



# Understanding the role of insulin in the management of type 1 diabetes

Insulin treatment is an essential component of type 1 diabetes management. Achieving and maintaining good glycaemic control helps prevent the short-term adverse consequences of hyper- and hypoglycaemia and reduces the risk of long-term complications. Primary care can support patients with type 1 diabetes by understanding their insulin regimen, ensuring that treatment is optimised and identifying any issues with adherence.

## KEY CONCEPTS:

- Most people with type 1 diabetes use a basal-bolus regimen, i.e. a short-acting insulin administered before meals and an intermediate/long-acting insulin (basal) administered once or twice daily
- Insulin pumps (subsidised with Special Authority approval) deliver a short-acting insulin continuously via subcutaneous infusion, replacing multiple daily injection regimens
- Insulin pump use can be associated with improved HbA<sub>1c</sub> levels, reductions in hypoglycaemia and higher patient satisfaction, however, if the pump malfunctions there is a risk of hyperglycaemia and diabetic ketoacidosis. There is also a risk of infection at the cannula site.
- All adults with type 1 diabetes should ideally be testing their blood glucose levels at least four times per day, i.e. before each main meal and before bed

## Insulin: the key to life for people with type 1 diabetes

Type 1 diabetes is caused by the loss of pancreatic beta cells, resulting in insulin deficiency. Without insulin treatment, hyperglycaemia causes diabetic ketoacidosis, which can be fatal. Insulin is usually initiated in secondary care or an outpatient diabetes clinic. The aim of an insulin treatment regimen is to prevent hyperglycaemia by mimicking endogenous insulin secretion. Achieving and maintaining good diabetes control in both the short and long-term requires an appropriate insulin regimen that is optimised for the individual.


### Insulin regimens

There are three main types of insulin regimen used by people with diabetes: basal-bolus, biphasic and continuous subcutaneous infusion. People with type 1 diabetes typically use basal-bolus or continuous subcutaneous infusion regimens; biphasic regimens are not usually recommended, unless the

patient is unable to adhere to the other regimens (also see: “The role of insulin in the management of type 2 diabetes”).<sup>1</sup>

**Basal-bolus regimens** use a short-acting insulin injected before or with meals and snacks and an intermediate/long-acting (basal) insulin injected once or twice daily. A variety of short-acting and basal insulins are available fully subsidised (Table 1). Basal-bolus insulin regimens are usually administered as a flexible dose but some patients may use a fixed dose, depending on their circumstances. Flexible dose regimens are adapted to the carbohydrate content of upcoming meals (see: “A brief “how to” guide for carbohydrate counting”), thereby allowing more freedom with meal timing and food choices, and reducing the risk of hypoglycaemic episodes if there are changes to the daily schedule, e.g. exercise.<sup>3</sup> People using fixed-dose regimens, e.g. if they are unable to count carbohydrates, must regulate their carbohydrate intake and ensure that it is distributed across the day to match their insulin regimen to prevent hypoglycaemia.<sup>3</sup>

**Continuous subcutaneous infusion regimens** use a short-acting insulin delivered by a pump (available fully subsidised with Special Authority approval – see below) in small doses over 24 hours, i.e. a basal rate, with boluses delivered at meal times. This replaces the need for an intermediate or long-acting insulin. This regimen most closely matches normal endogenous basal-bolus insulin release.<sup>4</sup> The basal rate is programmed to fit the individual’s changing insulin requirements across the day. The bolus doses are adjusted for carbohydrate content of the upcoming meal; patients enter the information into the pump and it calculates the insulin dose. Correction doses can also be administered between meals if blood glucose levels are high.


