TYPE 1 DIABETES

Introduction

Type 1 diabetes is the most common type of diabetes in children and young people. The majority of cases are thought to arise from an environmentally triggered autoimmune destruction of the beta cells of the pancreas, set against a background of genetic risk. However, it is thought that, in a small number of cases, beta cell failure may occur for other reasons [1]. The incidence of type 1 diabetes increases from birth, peaks at around 10–14 years of age, and then declines after puberty. The initial onset is typically acute, with symptoms of thirst, frequent urination and weight loss. Beta cell destruction is normally progressive, resulting in an increasing and on-going need for exogenous insulin [1].

Internationally the incidence of type 1 diabetes has been increasing [1]. Local research suggests that similar trends have been occurring in New Zealand. In one recent Auckland review [2], the incidence of type 1 diabetes in children aged 0–14 years, rose from per 10.9 per 100,000 in 1990, to 22.5 per 100,000 in 2009, with the most rapid rises occurring in older children (aged 10–14 years) [2]. A similar study, which reviewed type 1 diabetes in Canterbury young people aged 15–24 years, found that the prevalence had increased by 45 per 100,000 (12%) between 2003 and 2010. While this increase was not statistically significant, the study authors noted that the absolute increase in the number of young people with type 1 diabetes had significant implications for health service demand [3].

In the same Auckland review [2], the incidence of type 1 diabetes was higher for European children and young people than for those from other ethnic groups. However, another Auckland study during 1995–2005 [4] found that Māori and Pacific children and young people with type 1 diabetes had poorer metabolic control (as measured by HbA1c) than European children and young people, as well as higher rates of hypoglycaemia. Low socioeconomic status was also independently associated with poor glycaemic control [4].

Increases in the incidence and prevalence of type 1 diabetes have significant implications for service delivery, as optimal long term outcomes require intensive management by the patient, their family and their health care team [5]. In addition, there are implications for schools. With estimates that 1 in 500 school children have type 1 diabetes, most secondary schools likely to have at least one diabetic child [5]. In the longer term, such increases may also lead to higher rates of both microvascular (e.g. retinopathy and nephropathy) and macrovascular disease (e.g. coronary heart disease, stroke and peripheral vascular disease) as the current generation of children and young people with type 1 diabetes reaches adulthood [6].

The following section reviews hospital admissions for children and young people aged 0–24 years with any mention of type 1 diabetes in any of the first 15 diagnoses, as well as mortality for children and young people where type 1 diabetes was listed as the main underlying, or as a contributory cause of death.

Data Source and Methods

Definition

1. *Hospital admissions for children and young people aged 0–24 years with type 1 diabetes listed in any of the first 15 diagnoses*
2. *Mortality in children and young people aged 0–24 years with type 1 diabetes listed as the main underlying cause of death or as a contributory cause*

Data Source

1. National Minimum Dataset

Numerator: Hospital admissions for children and young people aged 0–24 years with type 1 diabetes (ICD-10-AM E10) listed in any of the first 15 diagnoses.

2. National Mortality Collection

Numerator: Mortality in children and young people aged 0–24 years with type 1 diabetes (ICD-10-AM E10) listed as the main underlying cause of death, or as a contributory cause.

Denominator: Statistics New Zealand Estimated Resident Population (projected from 2007).

Notes on Interpretation

Note 1: This analysis focuses on hospital admissions and mortality for children and young people with type 1 diabetes listed in any of the first 15 diagnoses, or as the main underlying, or a contributory cause of death. The rationale for looking beyond the primary diagnosis was the need to highlight the full spectrum of health issues experienced by children and young people with type 1 diabetes, and their requirements for health services.

For example, during 2008–2012, while 70% of hospitalisations in children and young people with type 1 diabetes were for diabetes related diagnoses, 30% were for other conditions. Some of these may have been more likely as a result of diabetes (e.g. some types of infection), or because their management may have been more complex in diabetic patients (e.g. acute gastroenteritis). However, the number of admissions in diabetic patients which were unrelated to their diabetes (e.g. viral infections), may slightly overinflate the impact diabetes has on acute service demand.

Note 2: The terminology used to describe diabetic complications differs to that used previously due to changes in the way ICD-10-AM Version 6 deals with coma and ketoacidosis. Previous ICD-10-AM versions included two sub-categories: diabetes with coma and diabetes with ketoacidosis without coma. In ICD-10-AM Version 6 ketoacidosis and lactic acidosis are grouped together, with additional digit extensions being used to identify the presence or absence of coma. Thus earlier reports grouped admissions into type 1 diabetes with coma and type 1 diabetes with ketoacidosis, whereas in this report, these have been combined into the category *Type 1 Diabetes with Ketoacidosis/Lactic Acidosis +/− Coma*.

Note 3: The admission rates presented here may differ from those presented previously due to a change between ICD-10-AM Version 3 and 6 which tightened up the way diabetes was assigned as an additional diagnosis. With the introduction of Version 6 in July 2008, new criteria were introduced for coding diabetes as a secondary diagnosis in the presence of another condition e.g. cystic fibrosis. While the impacts were greatest for type 2 diabetes, it is likely that these changes were responsible for some of the drop in admissions for type 1 diabetes which occurred in 2008–09, immediately after the introduction of ICD-10-AM V6.

Note 4: If no mention of type 1 diabetes was made in any of the first 15 diagnoses, these cases were not included, even if the patient had been assigned a diabetes related code on a previous admission.

New Zealand Distribution and Trends

Distribution by Primary Diagnosis

Primary Diagnosis: In New Zealand during 2008–2012, 70.0% of hospital admissions for children and young people with type 1 diabetes listed in any of their first 15 diagnoses had a diabetes-related primary diagnosis, with ketoacidosis/lactic acidosis +/− coma accounting for 33.3% and type 1 diabetes without complications for 17.7% of admissions. A further 30.0% of hospitalisations were for diagnoses other than diabetes, with gastroenteritis, injuries and poisoning, pregnancy and childbirth, and respiratory diseases being the most common reasons for non-diabetes related admissions (**Table 1**).

