabetologists, DSNs and Diabetes Dietitians should be trained in the use of diabetes technology in pregnancy. For insulin pump therapy, we recommend the team gain initial experience outside the pregnancy service where possible, as the team needs to be experienced particularly in dealing with pump emergencies (such as set or pump failures) as there are potentially serious consequences for both mother and fetus. Staff competencies need to be continually updated. Routine in-house diabetes technology updates are recommended to ensure the whole team remains up to date.

Obstetricians and midwives in the diabetes pregnancy service, and obstetricians, midwives and anaesthetists caring for women with type 1 diabetes on labour ward, should have an awareness of diabetes technology as it relates to their practice. This is covered in more detail in ABCD-DTN-UK 'CSII therapy in hospitalised patients'.[28]

Key points include:

- Diabetes technology does not 'manage' diabetes. Women using current diabetes technology spend more time thinking about and managing their diabetes than women using MDI and fingerstick glucose monitoring and require diabetes self-management skills. Women using diabetes technology can still have hypoglycaemia or hyperglycaemia.
- Insulin pump therapy (also called continuous subcutaneous insulin infusion (CSII)): people on CSII do not take any long-act-

ing insulin so if there is any interruption to insulin delivery then hyperglycaemia and ketoacidosis can develop very quickly.
- Glucose sensors (real-time continuous glucose monitoring (RT-CGM) and flash glucose monitoring): there may be a difference between fingerstick CBG and sensor glucose and sensor glucose lags behind fingerstick CBG. Fingerstick CBG (with clean hands) should be considered accurate. Therefore:
  - DO NOT use sensor glucose to check for hypoglycaemia
  - DO NOT use sensor glucose to monitor recovery from hypoglycaemia
  - DO NOT use sensor glucose to adjust variable rate intravenous insulin infusion
- Diabetes technology should only be adjusted by its user (who has received extensive training), her birth partner (provided he/she has been trained by the diabetes team) or a trained member of the diabetes team. If a pregnant woman is in hospital and she or her birth partner is unable to manage:
  - the insulin pump (CSII): Start variable rate intravenous insulin infusion (VRII) IMMEDIATELY. Remove CSII and tubing and place in a suitable container (there is no need to turn off the CSII or to remove the subcutaneous cannula).
  - the sensor (RT-CGM or flash glucose monitoring): the sensor can be left in place. Institute fingerstick capillary glucose monitoring.

  Please inform the diabetes team.

  Diabetes technology is expensive, so please put all removed technology in a safe place and document.
- Staff responsibilities for women using CSII through birth (see separate section).

Capacity and organisation

Capacity requirements

Estimate the numbers of women eligible for CSII, RT-CGM and flash glucose monitoring in your clinic for forthcoming years. Estimate the numbers: already established on diabetes technology prior to planning pregnancy or becoming pregnant; starting diabetes technology in pre-pregnancy; and starting diabetes technology in pregnancy. Current CSII use varies between centres, but in UK centres with higher pump use, 50% of women with type 1 diabetes are using CSII before pregnancy and 60–80% by the end of pregnancy. As of April 2019, all pregnant women with type 1 diabetes are eligible for flash glucose monitoring and by 2020/21 all should be offered continuous glucose monitoring.

Starting diabetes technology before and during pregnancy: service considerations

Diabetes teams should have skills and knowledge to undertake CSII and sensor initiation independently. Initiation is usually led by a specialist nurse or a dietitian within the team.

Outside of pregnancy, diabetes technology starts are usually done in groups.[9] Women who are planning pregnancy who fulfil criteria for diabetes technology can usually join these groups, although they may need to be prioritised. Pregnant women can also join these groups, however are likely to require fast track individual diabetes technology starts. For women starting sensors for pregnancy, current recommendations envisage starting RT-CGM and/or flash glucose monitoring once women are pregnant. It is important that this is considered in job-planning.

Both pump and sensor starts are twofold. Build in the following time/skill staffing requirements for your service

1. Teaching the person with diabetes the 'mechanics' of using the device (eg, how to insert a pump cannula or sensor; how to navigate the menus and functions; how to link to Apps).
2. Training and supporting the woman in day-to-day use of the technology, to make sense of the data and to make the necessary changes herself.