 Further information for primary care providers on insulin pumps is available from the PHARMAC seminar series: [www.pharmac.govt.nz/seminars/seminar-resources/diabetes/#diabetes4](http://www.pharmac.govt.nz/seminars/seminar-resources/diabetes/#diabetes4)

### Short-acting insulin

There are four fully subsidised types of short-acting insulins available in New Zealand (see Table 1 for brand names and product variations). Insulin aspart, insulin glulisine and insulin lispro (also called rapid-acting insulin analogues) have a faster onset and shorter duration of action than human neutral insulin (a recombinant insulin identical to human insulin) and have been associated with fewer hypoglycaemic episodes and lower post-prandial blood glucose levels in some studies.<sup>5</sup> The rapid-acting insulin analogues can be used in insulin pumps\*; human neutral insulin is not recommended for use in pumps due to the risk of precipitation in the catheter or needle.<sup>3</sup> There are no clinical differences in the onset or duration of action between the different rapid-acting insulin analogues.<sup>2</sup>

Most people with type 1 diabetes who use a basal-bolus regimen use a pen device for insulin administration. There is some variability in the pens provided by different manufacturers which may make one preferable to another, e.g. maximum number of doses, whether they deliver insulin in half-unit increments, size of the dial, pressure needed on the injection button to deliver the dose.<sup>6</sup>

\* Only insulin aspart and insulin lispro should be used in subsidised pumps


 For a schematic representation comparing the duration of action of different insulins, see: [www.nzf.org.nz/nzf\\_3629](http://www.nzf.org.nz/nzf_3629)

### Basal insulin

Basal insulin is administered once or twice daily to mimic normal basal insulin secretion. There are two types of basal insulin available fully subsidised in New Zealand (see Table 1 for brand names and product variations):

- Isophane insulin, also known as NPH\* insulin, is an intermediate-acting insulin
- Insulin glargine, an insulin analogue, is a long-acting insulin

A long-acting insulin is the first choice for most patients with type 1 diabetes, however, there may be some circumstances where patients are initiated on isophane insulin, e.g. renal failure.

 For further information on initiating basal insulin in people with type 2 diabetes, see: [www.bpac.org.nz/2019/hba1c.aspx](http://www.bpac.org.nz/2019/hba1c.aspx)

\* Neutral Protamine Hagedorn (NPH); the name refers to neutral pH, protamine (a protein), and Hans Christian Hagedorn (an insulin researcher)

### Strategies to reduce the risk of insulin dosing errors

There are many steps in an insulin regimen where potential errors can occur. Strategies to minimise these risks include:<sup>7,8</sup>

- Using the selected insulin with the appropriate delivery device, e.g. cartridge, disposable pen
- Using a short-acting and basal insulin from the same manufacturer as the patient will be familiar with the delivery system, e.g. Novorapid and Protaphane (Table 1)
- Ensure the needle length is appropriate; most people with type 1 diabetes use 4 mm length needles
- Writing out the word “units” in full
- Prescribing insulin using the full brand name; taking care when prescribing and dispensing products with similar names, e.g. Humalog, Humalog Mix and Humulin; Novomix and Novorapid