Distribution by Age

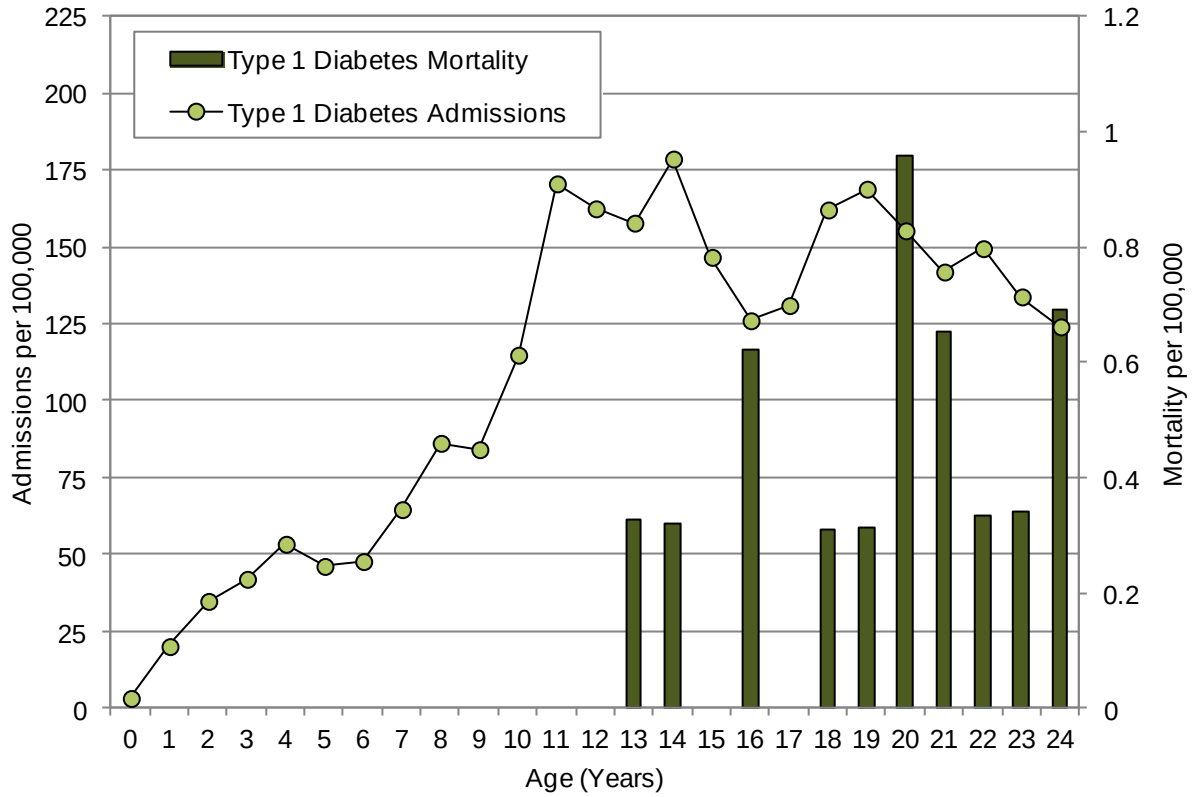
In New Zealand during 2008–2012, hospitalisations for children and young people with type 1 diabetes increased during childhood, reached a peak at 14 years of age, and then fluctuated. Mortality was highest amongst those in their late teens and early twenties, with 15 young people having type 1 diabetes listed as the main underlying cause of death, or as a contributory cause, during 2006–2010. However, none of these deaths occurred in children aged less than 13 years (**Figure 1**).

Table 1. Hospital Admissions in Children and Young People Aged 0–24 Years with Type 1 Diabetes by Primary Diagnosis, New Zealand 2008–2012

Primary Diagnosis	Number of Admissions: Total 2008−2012	Number of Admissions: Annual Average	Rate per 100,000 Population	% of Admissions in those with Type 1 Diabetes
Type 1 Diabetes				
Diagnosis other than Type 1 Diabetes*	2,490	498.0	32.61	30.0
Type 1 Diabetes with Ketoacidosis/Lactic Acidosis +/− Coma	2,769	553.8	36.26	33.3
Type 1 Diabetes without Complications	1,470	294.0	19.25	17.7
Type 1 Diabetes with Ophthalmic Complications	87	17.4	1.14	1.0
Type 1 Diabetes with Neurological Complications	41	8.2	0.54	0.5
Type 1 Diabetes with Renal Complications	22	4.4	0.29	0.3
Type 1 Diabetes with Multiple Complications	13	2.6	0.17	0.2
Type 1 Diabetes with Unspecified Complications	5	1.0	0.07	0.1
Type 1 Diabetes with Other Specified Complications	1,412	282.4	18.49	17.0
New Zealand Total	8,309	1,661.8	108.81	100.0
*Diagnoses other than Type 1 Diabetes				
Gastroenteritis	441	88.2	5.78	5.3
Injury and Poisoning	243	48.6	3.18	2.9
Pregnancy Childbirth Post-partum	229	45.8	3.00	2.8
Diseases of the Respiratory System	200	40.0	2.62	2.4
Skin Infections	133	26.6	1.74	1.6
Abdominal and Pelvic Pain	117	23.4	1.53	1.4
Viral Infection Unspecified Site	94	18.8	1.23	1.1
Complications Medical Surgical Care	53	10.6	0.69	0.6
Other Infectious Diseases	46	9.2	0.60	0.6
Cystic Fibrosis	32	6.4	0.42	0.4
Other Diagnoses	902	180.4	11.81	10.9
Total Diagnoses other than Type 1 Diabetes	2,490	498.0	32.61	30.0

Source: Numerator: National Minimum Dataset, hospital admissions by primary diagnosis for children and young people with type 1 diabetes listed in any of the first 15 diagnoses; Denominator: Statistics NZ Estimated Resident Population (projected from 2007)

Figure 1. Hospital Admissions (2008–2012) and Mortality (2006–2010) for New Zealand Children and Young People with Type 1 Diabetes by Age



Source: Numerator Admissions: National Minimum Dataset, hospital admissions for children and young people with type 1 diabetes listed in any of the first 15 diagnoses; Numerator Mortality: National Mortality Collection, deaths with type 1 diabetes listed as the main underlying or a contributory cause of death; Denominator: Statistics NZ Estimated Resident Population (projected from 2007)