Group pump start is discussed in the DTN Best Practice Guide: CSII.[9]

For one-to-one pump therapy initiation during pregnancy:
- Day 1 – insulin start. Allow 2 hours for the face-to-face visit.
- Daily contact by phone/email for the first week. Allow 1–2 hours throughout the week for this.
- Day 3 – review cannula change and complete education. Allow 1 hour. This can be done virtually for some women.
- Twice weekly (or more) contact by phone/email for the second week. Allow 30–60 min throughout the week for this.

For one-to-one sensor initiation during pregnancy:
- Day 1: allow 1–2 hours.
- Week 2: allow 1 hour.

Follow-up for women using diabetes technology before and during pregnancy

Nature of contact

Contacts may be:
- Face-to-face
- Remote consultations, usually with the diabetes educators via telephone, webcam or email

Follow-up for women with type 1 diabetes planning pregnancy

Women with diabetes who are planning to become pregnant should be offered pre-pregnancy care and advice before discontinuing contraception.[1] This may be best provided in a dedicated pre-pregnancy service. Pre-pregnancy care is discussed in detail in the NICE guideline.[1] Women with type 1 diabetes planning pregnancy should be encouraged to attend type 1 diabetes structured education. Those who are using glucose sensors should aim for 70% in glucose range 3.9–10 mmol/L. They should be advised of the availability of diabetes technology in pregnancy. Frequency of contact should be individualised, but likely to be monthly virtual contact with 3-monthly face-to-face appointments.

Follow-up for women with type 1 diabetes who are pregnant

NICE recommend that women with diabetes have contact with the joint diabetes and antenatal clinic for assessment of blood glucose levels every 1–2 weeks throughout pregnancy.[1] Women using diabetes technology should continue to be seen in the joint diabetes and antenatal clinic where they have access to specialist obstetric and midwifery care as well as diabetes technology expertise. It is our experience that women may need more frequent contact (whether or not they are using diabetes technology), particularly when insulin requirements are changing rapidly, when the target glucose levels are not achieved or when a new treatment has been started.

For pregnant women already established on diabetes technology, we recommend the clinic bases capacity requirements on an average of weekly scheduled contact alternating face-to-face and remote consultations throughout pregnancy plus one unscheduled contact (usually remote) per month. Some women will need more frequent and some less frequent contact. Women starting diabetes technology in pregnancy will need more frequent contact (see below).

Face-to-face clinic appointment duration

It is important to allow adequate appointment time.[24] The consensus from across the working group is:

- 30–45 min for certain visits, for example:
  - first visit in pregnancy (45 min)
  - detailed review (to include proactive review of hypoglycaemia, sick day rules, and specific issues for CSII and sensor users (see section 'Issues to actively review periodically in pregnancy')) perhaps at 12, 20 and 28 weeks (30 min)
  - 34–36-week visit (30–40 min) to include planning for diabetes management for birth and after birth.
- 20–30 min for routine follow-up

Note these appointment times do not include time for downloading or obstetric/midwife review. Women with additional medical problems or diabetes complications may require longer appointments. The appointment length also depends on the model used for the MDT clinic detailed below. Some models (eg, models 3 and 4 below) will require extra capacity for ad hoc reviews by more than one MDT member to deliver the desired efficiencies. The clinic template must also take into account time needed for post-clinic MDT meetings (essential requirement for models 2–5 below).

Face-to-face clinic set-up and structure

There are three main clinic types for face-to-face consultant-led clinics for women using diabetes technology in pregnancy:

1. Women using diabetes technology seen in a general joint diabetes antenatal clinic. Such clinics include women with pre-existing diabetes (eg, type 1 and type 2 diabetes) and women with gestational diabetes. Care must be taken that women using diabetes technology are seen by staff with the appropriate competencies and there is time for longer appointments.
2. Women using diabetes technology seen in a separate joint diabetes antenatal clinic specifically for women with pre-existing diabetes.
3. Women using diabetes technology in pregnancy seen in a diabetes clinic separate from antenatal clinic. Note this does not meet NICE requirements for joint diabetes and antenatal clinic care, however, it may be useful particularly in early pregnancy when there is less requirement for obstetric/midwifery input.