**Table 1:** Subsidised short, intermediate and long-acting insulins<sup>3</sup>


Insulin	Manufacturer	Brand	Formulation*	Injection devices†	Time course (subcutaneous injection)	
<b>Rapid/short-acting insulin</b>						
<b>Insulin aspart</b>	Novo Nordisk	Novorapid	10 mL vial × 1	Prescribe injection syringes with attached needle		
		Novorapid Penfill	3 mL cartridge × 5	Use with Novo Nordisk insulin delivery systems		
		Novorapid FlexPen	3 mL prefilled disposable device × 5			
<b>Insulin glulisine</b>	Sanofi-Aventis	Apidra	10 mL vial × 1	Prescribe injection syringes with attached needle	Onset: 10–20 minutes Peak: 1 hour Duration: 2–5 hours	
			3 mL cartridge × 5	Use with the following reusable injection pens: ■ AllStar ■ AllStar Pro ■ JuniorStar ■ KlikStar		
		Apidra Solostar	3 mL disposable device × 5			
<b>Insulin lispro</b>	Eli Lilly	Humalog	10 mL vial × 1	Prescribe injection syringes with attached needle		
			3 mL cartridge × 5	Use with Humapen injection device		
<b>Short-acting insulin</b>						
<b>Human neutral insulin</b>	Novo Nordisk	Actrapid	10 mL vial × 1	Prescribe injection syringes with attached needle	Onset: 30–60 minutes Peak: 2–4 hours Duration: up to 8 hours	
			3 mL cartridge × 5	Use with Novo Nordisk insulin delivery systems		
	Eli Lilly	Humulin	10 mL vial × 1	Prescribe injection syringes with attached needle		
			Humulin R	3 mL cartridge × 5		Use with Humapen injection device
<b>Intermediate-acting insulin</b>						
<b>Isophane insulin</b>	Eli Lilly	Humulin NPH	10 mL vial × 1	Prescribe injection syringes with attached needle	Onset: 1–2 hours Peak: 4–12 hours Duration: 8–24 hours	
			3 mL cartridge × 5	Use with Humapen injection device		
	Novo Nordisk	Protaphane	10 mL vial × 1	Prescribe injection syringes with attached needle		
			Protaphane Penfill	3 mL cartridge × 5		Use with Novo Nordisk insulin delivery systems
<b>Long-acting insulin</b>						
<b>Insulin glargine</b>	Sanofi-Aventis	Lantus	10 mL vial × 1	Prescribe injection syringes with attached needle	Onset: 1–2 hours No pronounced peak Duration: 24 hours	
			3 mL cartridge × 5	Use with the following reusable injection pens: ■ AllStar ■ AllStar Pro ■ JuniorStar ■ KlikStar		
		Lantus SoloStar	3 mL disposable device × 5			

\* All funded insulin formulations are at a concentration of 100 units/mL. Three months' supply may be dispensed at one time if endorsed "certified exemption" by the prescriber

† Injection syringes and pen needles may be prescribed with subsidy if prescribed on the same form as insulin or if the patient has previously had a prescription of insulin and the prescription is endorsed; pharmacists may endorse the prescription if there is a prior record of insulin dispensing<sup>10</sup>

## The role of insulin in the management of type 2 diabetes

Many people with type 2 diabetes also use insulin for glycaemic control. Typically, people with type 2 diabetes are initiated on basal insulin (isophane insulin is an appropriate choice for most patients with type 2 diabetes) and if needed treatment is intensified by switching patients to a biphasic regimen or by adding a short-acting insulin at mealtimes.

 For further information on initiating basal insulin in people with type 2 diabetes, see: [www.bpac.org.nz/2019/hba1c.aspx](http://www.bpac.org.nz/2019/hba1c.aspx)

**Biphasic regimens** use an intermediate-acting insulin mixed with a short-acting insulin, injected twice daily, i.e. before breakfast and dinner. As these insulins are premixed, the proportion of intermediate-acting and short-acting insulin is fixed and therefore less flexible in terms of meal times, carbohydrate intake and exercise. A variety of pre-mixed biphasic insulins with differing proportions of intermediate-acting and short-acting insulin are subsidised (Table 2). A reasonable initial choice is a biphasic insulin containing a rapid-acting insulin analogue, e.g. Humalog Mix25 (insulin lispro) or Novomix30 (insulin aspart), because of the faster onset of action than those containing human neutral insulin, allowing patients to “inject and eat”.