Distribution by Ethnicity and Gender

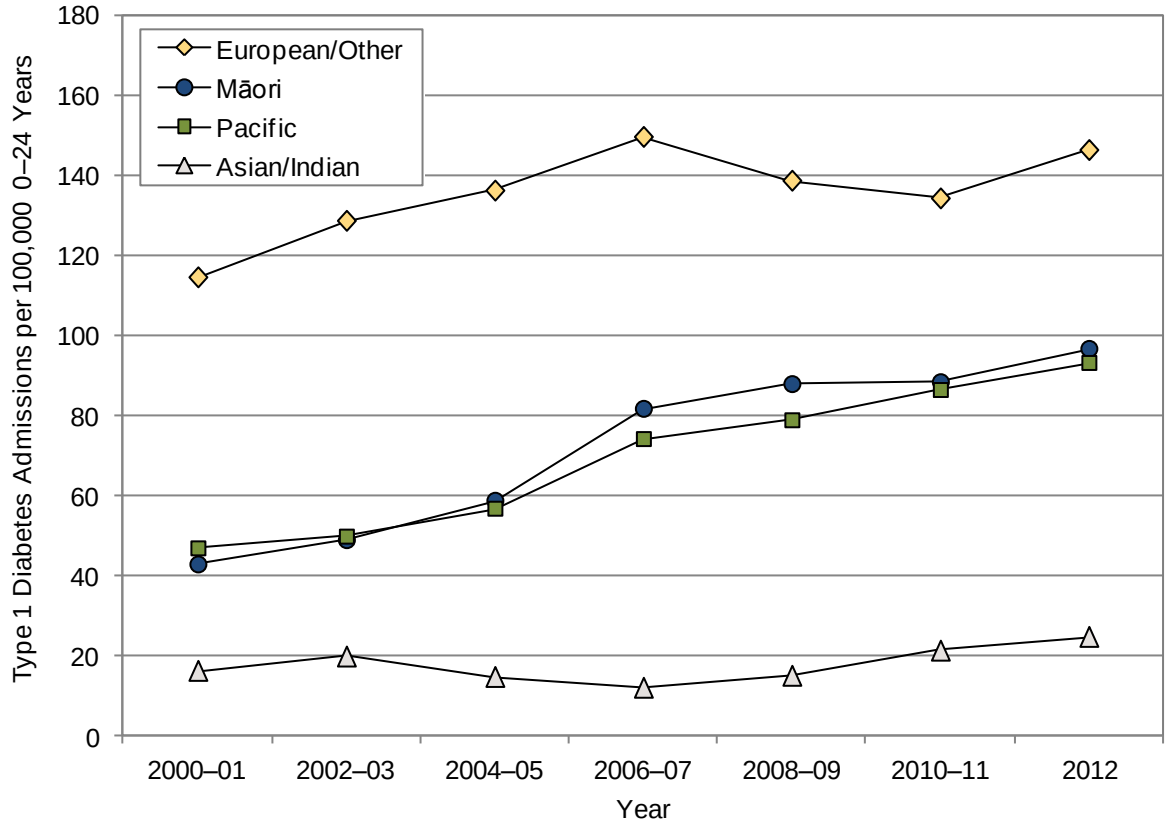
In New Zealand during 2008–2012, hospital admissions for those with type 1 diabetes were *significantly* higher for females and for European/Other > Māori and Pacific > Asian/Indian children and young people (**Table 2**). Similar ethnic differences were seen during 2000–2012 (**Figure 2**).

Table 2. Hospital Admissions for Children and Young People Aged 0–24 Years with Type 1 Diabetes by Ethnicity and Gender, New Zealand 2008–2012

Variable	Rate	Rate Ratio	95% CI	Variable	Rate	Rate Ratio	95% CI
Type 1 Diabetes							
Asian/Indian	19.44	0.14	0.12–0.16	Female	127.92	1.00	
European/Other	138.29	1.00		Male	90.65	0.71	0.68–0.74
Māori	89.71	0.65	0.61–0.69				
Pacific	84.72	0.61	0.56–0.67				

Source: Numerator: National Minimum Dataset, hospital admissions for children and young people with type 1 diabetes listed in any of the first 15 diagnoses; Denominator: Statistics NZ Estimated Resident Population (projected from 2007); Note: Ethnicity is Level 1 Prioritised; Rate is per 100,000 population

Figure 2. Hospital Admissions for Children and Young People Aged 0–24 Years with Type 1 Diabetes by Ethnicity, New Zealand 2000–2012



Source: Numerator: National Minimum Dataset, hospital admissions for children and young people with type 1 diabetes in any of the first 15 diagnoses; Denominator: Statistics NZ Estimated Resident Population (projected from 2007); Note: Ethnicity is Level 1 Prioritised; Note: See Note 2 in Methods box regarding cautions in interpreting time series information as a result of a change in the way diabetes codes were assigned in 2008.

South Island DHBs Distribution and Trends

South Island Distribution

In the South Island during 2008–2012, 95 Nelson Marlborough, 51 South Canterbury, 375 Canterbury, 28 West Coast, 160 Otago and 107 Southland children and young people were hospitalised with a diagnosis of type 1 diabetes. Admission rates per 100,000 in South Canterbury and Otago and Southland were *significantly* higher than the New Zealand rate, while rates in the remaining DHBs were not *significantly* different (**Table 3**).

South Island Trends

In the South Island DHBs during 2000–2012, large year to year variations (likely as a result of small numbers) made individual DHB's trends in admission rates difficult to interpret However, rates in South Canterbury, Otago and Southland remained higher than the New Zealand rate throughout this period (**Figure 3**).

Distribution by Primary Diagnosis

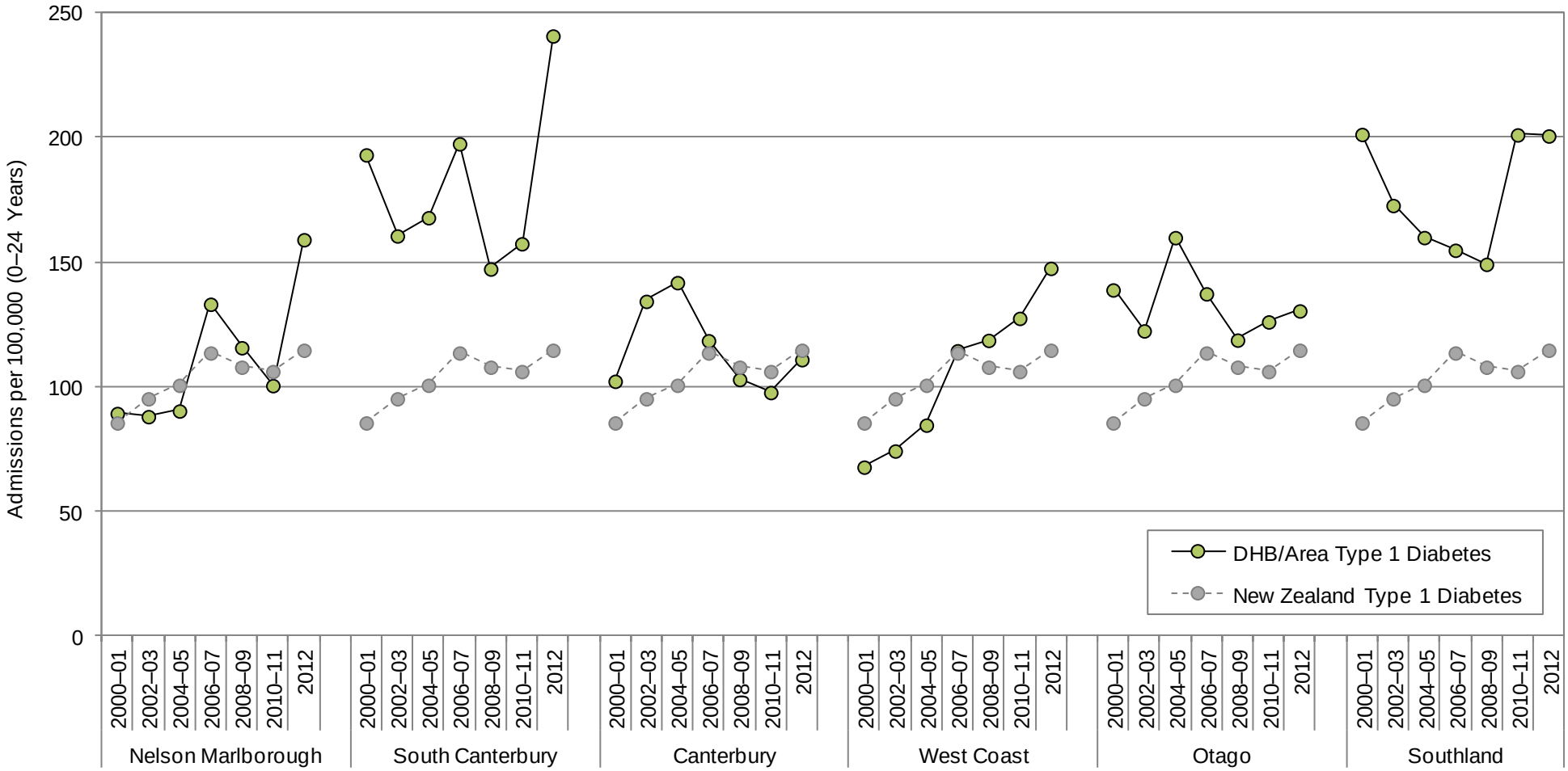
In the South Island DHBs during 2008–2012, the majority (range 64.6%–78.5%) of hospital admissions in children and young people with type 1 diabetes listed in any of their first 15 diagnoses, had a diabetes-related primary diagnosis. Ketoacidosis/lactic acidosis +/− coma was the most frequent primary diagnosis in those with type 1 diabetes in all South Island DHBs (**Table 4**, **Table 5**).