Within this there are five models of providing the diabetes aspects of diabetes in pregnancy care (discussed in detail in ABCD-DTN-UK Service Delivery Guide[24]). In brief:

- **Model 1**: all women seen simultaneously in a joint MDT appointment with diabetes doctor, DSN and dietitian. This is resource intensive, but may be appropriate for teams starting a new diabetes technology in pregnancy service with small patient numbers or services where pregnant women with pre-existing diabetes are seen in a separate clinic to those with gestational diabetes.
- **Model 2**: all women seen by each member of the diabetes MDT individually and sequentially at each visit in a 'one-stop shop' fashion. Very resource intensive.
- **Model 3**: women seen by one or more diabetes MDT team members at each appointment matched according to the needs of the woman and the requirements at that stage of pregnancy. Requires: either pre-clinic or in-clinic triage; all members of the diabetes pregnancy MDT to be able to function as diabetes educators and see diabetes technology users independently while recognising when a woman may benefit from specific physician, nurse or dietitian input; and the capacity to arrange reviews by additional MDT members within the clinic.
- **Model 4**: mixture of MDT and single clinician appointments matched according to the needs of the woman and the requirements at that stage of pregnancy. Requirements as for model 3.
- **Model 5**: group diabetes educator sessions in addition to individual scheduled appointments (delivered according to models 1–4). Group sessions in pregnancy may not be practical due to relatively small numbers at different stages of pregnancy with different requirements. However, group sessions may be useful for starting diabetes technology (see below).

Models 2–5 require either a post clinic multidisciplinary meeting (MDM) or the ability to discuss patients within clinic. We have found models 3 or 4 with the option for model 2 at the first visit in pregnancy to be the most workable.

Remote consultations

Remote consultation by telephone, email or webcam are useful for supporting change between face-to-face clinic visits. Consultations may be scheduled or ad hoc. The advantages and requirements are outlined in ABCD DTN-UK Best Practice Guide: Service

Requirements.[24] Remote consultations require the person with diabetes to download remotely. Remote consultations typically take 15 min; however, additional time for administration (eg, time for set-up, capturing activity, documentation, etc) and review of downloads will be required.

Clinical MDT meetings

Clinical MDT meetings are important for discussing cases and for fostering a consistent approach to diabetes technology by the whole team. It is usually not practical to include obstetricians and midwives in a clinical MDT meeting focused on diabetes technology and glycaemic control and a separate clinical MDT meeting may be required.

The format, remit and frequency of a diabetes clinical MDT meeting will depend on the size of the service, clinic model (for example, model 1 may not require a separate MDM) and experience of the team. Cases may be discussed in a specific diabetes technology and pregnancy MDM, a pregnancy and diabetes MDM (including all women with type 1 diabetes or pre-existing diabetes whether or not using diabetes technology) or as part of a general type 1 diabetes MDM (including non-pregnant people). The forum for discussing women planning pregnancy must also be considered. Criteria for MDT discussion may be all pregnant (± planning pregnancy) women using, or being considered for, diabetes technology at every MDT meeting or specific criteria such as:

- Considering starting diabetes technology.
- Considering changing diabetes technology (eg, flash glucose monitoring to RT-CGM).
- Not reaching targets.
- Complex, challenging and difficult cases, problems or situations.
- Problematic hypoglycaemia (impaired awareness of hypoglycaemia or severe hypoglycaemia)
- Routine discussion of all pregnant women using diabetes technology at particular pre-defined times in pregnancy.
- For those who started diabetes technology in pregnancy, plan for ongoing provision or withdrawal of diabetes technology after pregnancy.

Clinical MDT meetings might be needed weekly or less frequently depending on all the above. It is particularly important to avoid delay in appropriate change in therapy in pregnancy. The MDT meetings do not replace the need for in-clinic discussions and actions and some decisions may need to be made outside the MDT meetings, particularly if less frequent.

Service development MDT meetings

Service development meetings specific to the diabetes technology in pregnancy service are important. These should include:

- Audit, planning and reflection (local audits and National Pregnancy in Diabetes Audit (NPID)).
- Service development.
- Safety: individual patient safety concerns, device concerns, mortality and morbidity.
- Staff development: sharing best practice, agreeing clinic policy (eg, to decide the levels to use for sensor alerts, use of sensor suspensions during the day, compared with overnight), guideline development, education, training needs of the team, mentorship and quality assurance.

It is important to consider the appropriate involvement of both the wider diabetes and pregnancy team (anaesthetists, obstetricians and midwives) and wider diabetes team.