**Table 2:** Subsidised 50/50, 60/40, 70/30 and 75/25 biphasic insulins.<sup>3</sup>

Insulin	Manufacturer	Brand	Mix	Intermediate-acting insulin component	Short-acting insulin component	Formulation*	Injection devices <sup>†</sup>
<b>Biphasic insulin lispro</b>	Eli Lilly	Humalog Mix25	75/25	Insulin lispro protamine <sup>‡</sup> 75 units/mL	Insulin lispro 25 units/mL	3 mL cartridges × 5	For use with Humapen injection device
		Humalog Mix50	50/50	Insulin lispro protamine <sup>‡</sup> 50 units/mL	Insulin lispro 50 units/mL	3 mL cartridges × 5	
<b>Biphasic isophane insulin</b>	Eli Lilly	Humulin 30/70	70/30	Isophane insulin 70 units/mL	Neutral human insulin 30 units/mL	10 mL vial × 1	Prescribe injection syringes with attached needle
						3 mL cartridge × 5	For use with Humapen injection device
	Novo Nordisk**	Mixtard 30	70/30	Isophane insulin 70 units/mL	Neutral human insulin 30 units/mL	10 mL vial × 1	Prescribe injection syringes with attached needle
		Penmix 30	70/30	Isophane insulin 70 units/mL	Neutral human insulin 30 units/mL	3 mL cartridge × 5	For use with Novo Nordisk insulin delivery systems
Penmix 50	50/50	Isophane insulin 50 units/mL	Neutral human insulin 50 units/mL	3 mL cartridge × 5			
<b>Biphasic insulin aspart</b>	Novo Nordisk	Novomix Flexpen	70/30	Insulin aspart protamine <sup>‡</sup> 70 units/mL	Insulin aspart 30 units/mL	Prefilled disposable devices × 5	

\* All funded insulin formulations are at a concentration of 100 IU/mL. Three months' supply may be dispensed at one time if endorsed “certified exemption” by the prescriber

† Injection syringes and pen needles may be prescribed with subsidy if prescribed on the same form as insulin or if the patient has previously had a prescription of insulin and the prescription is endorsed; pharmacists may endorse the prescription if there is a prior record of insulin dispensing<sup>10</sup>

‡ Insulin lispro protamine and insulin aspart protamine are intermediate-acting insulins that are only available as part of premixed biphasic preparations in New Zealand

\*\* Novo Nordisk brands of biphasic insulin isophane with insulin neutral (Mixtard 30, Penmix 30 and Penmix 50) are being discontinued. Penmix 40 was discontinued in 2022. Mixtard 30, Penmix 30 and Penmix 50 will continue to be listed on the Pharmaceutical Schedule until stock is exhausted (final shipment due by 30<sup>th</sup> September, 2024).



## The role of technology in type 1 diabetes management

### Insulin pumps

In New Zealand, insulin pumps and consumables, i.e. insulin cartridges/reservoirs and infusion sets are fully subsidised for patients who meet criteria for Special Authority approval (see below). Pump use is much higher among young people; in 2016, approximately one-quarter of people aged under 20 years were using an insulin pump compared to approximately 8–10% of people aged 20–60 years.<sup>11</sup> There is also a disparity in the use of insulin pumps by ethnicity; pump use is at least two-fold higher in New Zealand Europeans with type 1 diabetes compared to Māori, Pacific and Asian peoples.<sup>11</sup> Ensure that eligible patients are aware of the availability of fully subsidised insulin pumps; this technology can be beneficial for people of all ages, provided they have the appropriate support, training, commitment to monitoring and cognitive capacity.

Insulin pumps replace the need for multiple daily injections, thereby eliminating one of the burdens of diabetes management, however, patient education and adherence are critical for treatment to be successful. Clinical trials comparing insulin pumps with multiple daily injection regimens have reported improved HbA<sub>1c</sub> levels, reductions in hypoglycaemia and higher patient satisfaction with pump use.<sup>2</sup> When functioning optimally, use of an insulin pump is associated with lower rates of diabetic ketoacidosis, however, adverse events such as pump malfunction or problems with the infusion sets are not uncommon and can lead to diabetic ketoacidosis if the malfunction and hyperglycaemia are not detected.<sup>2</sup> Pump users may become de-skilled in managing a multiple daily injection regimen which can cause problems if they need to return to injections for any reason.

Insulin pumps do not eliminate the need for blood glucose testing; pump users need to test frequently to optimise their insulin regimen. More frequent testing, including during the night, is necessary when first establishing the appropriate basal insulin requirements. Continuous glucose monitoring can make this easier, however these devices are not subsidised in New Zealand (see: “Continuous and intermittent [flash] glucose monitoring”).