Table 3. Hospital Admissions for Children and Young People Aged 0–24 Years with Type 1 Diabetes, South Island DHBs vs. New Zealand 2008–2012

DHB/Area	Total Number of Individuals 2008−2012		Total Number of Admissions 2008−2012	Average Number of Admissions per Individual per Year	Admission Rate per 100,000 Population	Rate Ratio	95% CI
	A*	B*					
Type 1 Diabetes							
Nelson Marlborough	92	95	252	0.53	118.6	1.09	0.96–1.23
South Canterbury	46	51	145	0.57	170.3	1.56	1.33–1.84
Canterbury	360	375	854	0.46	102.7	0.94	0.88–1.01
West Coast	23	28	65	0.46	128.2	1.18	0.92–1.50
Otago	145	160	417	0.52	124.3	1.14	1.04–1.26
Southland	98	107	331	0.62	180.6	1.66	1.49–1.85
New Zealand	2,916		8,309	0.57	108.8	1.00	

Source: Numerator: National Minimum Dataset, hospital admissions for children and young people with type 1 diabetes listed in any of the first 15 diagnoses; Denominator: Statistics NZ Estimated Resident Population (projected from 2007); Note: A*: Each individual only counted once in DHB in which they first reside (DHB total = NZ total); B*: Each individual counted once in each DHB in which they reside (sum of DHB totals exceeds NZ total). Rate Ratios are compared to NZ rate and have not been adjusted for population demographics

Figure 3. Hospital Admissions for Children and Young People Aged 0–24 Years with Type 1 Diabetes, South Island DHBs vs. New Zealand 2000–2012



Source: Numerator: National Minimum Dataset, hospital admissions for children and young people with type 1 diabetes listed in any of the first 15 diagnoses; Denominator: Statistics NZ Estimated Resident Population (projected from 2007); Note: See Note 2 in Methods box regarding cautions in interpreting time series information as a result of a change in the way diabetes codes were assigned in 2008.

Table 4. Hospital Admissions in Children and Young People Aged 0–24 Years with Type 1 Diabetes by Primary Diagnosis, Nelson Marlborough, South Canterbury and Canterbury DHBs 2008–2012

Primary Diagnosis	No. of Admissions: Total 2008–2012	No. of Admissions: Annual Average	Rate per 100,000 Population	% of Admissions in those with Type 1 Diabetes
Nelson Marlborough				
Type 1 Diabetes with Ketoacidosis/Lactic Acidosis +/− Coma	103	20.6	48.46	40.9
Diagnosis other than Type 1 Diabetes	77	15.4	36.22	30.6
Type 1 Diabetes without Complications	39	7.8	18.35	15.5
Type 1 Diabetes with Other Specified Complications	33	6.6	15.52	13.1
Nelson Marlborough Total	252	50.4	118.55	100.0
South Canterbury				
Type 1 Diabetes with Ketoacidosis/Lactic Acidosis +/− Coma	56	11.2	65.76	38.6
Diagnosis other than Type 1 Diabetes	33	6.6	38.75	22.8
Type 1 Diabetes without Complications	21	4.2	24.66	14.5
Type 1 Diabetes with Other Specified Complications	35	7.0	41.10	24.1
South Canterbury Total	145	29.0	170.26	100.0
Canterbury				
Diagnosis other than Type 1 Diabetes	295	59.0	35.47	34.5
Type 1 Diabetes with Ketoacidosis/Lactic Acidosis +/− Coma	294	58.8	35.35	34.4
Type 1 Diabetes without Complications	136	27.2	16.35	15.9
Type 1 Diabetes with Ophthalmic Complications	18	3.6	2.16	2.1
Type 1 Diabetes with Neurological Complications	6	1.2	0.72	0.7
Type 1 Diabetes with Other Specified Complications	105	21.0	12.63	12.3
Canterbury Total	854	170.8	102.69	100.0

Source: Numerator: National Minimum Dataset, hospital admissions by primary diagnosis for children and young people with type 1 diabetes listed in any of the first 15 diagnoses; Denominator: Statistics NZ Estimated Resident Population (projected from 2007)

Table 5. Hospital Admissions in Children and Young People Aged 0–24 Years with Type 1 Diabetes by Primary Diagnosis, the West Coast and Southern DHBs 2008–2012

Primary Diagnosis	No. of Admissions: Total 2008–2012	No. of Admissions: Annual Average	Rate per 100,000 Population	% of Admissions in those with Type 1 Diabetes
West Coast				
Type 1 Diabetes with Ketoacidosis/Lactic Acidosis +/− Coma	24	4.8	47.35	36.9
Diagnosis other than Type 1 Diabetes	23	4.6	45.37	35.4
Type 1 Diabetes without Complications	7	1.4	13.81	10.8
Type 1 Diabetes with Other Specified Complications	11	2.2	21.70	16.9
West Coast Total	65	13.0	128.23	100.0
Otago				
Type 1 Diabetes with Ketoacidosis/Lactic Acidosis +/− Coma	156	31.2	46.50	37.4
Diagnosis other than Type 1 Diabetes	123	24.6	36.66	29.5
Type 1 Diabetes without Complications	69	13.8	20.57	16.5
Type 1 Diabetes with Renal Complications	3	0.6	0.89	0.7
Type 1 Diabetes with Other Specified Complications	66	13.2	19.67	15.8
Otago Total	417	83.4	124.29	100.0
Southland				
Type 1 Diabetes with Ketoacidosis/Lactic Acidosis +/− Coma	110	22.0	60.01	33.2
Type 1 Diabetes without Complications	76	15.2	41.46	23.0
Diagnosis other than Type 1 Diabetes	71	14.2	38.73	21.5
Type 1 Diabetes with Ophthalmic Complications	22	4.4	12.00	6.6
Type 1 Diabetes with Other Specified Complications	52	10.4	28.37	15.7
Southland Total	331	66.2	180.56	100.0