Job planning

Job planning requirements are outlined in ABCD DTN-UK 'Best Practice Guide: Service Requirements'[24] and include time for:

- Outpatient clinics and associated administration
- Additional or ad hoc face-to-face contacts
- Virtual clinics and remote consultations and associated administration
- Reviewing and analysing pump and sensor downloads
- Preparing, supporting and running patient group education sessions
- Clinical and service MDT meetings
- Ongoing staff training

In addition, for services supporting women using diabetes technology in pregnancy, time is required for:

- Fast track individual diabetes technology starts
- Support for women using diabetes technology when in hospital (eg, for steroids or birth)

Pathways and programmes

Access to type 1 diabetes education programmes

Access to type 1 diabetes education programmes is an essential requirement for any service looking after people with type 1 diabetes.[24] Outside of pregnancy, people with type 1 diabetes being considered for diabetes technology will usually have completed structured education[24] and women with type 1 diabetes planning pregnancy should be encouraged to complete structured type 1 diabetes education if they have not already done so.[1] Pregnant women may fulfil criteria for diabetes technology but have not completed structured education. It is not reasonable to defer starting diabetes technology until the person has completed structured education and one-to-one input will be required. Such women should be encouraged to complete type 1 diabetes structured education either in pregnancy or after pregnancy, particularly if ongoing use of diabetes technology is being considered.

Out-of-hours support pathway

As outlined in ABCD DTN-UK 'Best Practice Guide: Service Requirements',[24] all pump users should be educated on how to deal with clinical diabetes emergencies or technical problems out of hours with written algorithms and emergency contact details. Ideally, the pump service should provide a 24-hour, 7-day emergency advice service to deal with clinical problems out of hours, which may require working with other local centres. This is particularly important for women using pumps in pregnancy.

Women using RT-CGM or flash glucose monitoring alone do not require out-of-hours support specifically related to the diabetes technology.

Inpatient and emergency department support

The team should ensure that pathways are in place in the emergency department, antenatal and labour ward to manage pregnant women using diabetes technology, particularly pumps, presenting as emergencies out of hours. Processes for the referral to the diabetes pregnancy team should be in place.

System choice, informatics and data requirements

Pump and sensor choice:

- It is important that the team are comfortable and skilled in the products they are using and, while this may on occasion lead to reduced choice of pumps available within a service, safety of the insulin pump user must be paramount. An insulin pump service should only offer a range of pumps which they feel their team are able to safely support.[9] This also applies to sensors.
- Large insulin requirements in the second and third trimesters make pumps with cartridges/reservoirs of less than 200 units more time consuming for the person with diabetes and the consumables more costly.
- You must be able to review pump and sensor data. Consider how your service is going to manage seeing the downloads.

Data download

Access to software and IT infrastructure to download and display data from pumps, meters, RT-CGM, and flash glucose monitoring devices in clinic is essential. This may already be in place in the diabetes clinic, but will need additional work if the Diabetes Pregnancy clinic is held outside the usual location of the Diabetes Clinic. Consider the work that needs to be done with your ICT team to get permission for software to be installed onto clinic computers. Consider the training the team requires to review data presented in different ways. Consider the ease for which people using the technology can download their own data so that it can be seen by them and shared with you. Those using diabetes technology should be advised to download before their appointments.

The existing downloading facilities needed by services depend on the diabetes technology used:

- **CareLink** for Medtronic pumps, Enlite and Guardian Sensor 3 sensors. Data are stored in the 'cloud'. Users can download at home.
- **Clarity**: for Dexcom RT-CGM. For those using the Dexcom mobile phone app, data are uploaded automatically. Those using the Dexcom receiver can download at home. Clinics have their own identity for people to 'share' their data to a specific diabetes department. Clinics can add a separate antenatal clinic so that the pregnancy time-in-range glucose targets can be applied.
- **Glooko/Diasend**: for Insulet and Roche pumps and Dexcom (RT-CGM) receivers (but not App). Data are stored in the 'cloud'. Hardware and cables are needed to download in clinic. Users can download at home.
- **LibreView**: for Libre. For those using the LibreLink mobile phone app, data are uploaded automatically. Those using the Libre reader, users can download at home. Clinics have their own identity for people to 'share' their data to a specific diabetes department. Clinics can add a separate antenatal clinic so that the pregnancy time-in-range glucose targets can be applied.

Clinic letters and communication

A particular challenge in pregnancy is timely documentation and communication of changes made at the frequent contacts (both face-to-face and remote) in a way that is accessible to the woman and all the relevant healthcare professionals both at face-to-face and remote reviews without generating large volumes of repeated data. The approach is likely to be different in different services.

It may be appropriate to generate structured clinic letters at selected appointments (eg, first visit, 12 weeks, 20 weeks, 28 weeks, 34 weeks) including a comprehensive up-to-date summary of all details about the pump, settings and clinical issues so that a new clinician unfamiliar with the patient could continue their care. Other visits may record key issues and changes made.