#### Patients must meet specific criteria to be eligible for a fully subsidised insulin pump

People with type 1 diabetes may be eligible for a subsidised insulin pump under one of the following categories:

- HbA<sub>1c</sub> i.e. has unpredictable and variable blood glucose levels; average HbA<sub>1c</sub> ≥ 65 mmol/mol to ≤ 90 mmol/mol
- Severe unexplained hypoglycaemia, i.e. has had four severe unexplained hypoglycaemic episodes in six months; average HbA<sub>1c</sub> is ≥ 53 mmol/mol to ≤ 90 mmol/mol

- Previous use before 1 September, 2012, i.e. people who were already using a pump before they became publicly funded

N.B. People with permanent neonatal diabetes (appears in the first six months of life), cystic fibrosis-related diabetes or who have undergone a pancreatectomy are also eligible to apply for a subsidised insulin pump.


Within each of these categories there are a number of other criteria that the patient must meet, e.g. have undertaken carbohydrate counting education, be under the management of a multidisciplinary team, adhered to a multiple daily injection regimen for more than six months. Patients enquiring about insulin pumps in general practice should be given information and referred to their diabetes team in secondary care for further discussion. The initial Special Authority applications for the pump and consumables must be made by a diabetes specialist or diabetes nurse practitioner.


The Special Authority approval for insulin pump consumables must be renewed every two years; general practitioners often apply for these renewals. The Special Authority entitles patients to a prescription for a three-month supply of:

- Infusion sets (three boxes)
- Insulin cartridges/reservoirs (three boxes)

Patients can also be prescribed one extra box of infusion sets and cartridges/reservoirs each year (to cover possible equipment failure), but this must be listed on a separate prescription from their usual three-monthly supply.

Be sure when prescribing that the right product is selected so the correct items are ordered and provided by the pharmacy, i.e. the Paradigm consumables for the MiniMed 640G pump and the Autosoft 30 or TruSteel consumables for the Tandem t:slim X2 pump. Also confirm the patient’s cannula preferences (steel or teflon; straight or angled; length), line length and whether they need an autoinjector. See the NZF for further information: [www.nzf.org.nz/nzf\\_70437](http://www.nzf.org.nz/nzf_70437)

 The Special Authority criteria for a subsidised insulin pump is available here: [www.pharmac.govt.nz/latest/SA1603.pdf](http://www.pharmac.govt.nz/latest/SA1603.pdf)

 **Best practice tip:** Remind patients who use an insulin pump to have a back-up kit, including short- and intermediate/long-acting insulin, syringes/pens, blood glucose and blood ketone meters with test strips and information on their total daily basal insulin dose and ratios (insulin to carbohydrate and correction), so that they can convert back to a multiple daily injection regimen if necessary, e.g. pump failure, civil emergency.<sup>4</sup>

## Insulin injection or cannula sites should be routinely monitored for lipohypertrophy or infection

People using multiple daily injection regimens or an insulin pump are at risk for lipohypertrophy at the injection or cannula site. Injecting into lipohypertrophic tissue can reduce insulin absorption, therefore, it is important that patients rotate the injection or cannula site to minimise this risk.<sup>2</sup> People using insulin pumps have an increased risk of infections at the cannula site, e.g. by *Staphylococcus aureus* and *Staphylococcus epidermidis*.<sup>2</sup> To prevent infection, the cannula should be changed by the patient or their caregiver every three days using aseptic techniques.<sup>2</sup>

## Self-monitoring blood glucose levels

People with type 1 diabetes need to regularly monitor their blood glucose levels to adjust their insulin dose or carbohydrate intake to prevent hyper- and hypoglycaemia. For many people this is achieved by finger prick testing using blood glucose test strips and a handheld blood glucose meter. People with type 1 diabetes are eligible for any of the four CareSens meters that are available fully subsidised (Table 3); one of these, the CareSens Dual meter, measures both blood glucose and blood ketone levels and is only available for people with certain conditions, including those with type 1 diabetes.<sup>3</sup>

N.B. Prescribers can also order meters on a PSO.