Source: Numerator: National Minimum Dataset, hospital admissions by primary diagnosis for children and young people with type 1 diabetes listed in any of the first 15 diagnoses; Denominator: Statistics NZ Estimated Resident Population (projected from 2007)

Local Policy Documents and Evidence-Based Reviews Relevant to Type 1 Diabetes

In New Zealand a small number of policy documents are relevant to the management of children and young people with type 1 diabetes and these are reviewed in **Table 6,** along with a range of guidelines and reviews which consider these issues in the overseas context.

Table 6. Local Policy Documents and Evidence-Based Reviews Relevant to Type 1 Diabetes in Children and Young People

Ministry of Health Policy Documents
There are no specific Ministry of Health guidelines for Type 1 Diabetes in New Zealand. A small number of publications review different aspects of Diabetes care.
Campbell S, Suebwongpat A, Standfield L, Weston A. **Systematic review update and economic evaluation for the New Zealand setting: Subcutaneous insulin pump therapy**. HSAC Report 2008; 1(3). Health Services Assessment Collaboration (HSAC), University of Canterbury. http://www.healthsac.net/downloads/publications/HSAC04%20Subcutaneous%20Insulin%20Pump%20270308.pdf This systematic review update was performed at the request of the Ministry of Health and considers whether subcutaneous insulin pump therapy is effective, safe, and cost-effective compared with multiple daily injections. The update was based on the National Institute for Health and Clinical Excellence (NICE) guidance for the use of continuous subcutaneous insulin infusion (CSII) in diabetes http://publications.nice.org.uk/continuous-subcutaneous-insulin-infusion-for-the-treatment-of-diabetes-mellitus-ta151. It concluded that compared to multiple daily injections, CSII produces a modest improvement in glycosylated haemoglobin levels in all patient groups assessed, including children and that based on the studies identified there is there is limited evidence to support the contention that CSII produces a reduction in the incidence of severe hypoglycaemic events and improved quality of life (due to greater flexibility of lifestyle). The Ministry of Health guidelines for the prioritised use of sub-cutaneous insulin infusions (insulin pumps) (http://www.health.govt.nz/our-work/diseases-and-conditions/diabetes/about-diabetes/sub-cutaneous-insulin-infusions-insulin-pumps) note that access to insulin pumps varies across New Zealand. District Health Boards decide how to cater for the specific needs of their populations.
Ministry of Health. 2008. **National Diabetes Retinal Screening Grading System and Referral Guidelines 2006**. Wellington: Ministry of Health. http://www.health.govt.nz/publication/national-diabetes-retinal-screening-grading-system-and-referral-guidelines-2006-and-resources-2008 These guidelines are to provide ophthalmologists, optometrists and those involved with photographic retinal screening with a nationally consistent approach to classifying and referring people with significant diabetic retinopathy for review by an ophthalmologist, using eye screening photographs, with the ability to measure and monitor grading and referrals against a national grading and referral standard.
International Guidelines
American Diabetes Association. 2013. **Standards of medical care in diabetes—2013**. Diabetes Care, 36(Supplement 1), S11-S66. http://care.diabetesjournals.org/content/36/Supplement_1/S11.full.pdf+html doi: 10.2337/dc13-S01. **Executive Summary: Standards of Medical Care in Diabetes—2013** Diabetes Care January 2013 36:S4-S10; doi:10.2337/dc13-S004 http://care.diabetesjournals.org/content/36/Supplement_1/S4.full.pdf+html These standards of care are intended to provide clinicians, patients, researchers, payers, and other interested individuals with the components of diabetes care, general treatment goals, and tools to evaluate the quality of care. The recommendations included are screening, diagnostic, and therapeutic actions that are known or believed to favourably affect health outcomes of patients with diabetes. A large number of these interventions have been shown to be cost-effective. A grading system, developed by the American Diabetes Association (ADA) and modelled after existing methods, was utilised to clarify and codify the evidence that forms the basis for the recommendations. These standards of care are revised annually by the ADA's multidisciplinary Professional Practice Committee, incorporating new evidence. For the current revision, committee members systematically searched Medline for human studies related to each subsection and published since 1 January 2011.
Canadian Diabetes Association Clinical Practice Guidelines Expert Committee. Canadian Diabetes Association 2013 **Clinical Practice Guidelines for the Prevention and Management of Diabetes in Canada**. Can J Diabetes 2013; 37(suppl 1):S1-S212. http://guidelines.diabetes.ca/App_Themes/CDACPG/resources/cpg_2013_full_en.pdf These evidence-based clinical practice guidelines are intended to support healthcare decisions based on the most current evidence available. They provide recommendations on screening, prevention, diagnosis, education, care and management of diabetes. Chapters 4, 12, and 34 have specific recommendations for type 1 diabetes.

Scaramuzza A, et al. 2013. **Recommendations for self-monitoring in pediatric diabetes: a consensus statement by the ISPED**. Acta Diabetol. http://link.springer.com/article/10.1007%2Fs00592-013-0521-7/fulltext.html

These recommendations come from the Italian Society of Pediatric Endocrinology and Diabetology after an extensive review of the literature. Recommendations for the following issues were given: self-monitoring blood glucose, continuous glucose monitoring, glycemic variability, glycosuria, ketonuria, ketonemia, glycated hemoglobin, fructosamine and glycated albumin, logbook, data downloading, lancing devices, carbohydrate counting, and glycemic measurements at school.