National Pregnancy in Diabetes Audit (NPID)

All centres in England and Wales are required to submit data to the National Pregnancy in Diabetes Audit (NPID). This will include data on use of insulin pump therapy and glucose monitoring (RT-CGM or flash glucose monitoring). This allows centres to benchmark their data and outcomes.

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APPENDIX 1

Carbohydrate choices

This table lists foods that many pregnant women with diabetes have found result in glucose levels above target post-meal. The 'try instead' list suggests some alternatives that can work well. Many foods in the 'try instead' list will still need to be eaten in limited quantities to avoid glucose levels above target post-meal. Individual responses may differ.

✗ REFINED CARBOHYDRATES TO AVOID (High glycaemic index (GI))	✔ TRY INSTEAD (Low glycaemic index (GI))
All white breads: loaf, rolls, pitta, naan, non-traditional baguette, croissant, chapattis, Panini, wraps	**High fibre breads:** Rye bread and sourdough bread have the lowest GI. Whole-wheat, stoneground, granary and multi-grain varieties of breads have lower GIs. Chapattis made with whole meal flour Freezing bread first can help lower the GI
White flour based foods: Cakes, biscuits, cream crackers, water biscuits, Ritz, Tuc, Yorkshire pudding, dumplings, pizza, pastry (pies, pasties, quiche, sausage rolls, spring rolls) Breaded & battered foods eg, fish fingers, battered fish	Oatcakes Whole-wheat crackers and crispbread eg, Ryvita, Cracker wheat Wheatmeal Digestives, Hobnobs, Hovis biscuits (one or two)
Low fibre and sugar coated breakfast cereals: Cornflakes, Rice Krispies, Special K, Sugar Puffs, Cocoa Pops, sweetened muesli	**High fibre cereals:** Jumbo oats Most women don't tolerate any cereal in pregnancy. You may tolerate small amounts of some high fibre cereals earlier in pregnancy (up to 20 weeks): All Bran, Bran Buds, Shredded Wheat See breakfast guidance
Rice, pasta, grains: No types need to be avoided	The best rice is basmati. Brown rice and whole-wheat pasta may give benefit. Cooling rice, pasta and potato after cooking and then eating cold or re-heating will lower the GI Couscous, bulgur wheat, semolina, tapioca, quinoa
Processed potato products: Oven chips, French Fries, Smiley faces, waffles, croquettes, frozen roast potatoes, instant potato, ready meals with instant potato topping	**Home cooked potatoes:** Boiled is best Lightly mashed (non-instant) Small baked potato, sweet potato, yam, cassava
Processed savoury snacks: Hula Hoops, Quavers, Pringles, Monster Munch, French Fries, Skips, baked crisps	Sliced potato crisps (eg, Walker's or Kettle crisps) Ryvita snacks, Vegetable crisps Salted or natural popcorn
Cold drinks: Fruit juices, smoothies, full sugar squash and fizzy drinks, Lucozade	Water. Sugar-free squash, sugar-free carbonated drinks. DASH water. Soda water
Sugar: Sugar, glucose, maltose, dextrose, honey, treacle and syrup	Artificial sweeteners if a variety are used and in small quantities Splenda, Sweetex, Hermesetas, Nutrasweet, Candarel, Stevia
Preserves/spreads: Jam, marmalade, honey, lemon curd, maple syrup, chocolate spread	Marmite, Vegemite, nut butters such as peanut butter
Sweets/desserts: Melon, mango, pineapple (some people may tolerate small portions), Dried fruit Sweets, chocolates, mints Sweet puddings Tinned fruit in syrup	Fresh fruit, frozen fruit, tinned fruit in natural juice (juice drained off) Sugar-free jelly Yogurt: natural, Greek-style, Icelandic style (high protein such as Skyr), fruit yogurt (under 15 g total carbohydrate per portion or pot) 70% cocoa solids chocolate Full fat ice cream (no added biscuits/caramel ripple/etc.)
Condensed, evaporated milk	Crème fraiche, cream
Ready meals/stir in sauces/take away: Some ready meals and sauces contain significant amounts of sugar, for example sweet and sour sauces, jar or packet Chinese sauces, Chinese takeaway, tomato soup, baked beans, tinned spaghetti	Reduced sugar baked beans (drain off as much sauce as possible)
Bedtime and malted drinks such as Ovaltine, Horlicks, drinking chocolate	Cadbury's Highlight, Ovaltine Options, cocoa powder