### Monitor blood glucose at least four times per day

All adults with type 1 diabetes should be encouraged to test at least four times per day, i.e. before each main meal and before bed; testing before bed and before breakfast are the most important for detecting and preventing nocturnal hypoglycaemia.<sup>1</sup> Additional testing, e.g. up to 10 times per day, may be indicated in situations such as:<sup>1,12</sup>

- If the desired HbA<sub>1c</sub> target has not been achieved
- If the frequency of hypoglycaemic episodes increases
- If hypoglycaemia is suspected or after treating hypoglycaemia
- Before critical tasks, e.g. driving\*
- During periods of illness
- Before, during (if possible) and after exercise

**Table 3.** Subsidised blood glucose meters and eligibility criteria.<sup>3</sup>

Meter	Tests	Test strips	Eligibility
CareSens Dual	Blood glucose and blood ketones	CareSens PRO and KetoSens	People with: <ul style="list-style-type: none"> <li>■ Type 1 diabetes</li> <li>■ Permanent neonatal diabetes</li> <li>■ A pancreatectomy</li> <li>■ Cystic fibrosis-related diabetes</li> <li>■ Metabolic disease or epilepsy under the care of a paediatrician, neurologist or metabolic specialist</li> </ul>
CareSens N CareSens N Pop CareSens N Premier	Blood glucose	CareSens N	People who: <ul style="list-style-type: none"> <li>■ Are receiving insulin or sulphonylurea treatment</li> <li>■ Are pregnant with diabetes</li> <li>■ Are on home total parenteral nutrition at risk of hypoglycaemia or hyperglycaemia</li> <li>■ Have a genetic or an acquired disorder of glucose homeostasis, excluding type 1 or type 2 diabetes</li> </ul>

- Pregnancy and breastfeeding:
  - Poor glycaemic control at conception and during early pregnancy increases the risk of congenital malformations, miscarriage, stillbirth and neonatal death
  - The risk of hypoglycaemia is increased during pregnancy and breastfeeding

Blood glucose levels should be recorded in a log book or using a smartphone app. The recommended blood glucose targets for people aged > 18 years with type 1 diabetes are:<sup>1</sup>

- Pre-breakfast: 5.0–7.0 mmol/L
- Pre-lunch or dinner: 4.0–7.0 mmol/L
- Post-meal: 5.0–9.0 mmol/L (at least 90 minutes after eating)


\* People with type 1 diabetes need to be aware of the restrictions and requirements for driving; information from the New Zealand Transport Agency is available here: [www.nzta.govt.nz/assets/resources/factsheets/16/docs/16-diabetes.pdf](http://www.nzta.govt.nz/assets/resources/factsheets/16/docs/16-diabetes.pdf)

### Continuous and intermittent (flash) glucose monitoring

Continuous (i.e. glucose readings are reported automatically at regular intervals) glucose monitors and intermittent, or “flash”, glucose monitors (i.e. the patient scans the sensor to get a reading) detect and report glucose levels in the interstitial fluid through a subcutaneous sensor, largely replacing the need for routine finger prick testing.<sup>2</sup> \* The high frequency of measurements made by continuous glucose monitoring devices, e.g. every 5–15 minutes, can help to optimise insulin treatment by providing more detailed information about an individual’s blood glucose profile throughout the day and night.<sup>2</sup> Some devices also have an alarm feature which will alert the patient to the risk of hyperglycaemia or hypoglycaemia;<sup>2</sup> this can help reduce anxiety about blood glucose monitoring and hypoglycaemia, particularly at night. Data from a continuous or intermittent glucose monitor can be accessed through the reader or a smartphone app, allowing patients more convenient and discrete monitoring of their blood glucose levels.<sup>2</sup>

Continuous and intermittent glucose monitors are not subsidised in New Zealand, therefore cost is likely to be the limiting factor for most patients considering this technology. For example, one of these devices costs approximately \$90 for the reader and \$90 for the sensor, which needs to be replaced every two weeks. Continuous and intermittent glucose monitors must be purchased directly from the manufacturer or their New Zealand distributor.