Craig ME, et al. for the Australian Type 1 Diabetes Guidelines Expert Advisory Group. **National evidence-based clinical care guidelines for type 1 diabetes in children, adolescents and adults**. Australian Government Department of Health and Ageing, Canberra 2011.
http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/ext004_type1_diabetes_children_adolescents_adults.pdf

This national evidence-based guideline provides a comprehensive resource for the healthcare professional team in the modern clinical care of people with type 1 diabetes in Australia. It was developed by an Expert Advisory Group (EAG) representing specialist societies and organisations, with the active participation of consumer groups and the community. The guidelines are to be used in both the hospital and ambulatory healthcare setting. The guideline produced recommendations – based on evidence from the systematic reviews; and practice points – based on consensus decision-making, where the systematic review found insufficient high-quality data to produce evidence-based recommendations, but clinicians require guidance to ensure good clinical practice. The technical report that presents the findings from the systematic reviews that underpin these guidelines can be found here:
http://www.diabetessociety.com.au/downloads/guidelinesTechReport1.pdf

International Diabetes Federation (IDF)/International Society for Pediatric and Adolescent Diabetes (ISPAD) 2011 **Global Guideline for Diabetes in Childhood and Adolescence**.
http://www.ispad.org/sites/default/files/resources/files/idf-ispad_diabetes_in_childhood_and_adolescence_guidelines_2011_0.pdf

This guideline is based on the ISPAD Clinical Practice Consensus Guidelines Compendium 2009 (*Pediatr Diabetes* 2009; 10 (Suppl 12): 1-210) http://www.ispad.org/content/ispad-clinical-practice-consensus-guidelines-2009 using evidence from reports from key meta-analyses, evidence-based reviews, clinical trials, cohort studies, epidemiological studies, animal and basic science studies, position statements and guidelines. The guideline provides a practical approach to promote the implementation of cost-effective, evidence-based care for children and adolescents across settings where resources may vary. Three levels of care are outline: recommended care; limited care for very limited resource locations; and comprehensive care for settings with considerable resources.

Klonoff DC, et al. 2011. **Continuous glucose monitoring: an Endocrine Society Clinical Practice Guideline**. J Clin Endocrinol Metab, 96(10), 2968-79.
http://jcem.endojournals.org/content/96/10/2968.long

These evidence-based practice guidelines were developed to determine settings where patients are most likely to benefit from the use of continuous glucose monitoring (CGM). Real-time CGM (RT-CGM) alone was not recommended for adults in intensive care units or operating rooms pending further research. RT-CGM was recommended for children, adolescents and adult outpatients with some provisos including the ability to use the device.

Scottish Intercollegiate Guidelines Network (SIGN). **Management of diabetes. A national clinical guideline**. Edinburgh (Scotland): SIGN; 2010 Mar. 170 p. (SIGN publication; no. 116) http://www.sign.ac.uk/guidelines/fulltext/116/index.html

This guideline updates a previous version (2001) and provides recommendations based on current evidence for best practice in the management of diabetes for children and adults with type 1 and type 2 diabetes mellitus, and for pregnant women with gestational diabetes. Major recommendations include: lifestyle management; psychosocial factors; and management of diabetes and related conditions. Management of type 1 diabetes includes: diagnosis and epidemiology; initiating therapy at diagnosis; continuing management; quality of life; and long term complications and screening. The full guidelines and a summary of recommendations can be found at the link above.

National Institute for Clinical Excellence. **Type 1 diabetes: diagnosis and management of type 1 diabetes in children, young people and adults.** Clinical Guideline 14, July 2004; updated in June 2009 and March 2010.
http://www.nice.org.uk/nicemedia/live/10944/29390/29390.pdf

This NICE guideline addresses the diagnosis and management of babies, children, adolescents, adults and older people with type 1 diabetes. It covers care in primary and secondary health care and addresses the interface between community and specialist care, and between paediatric and adult services. The guideline also addresses support from the health system to early childhood services, schools and other institutions in the UK context.

Cochrane Systematic Reviews
Langendam M, et al. 2012. **Continuous glucose monitoring systems for type 1 diabetes mellitus**. Cochrane Database of Systematic Reviews (2). Continuous glucose monitoring (CGM) systems measure interstitial fluid glucose levels to provide semi-continuous information about glucose levels. Currently, the use of CGM is not common practice and its reimbursement status is a point of debate in many countries. This systematic review assessed the effects of CGM systems compared to conventional self-monitoring of blood glucose (SMBG) in patients with diabetes mellitus type 1. Twenty-two RCTs were included with results of the meta-analyses (across all age groups) indicating benefit of CGM for patients starting on CGM sensor augmented insulin pump therapy compared to patients using multiple daily injections of insulin (MDI) and standard monitoring blood glucose (SMBG). After six months there was a significant larger decline in HbA1c level for real-time CGM users starting insulin pump therapy compared to patients using MDI and SMBG (mean difference (MD) in change in HbA1c level -0.7%, 95% CI -0.8% to -0.5%, 2 RCTs, 562 patients, I^2=84%). The risk of hypoglycaemia was increased for CGM users, but CIs were wide and included unity (4/43 versus 1/35; RR 3.26, 95% CI 0.38 to 27.82 and 21/247 versus 17/248; RR 1.24, 95% CI 0.67 to 2.29). There is limited evidence for the effectiveness of real-time continuous glucose monitoring (CGM) use in children, adults and patients with poorly controlled diabetes. The largest improvements in glycaemic control were seen for sensor-augmented insulin pump therapy in patients with poorly controlled diabetes who had not used an insulin pump before. There are indications that higher compliance of wearing the CGM device improves glycosylated haemoglobin A1c level (HbA1c) to a larger extent.
Misso ML, et al. 2010. **Continuous subcutaneous insulin infusion (CSII) versus multiple insulin injections for type 1 diabetes mellitus**. Cochrane Database of Systematic Reviews (1). Glycaemic control is maintained in type 1 diabetes by replacement of insulin and may be in the form of 'conventional' insulin therapy (multiple injections per day) or continuous subcutaneous insulin infusion (CSII). This systematic review assessed the effects of CSII compared to multiple insulin injections (MI) in people with type 1 diabetes mellitus. Twenty three randomised controlled trial studies (976 participants) comparing CSII with three or more insulin injections per day in people with type 1 diabetes were included in the analysis. There was a statistically significant difference in glycosylated haemoglobin A1c (HbA1c) favouring CSII (weighted mean difference -0.3% (95% confidence interval -0.1 to -0.4). There were no obvious differences between the interventions for non-severe hypoglycaemia, but severe hypoglycaemia appeared to be reduced in those using CSII. Quality of life measures suggest that CSII is preferred over MI. There is some evidence to suggest that CSII may be better than MI for glycaemic control in people with type 1 diabetes. Non-severe hypoglycaemic events do not appear to be reduced with CSII. There is insufficient evidence regarding adverse events, mortality, morbidity and costs.
Abdelghaffar S, et al. **Metformin added to insulin therapy for type 1 diabetes mellitus in adolescents**. Cochrane Database of Systematic Reviews 2009(1):CD006691. This review found two trials (60 participants) which investigated the effect of metformin added to insulin therapy for three months in adolescents with poorly controlled type 1 diabetes. The authors concluded “There is some evidence suggesting improvement of metabolic control in poorly controlled adolescents with type 1 diabetes, on addition of metformin to insulin therapy. Stronger evidence is required from larger studies, carried out over longer time periods to document the long-term effects on metabolic control, health-related quality of life as well as morbidity and mortality in those patients.”
Clar C, et al. 2009. **Routine hospital admission versus out-patient or home care in children at diagnosis of type 1 diabetes mellitus**. Cochrane Database of Systematic Reviews (1). This systematic review assessed the effects of routine hospital admission compared to out-patient or home-based management in children newly diagnosed with type 1 diabetes mellitus. Seven studies were included in the review, including a total of 298 children in the out-patient/home group. There was only one high quality trial identified which suggested that home-based management of children with newly diagnosed type 1 diabetes may lead to slightly improved long term metabolic control (at two and three years follow-up). No differences between comparison groups were found in any of the psychosocial and behavioural variables or rates of acute diabetic complications within two years. Due to the generally low quality or limited applicability of the studies identified, the results of this review are inconclusive. Generally, the data seem to suggest that where adequate out-patient/home management of type 1 diabetes in children at diagnosis can be provided, this does not lead to any disadvantages in terms of metabolic control, acute diabetic complications and hospitalisations, psychosocial variables and behaviour, or total costs.
Vardi M, et al. **Intermediate acting versus long acting insulin for type 1 diabetes mellitus**. Cochrane Database of Systematic Reviews 2008(3):CD006297. As part of their treatment regimen patients with type 1 diabetes require basal insulin replacement. This review compares the use of intermediate versus long acting insulin for this purpose. Twenty three randomised controlled trials involving 3872 patients in the intervention group and 2915 patients in the control group were analysed. Overall the differences between the two groups were small and there were no differences in the quantity or quality of severe adverse events or deaths but the authors noted that there appeared to be a beneficial effect of long acting insulin on nocturnal glucose levels.

Other Systematic Reviews
Macmillan F, et al. 2013. **A systematic review of physical activity and sedentary behavior intervention studies in youth with type 1 diabetes: study characteristics, intervention design, and efficacy**. Pediatr Diabetes. This systematic review explored physical activity and/or sedentary behaviour randomised controlled intervention studies for youth (<18 years) with type 1 diabetes. Eleven studies were included with 8 improving physical activity and/or fitness. Meta-analysis of 10 studies showed the interventions have a significant beneficial reduction of HbA1c (%), indicating an improvement in glycaemic control [WMD, -0.85% (95% CI, -1.45 to -0.25%)]. Limited reporting made comparison of findings challenging. There was an overall significant beneficial effect of physical activity on HbA1c.
Kennedy A, et al. 2013. **Does exercise improve glycaemic control in type 1 diabetes? A systematic review and meta-analysis**. PLoS One, 8(3), e58861. This systematic review and meta-analysis explored the evidence for a glycaemic benefit of exercise in type 1 diabetes, defined as an improvement in glycosolated haemoglobin (HbA1c). Eight randomised and five non-randomised controlled trials were included. A meta-analysis of 12 studies (452 patients) demonstrated a trend towards HbA1c reduction (standardised mean difference (SMD) -0.25; 95% CI, -0.59 to 0.09), with no reduction seen in the four adult studies. This meta-analysis does not reveal evidence for a glycaemic benefit of exercise as measured by HbA1c although exercise does have other proven benefits in type 1 diabetes, and remains an important part of its management.
Herbert L, et al. 2013. **Text message interventions for children and adolescents with type 1 diabetes: a systematic review**. Diabetes Technol Ther, 15(5), 362-70. This review was to identify studies that used a text message-based intervention for youth with type 1 diabetes. Seven studies were included (3 randomised controlled trials) with the majority aiming to evaluate the feasibility and effectiveness of a text message intervention to improve glycaemic control. The reviewed articles had small sample sizes and mixed results regarding the effectiveness of text message interventions with respect to daily type 1 diabetes management behaviours and glycaemic control. However, they did demonstrate their feasibility and high levels of participant satisfaction. Further research using experimental designs and grounded in behavioural theory is needed.
Tsiouli E, et al. 2013. **Effects of diabetes-related family stress on glycemic control in young patients with type 1 diabetes: Systematic review**. Can Fam Physician, 59(2), 143-9. This review investigated the way that family stress influences glycaemic control among patients with diabetes less than 18 years of age. Six cohort and 3 cross-sectional studies, and 1 qualitative review were included. In most studies family stress was negatively correlated with patients' glycaemic control. Family function was strongly related to patients' glycaemic control, while family conflict was adversely associated with glycaemic control. Families of low socioeconomic status, those of adolescents with diabetes, and those of single parents were more prone to diabetes-related stress and thus more susceptible to worse glycaemic control. Therapeutic psychological interventions and educational programmes can help alleviate family diabetes-related stress and will likely improve glycaemic control.
Tonoli C, et al. 2012. **Effects of different types of acute and chronic (training) exercise on glycaemic control in type 1 diabetes mellitus: a meta-analysis**. Sports Med, 42(12), 1059-80. This meta-analysis was conducted to determine the overall effects of exercise (acute bouts of exercise and chronic exercise [or training]) on acute and chronic glycaemic control in patients with type 1 diabetes, the effects of different types of exercise on glycaemic control and which conditions are required to obtain these positive effects. Thirty-three studies were included. Aerobic exercise, resistance exercise, mixed exercise (aerobic combined with resistance training) and high-intensity exercise acutely decreased blood glucose levels. To prevent late-onset hypoglycaemic episodes, the use of single bouts of sprints into an aerobic exercise can be recommended. Only regular aerobic training will improve the glycated haemoglobin level of a patient with type 1 diabetes.
John M Eisenberg Center for Clinical Decisions & Communications Science. 2007. **AHRQ Comparative Effectiveness Reviews. Insulin Delivery and Glucose Monitoring Methods for Diabetes Mellitus: Comparative Effectiveness**. Comparative Effectiveness Review Summary Guides for Clinicians. Rockville (MD): Agency for Healthcare Research and Quality (US). http://www.effectivehealthcare.ahrq.gov/glucose.cfm This systematic review was conducted to determine the benefits and harms of current modes of intensive insulin therapy (continuous subcutaneous insulin infusion [CSII] vs. multiple daily injections [MDI]) and modes of blood glucose monitoring (real-time continuous glucose monitoring [rt-CGM] vs. self-monitoring of blood glucose [SMBG]). Forty-one studies were included and clinical outcomes were assessed in individuals with type 1 diabetes and type 2 diabetes. Both CSII and MDI had similar effects on glycaemic control and rates of severe hypoglycaemia in children and adolescents with type 1 diabetes and adults with type 2 diabetes. In contrast, some studies suggested that CSII was superior to MDI for glycaemic control in adults with type 1 diabetes with no difference in hypoglycaemia and weight gain. Limited evidence suggested that measures of quality of life or treatment satisfaction improved in patients with type 1 diabetes. rt-CGM/CSII in the form of sensor-augmented pumps was superior to MDI/SMBG in lowering HbA_{1c} in the research studies analysed in this review.

Floyd B, et al. 2012. **Comparative analysis of the efficacy of continuous glucose monitoring and self-monitoring of blood glucose in type 1 diabetes mellitus**. J Diabetes Sci Technol, 6(5), 1094-102.