\* Devices may require finger prick testing for calibration; finger prick testing is also still indicated in certain circumstances, e.g. if blood glucose levels are changing rapidly, if hypoglycaemia is reported by the device, if symptoms do not match the reading from the device.<sup>13</sup>

 Patient information on intermittent glucose monitors is available from: [www.diabetes.org.nz/news-and-update/2018/3/7/news-children-free-from-pain-of-routine-finger-pricks-with-revolutionary-diabetes-sensing-technology](http://www.diabetes.org.nz/news-and-update/2018/3/7/news-children-free-from-pain-of-routine-finger-pricks-with-revolutionary-diabetes-sensing-technology)

**Acknowledgement:** Thank you to **Dr Catherine McNamara**, Diabetes Specialist, Chair of Northern Region Diabetes Network, Northern Regional Alliance Limited for expert review of this article.

N.B. Expert reviewers do not write the articles and are not responsible for the final content.

### References

1. National Institute for Health and Care Excellence (NICE). Type 1 diabetes in adults: diagnosis and management. 2016. Available from: <https://www.nice.org.uk/evidence/guidance/ng17/chapter/1-Recommendations#blood-glucose-and-plasma-glucose> (Accessed May, 2019).
2. International Society for Pediatric and Adolescent Diabetes. ISPAD Clinical practice consensus guidelines 2018. 2018. Available from: <https://www.ispad.org/page/ISPADGuidelines2018> (Accessed May, 2019).
3. New Zealand Formulary (NZF). NZF v84. 2019. Available from: [www.nzf.org.nz](http://www.nzf.org.nz) (Accessed Apr, 2019).
4. Bridget Lydon. The what, how, why and who of insulin pumps. 2016. Available from: <https://www.pharmac.govt.nz/assets/seminar-diabetes-insulin-pumps-b-lydon.pdf> (Accessed Jun, 2019).
5. Melo KFS, Bahia LR, Pasinato B, et al. Short-acting insulin analogues versus regular human insulin on postprandial glucose and hypoglycemia in type 1 diabetes mellitus: a systematic review and meta-analysis. *Diabetol Metab Syndr* 2019;11:2. doi:10.1186/s13098-018-0397-3
6. Pisano M. Overview of insulin and non-insulin delivery devices in the treatment of diabetes. *P T* 2014;39:866–76.
7. Health Quality & Safety Commission New Zealand. Insulin prescribing: review the safety of insulin prescriptions – use the five elements to audit insulin prescribing. 2014. Available from: <http://www.open.hqsc.govt.nz/assets/Open-for-better-care/Medication/PR/one-step-insulin-prescribing-Dec-2014.pdf> (Accessed Jun, 2019).
8. Health Quality & Safety Commission New Zealand. Medication alert: Humalog insulin preparations. 2010. Available from: <http://www.open.hqsc.govt.nz/assets/Open-for-better-care/Medication/PR/one-step-insulin-prescribing-Dec-2014.pdf> (Accessed Jun, 2019).
9. O’Neal KS, Johnson J, Swar S. Nontraditional considerations with insulin needle length selection. *Diabetes Spectrum* 2015;28:264–7. doi:10.2337/diaspect.28.4.264
10. Schedule Online. Available from: <https://www.pharmac.govt.nz/wwwtrts/ScheduleOnline.php> (Accessed Mar, 2019).
11. Wheeler BJ, Braund R, Galland B, et al. District health board of residence, ethnicity and socioeconomic status all impact publicly funded insulin pump uptake in New Zealand patients with type 1 diabetes. *N Z Med J* 2019;132.
12. American Diabetes Association. 7. Diabetes Technology: Standards of Medical Care in Diabetes—2019. *Dia Care* 2019;42:S71–80. doi:10.2337/dc19-S007
13. Diabetes New Zealand. NEWS - Children free from pain of routine finger pricks, with revolutionary diabetes sensing technology. 2018. Available from: <https://www.diabetes.org.nz/news-and-update/2018/3/7/news-children-free-from-pain-of-routine-finger-pricks-with-revolutionary-diabetes-sensing-technology> (Accessed May, 2019).
14. Diabetes UK. Carbs count: an introduction to carbohydrate counting and insulin dose adjustment. 2012. Available from: <http://www.diabeteshelp.org.nz/uploads/A%20Carbs-Count-2012-reducedsize.pdf> (Accessed Jun, 2019).