This comparative analysis considered whether continuous glucose monitoring (CGM) provides further efficacy and safety benefits beyond self-monitoring of blood glucose (SMBG) in the management of type 1 diabetes. Fourteen randomised controlled trials (1188 patients) were included. Compared with SMBG, the use of CGM was associated with a greater reduction in HbA1c [-0.3% (confidence interval: 0.4, -0.2), $p < 0.0001$]. The number of hypoglycaemic events was not significantly different between the CGM and SMBG groups (0.52 ± 0.52 versus 0.52 ± 0.63 events/day, p=0.5), but duration of hypoglycaemia was shorter for the CGM group (75 ± 39 versus 89 ± 19 min/day. Continuous glucose monitoring also resulted in a shorter duration of hyperglycaemia than SMBG (172 ± 125 versus 217 ± 152 min/day, p=0.04). The use of CGM is associated with improvement in metabolic control in T1DM, with significant short- and long-term reductions in HbA1c and reduction in the duration of periods of hypoglycaemia and hyperglycaemia versus SMBG.

Tricco AC, et al. 2012. **Effectiveness of quality improvement strategies on the management of diabetes: a systematic review and meta-analysis**. Lancet, 379(9833), 2252-61.

This systematic review aimed to assess the effects of quality improvement (QI) strategies on glycated haemoglobin (HbA1c), vascular risk management, microvascular complication monitoring, and smoking cessation in patients with diabetes. Randomised controlled trials of patients with either type 1 or type 2 diabetes were included. Forty-eight cluster-randomised controlled trials (2538 clusters and 84,865 patients) and 94 patient randomised controlled trials (38,664 patients) were reviewed. Many trials of QI strategies showed improvements in diabetes care. Interventions targeting the system of chronic disease management along with patient-mediated QI strategies should be an important component of interventions aimed at improving diabetes management. Interventions solely targeting health-care professionals seem to be beneficial only if baseline HbA1c control is poor.

Zeh P, et al. 2012. **The impact of culturally competent diabetes care interventions for improving diabetes-related outcomes in ethnic minority groups: a systematic review**. Diabet Med, 29(10), 1237-52.

This systematic review examined the evidence on culturally competent interventions for the needs of people with diabetes from ethnic minority groups. Studies were included if they reported primary research on the impact of culturally competent interventions on outcome measures of any ethnic minority group with diabetes. Eleven studies were included with varying study designs. A consistent finding from 10 of the studies was that any structured intervention, tailored to ethnic minority groups by integrating elements of culture, language, religion and health literacy skills, produced a positive impact on a range of patient-important outcomes.

Peters A & Laffel L. 2011. **Diabetes care for emerging adults: recommendations for transition from pediatric to adult diabetes care systems:** a position statement of the American Diabetes Association, with representation by the American College of Osteopathic Family Physicians, the American Academy of Pediatrics, the American Association of Clinical Endocrinologists, the American Osteopathic Association, the Centers for Disease Control and Prevention, Children with Diabetes, The Endocrine Society, the International Society for Pediatric and Adolescent Diabetes, Juvenile Diabetes Research Foundation International, the National Diabetes Education Program, and the Pediatric Endocrine Society (formerly Lawson Wilkins Pediatric Endocrine Society). Diabetes Care, 34(11), 2477-85.

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3198284/

This statement provides a framework for health care delivery during the transition period from late adolescence to young adulthood (18-30 years of age) for individuals with type 1 or type 2 diabetes. The statement addresses issues including the transition between paediatric and adult diabetes care and gives evidence-based recommendations for approaches to improve care transition of emerging adults with diabetes.

Other Relevant Publications and Websites

NZSSD EXPERT OPINION **Long-Acting Insulin Analogues**. Dr Jeremy Krebs, Endocrinologist, Wellington 2008
http://www.nzssd.org.nz/documents/expertopinion/Expert%20Opinion%20-%20Long-acting%20Insulin%20Analogues%2002-09-08.pdf

This Expert Opinion from the New Zealand Society for the Study of Diabetes compares the current situation regarding the use of the long acting insulin glargine in New Zealand with that in other countries. The references used for this expert opinion are now outdated.

Footnote: Some changes in this area have occurred according to a media release from Pharmac (16th August, 2010) http://www.pharmac.govt.nz/2010/08/16/Enhance%20access%20to%20diabetes%20treatments.pdf

- Widening access to the long-acting insulin glargine (Lantus);
- Funding a new rapid-acting insulin glulisine (Apidra);
- Widening access to blood ketones testing strips (Optium); and
- Widening access to the diabetes treatment acarbose (Glucobay).

New Zealand Society for the Study of Diabetes. **NZSSD Position Statement on Insulin Pump Therapy**. New Zealand Society for the Study of Diabetes, 2008.http://www.nzssd.org.nz/position_statements/insulinpump.html In this position statement the members of the executive of the NZSSD offer their recommendations on who should be eligible for Insulin Pump therapy and how such therapy should be administered. http://www.pharmac.health.nz/ckeditor_assets/attachments/154/notification_-_insulin_pumps.pdf Funding of New Zealand medical and scientific insulin pump and consumables was approved and available from 1 September 2012 under certain criteria as outlined in the following document: http://www.pharmac.govt.nz/2012/08/31/Insulin%20pumps%20and%20consumables%20SA%20criteria.pdf
http://www.diabetes.org.nz/home Diabetes New Zealand is a non-government non-profit organisation that was established in 1962 to represent and support people affected by diabetes. Diabetes New Zealand provides local support, advocacy, education and information and support of research with 22 branches throughout New Zealand.
http://www.diabetesyouth.org.nz/ Diabetes Youth New Zealand is a voluntary society established to provide support for children with diabetes and their families. It provides information about diabetes, news about camps and events and gives links to useful New Zealand and international websites related to diabetes for young people and young adults with diabetes.
http://www.kidshealth.org.nz/tags/diabetes Paediatric Society of New Zealand (PCNZ) is a multi-disciplinary Society committed to improving the health of children and young people. The KidsHealth website is a joint initiative between the Starship Foundation and PCNZ and provides information for New Zealand parents, caregivers, family and whānau, and for health professionals. This page gives information about diabetes.
http://www.diabetes.org/ This website of the American Diabetes Association gives information about diabetes, advocacy and news and research. The American Diabetes Association funds research to prevent, cure and manage diabetes, delivers services to communities, provides objective information and advocates for those denied their rights because of diabetes.
http://www.aboutkidshealth.ca/En/ResourceCentres/Diabetes/Pages/default.aspx This Diabetes Resource Centre is part of http://www.aboutkidshealth.ca from the Toronto Hospital for Sick Children. The resources are organised to follow the natural course of diabetes from symptoms, to diagnosis, to treatment, and to long-term conditions. It contains illustrations, animations and games to help children understand diabetes.

Note: The publications listed were identified using the search methodology outlined in Appendix 1 (Search Methods for Policy Documents and Evidence-Based Reviews)

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