This article is available online at:  
[www.bpac.org.nz/2019/diabetes-insulin.aspx](http://www.bpac.org.nz/2019/diabetes-insulin.aspx)



## A brief “how to” guide for carbohydrate counting

Many people with type 1 diabetes use carbohydrate counting to match their insulin requirements to the carbohydrate content of the upcoming meal, allowing greater flexibility in terms of food choices and meal timing. Carbohydrate counting is associated with improved glycaemic control and quality of life.<sup>2</sup>

Carbohydrate counting requires knowing:<sup>2</sup>

- The carbohydrate content of the upcoming meal or snack, usually quantified in terms of grams or carbohydrate portions (one portion = 10 grams carbohydrate); and
- The insulin to carbohydrate ratio, i.e. the amount of insulin needed to counteract a quantity of carbohydrate, e.g. 10 grams or one portion, and restore blood glucose levels to baseline


The insulin to carbohydrate ratio varies between individuals and is affected by factors such as age, weight, activity levels and sensitivity to insulin.<sup>2</sup> Most adults start with a carbohydrate ratio of 1 unit of insulin for every 10 grams of carbohydrate (or one portion of carbohydrate).


If the ratio is correct and carbohydrate content of the meal has been estimated appropriately, the blood glucose levels before the next meal would be in the target range, e.g. 4–7 mmol/L.<sup>14</sup> If there is a trend over several blood glucose readings indicating that the ratio is incorrect, the patient can make small changes to either increase or decrease the amount of insulin per 10 grams of carbohydrate or carbohydrate portion until the target blood glucose levels are met.<sup>14</sup> Some people may have a different ratio for each meal, e.g. the ratio they use at lunch may differ from the ratio they use at breakfast and dinner.<sup>14</sup>

*For example, Clara has an insulin to carbohydrate ratio of 1 unit short-acting (bolus) insulin for every 10 grams carbohydrate. This means that if Clara eats a meal containing 50 grams carbohydrate she will take 5 units short-acting (bolus) insulin. Clara has been monitoring her blood glucose levels and found that they are within the target range of 4–7 mmol/L before breakfast and before dinner, however, her pre-lunch blood glucose levels are consistently elevated (12–14 mmol/L). Clara needs to increase her insulin to carbohydrate ratio at breakfast to bring her lunchtime blood glucose levels within the target range. Clara adjusts her ratio so that at breakfast she uses 1 unit insulin for every 5 grams carbohydrate. If Clara has 50 grams of carbohydrate at breakfast she will use 10 units of insulin.*

Carbohydrate counting requires basic mathematical skills, the ability to read food labels and weigh and measure portions of food prepared at home. There are smartphone apps available to assist people with bolus insulin calculations.

N.B. In New Zealand, education in carbohydrate counting is part of the eligibility criteria for a subsidised insulin pump. Several centres offer Dose Adjustment for Normal Eating (DAFNE) courses (or an equivalent).

 Patient information on carbohydrate counting is available here: <https://static.diabetesaustralia.com.au/s/fileassets/diabetes-australia/22271a4e-3b97-4511-9ef0-e2e187519a88.pdf> and [www.diabeteshelp.org.nz/uploads/A%20Carbs-Count-2012-reducedsize.pdf](http://www.diabeteshelp.org.nz/uploads/A%20Carbs-Count-2012-reducedsize.pdf)

 Estimations of the carbohydrate content of different foods is available here: [www.starship.org.nz/media/241202/carbohydrates\\_list.pdf](http://www.starship.org.nz/media/241202/carbohydrates_list.pdf)

