

ORIGINAL ARTICLE

# Type 2 diabetes in youth from the Western Pacific region: glycaemic control, diabetes care and complications

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*Key words:* HbA<sub>1c</sub> – Hypertension – Microalbuminuria – Type 2 diabetes – Youth

## ABSTRACT

*Objective:* To describe the glycaemic control, diabetes care and prevalence of complications in youth with type 2 diabetes from the Western Pacific Region.

*Research design and methods:* Cross-sectional, clinic-based audit of 331 patients aged < 18 years from 56 centres in Australia, China-Beijing, China-Shanghai, China-Hong Kong, Indonesia, Japan, South Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand. Clinical and management data were recorded along with glycated haemoglobin (HbA<sub>1c</sub>), lipids and complication rates.

*Main outcome measures:* Glycaemic control, complications, diabetes management.

*Results:* Median age was 14.9 years (interquartile range 13.2–16.4 years) and median diabetes duration 2.3 years (1.4–3.6 years). Median HbA<sub>1c</sub> was 7% (5.9–9.9%) and HbA<sub>1c</sub> was > 7.5% in 40% of patients. In multiple regression analysis, glycaemic control varied significantly between countries ( $p = 0.02$ ); higher HbA<sub>1c</sub> was associated with fewer home blood glucose measurements ( $p = 0.005$ ) and higher insulin dose/kg ( $p < 0.0001$ ). Blood glucose monitoring was performed by 65% of patients (range 33–96% by country). In 25% of patients, management consisted of diet alone or no treatment (range 0–53% by country); oral anti-diabetic drugs alone

\* Members of the steering panel are set out in the Acknowledgement

were used in 49%, insulin alone in 11% and both in 15%. Microalbuminuria was found in 8% and hypertension in 24%. The risk of hypertension increased with higher BMI (OR 1.16, 95% CI 1.09–1.24,  $p < 0.0001$ ); antihypertensive agents were used in 4% of patients.

*Conclusions:* The management of type 2

diabetes in youth from the Western Pacific Region varies widely. Hypertension and microalbuminuria were frequent, but not commonly treated. Further investigation into the natural history and risk factors for complications in youth with type 2 diabetes is required to assist in developing evidence based management guidelines.

## Introduction

Type 2 diabetes is now recognised in children as a major public health concern with potentially serious health outcomes<sup>1–4</sup>. The incidence of childhood type 2 diabetes is increasing<sup>5–8</sup> and certain populations are at increased risk, particularly in Asia where industrialization is progressing rapidly<sup>9</sup>, and Asian immigrants in Western countries<sup>6</sup>. Increased rates of type 2 diabetes have been associated with an increased prevalence of obesity in Asian children<sup>8,10</sup>, in keeping with data from Western countries<sup>11–13</sup>.

Despite evidence of an emerging epidemic of type 2 diabetes in youth, there are limited published data regarding glycaemic control, natural history and complications in these patients. In a small clinic based study from the US, microalbuminuria was found in almost half of minority adolescents with type 2 diabetes<sup>14</sup>, while dyslipidaemia and abnormal ambulatory blood pressure were also common. In contrast, microalbuminuria is found in less than 10% of adolescents with type 1 diabetes<sup>15,16</sup>. Indeed, in a comparative study of young onset diabetes from Japan, the risk of nephropathy was significantly higher in those with type 2 diabetes compared with type 1<sup>17</sup>. Complications are common in Asian adults with type 2 diabetes: in a survey of more than 24 000 patients from 230 diabetes centres in Asia, the prevalence of microalbuminuria was 39%, retinopathy 21% and neuropathy 34%<sup>18</sup>. As the study included only 17 patients aged less than 18 years, the data may not be representative of youth with type 2 diabetes from the region.

The aim of the present study was to evaluate glycaemic control, reported rates of complications and management in a clinic population of youth with type 2 diabetes from the Western Pacific region (WPR).

## Patients and methods

### Study design

The study was a cross-sectional, clinic-based survey of glycaemic control, clinical care and complications in children and adolescents aged less than 18 years from the Western Pacific region. Participants were recruited from 56 diabetes centres in Western Australia, China-

Beijing, China-Shanghai, China-Hong Kong, Indonesia, Japan, South Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand. The study was performed concurrently in participating centres during 2003.

### Study population

The study population included all patients with type 2 diabetes with a minimum duration of 12 months and age less than 18 years at assessment. Patients were recruited for the study at the time of their usual clinic visit. Informed consent was obtained from all participants and their parents and ethics approval was obtained from all participating centres.

### Clinical assessment

The method of diagnosis of type 2 diabetes was documented (including oral glucose tolerance test, c-peptide or insulin levels, negative diabetes associated autoantibodies, or on clinical judgment if these investigations had not been performed). Characteristics examined included anthropometric indices, blood pressure, presence of acanthosis nigricans, family history of type 2 diabetes, presence of diabetes complications (neuropathy, cataract, retinopathy, microalbuminuria defined as albumin excretion rate of 30–300 mg/day ( $> 20 \mu\text{g}/\text{min}$  on timed overnight urine collection or  $> 2.5 \text{ mg}/\text{mmol}$  on spot urine albumin to creatinine ratio) and macroalbuminuria defined as albumin excretion  $> 300 \text{ mg}/\text{day}$ ), current diabetes management (oral diabetic medication and/or insulin treatment versus diet or no treatment), insulin usage (number of injections per day and units per day) and clinical care (frequency of clinic visits, glycated haemoglobin ( $\text{HbA}_{1c}$ ) measurements, home blood or urine glucose testing). Details were recorded on Data Collection Forms and provision for unavailable or missing data was made by means of specific fields.

Weight and height were recorded and BMI calculated as  $\text{kg}/\text{m}^2$ . Overweight and obesity were defined by the age and sex specified cut-offs provided by Cole *et al.*<sup>19</sup>. Hypertension was defined as systolic and diastolic blood pressure above the 95th percentile value for age, sex and height<sup>20</sup>.

## Central HbA<sub>1c</sub> measurements

Finger capillary blood samples for centralized HbA<sub>1c</sub> measurements were collected from participants at the enrolment visit using the Bio-Rad HbA<sub>1c</sub> sample preparation kit. All samples were stored at 2–8°C and mailed by batches to a Bio-Rad appointed central laboratory. At the central laboratory, HbA<sub>1c</sub> analyses were performed by automatic high-pressure liquid chromatography (Bio-Rad VARIANT, Bio-Rad Laboratories, Hercules, CA). The same lot numbers were used for all samples and internal and external quality assurance was undertaken as previously described<sup>18</sup>. The normal range for this assay was 4.6–6.5%.

## Biochemical measurements

Plasma glucose, total cholesterol, triglycerides, LDL-cholesterol and HDL-cholesterol levels were measured after an overnight fast. Results were included if they had been collected within 12 months prior to the study visit. Values were stratified as previously described for the Asian-Pacific Type 2 diabetes Policy Group (ADPG)<sup>21</sup>.

## Data handling and statistical analyses

Data were entered into the Statistical Analysis System (SAS 8.0, SAS Institute, Cary, USA) which was used for data cleaning and analysis. Descriptive statistics are presented as mean ± standard deviation (SD) for normally distributed data and median (interquartile range) for skewed data. Continuous data were compared using *t*-tests and for skewed data using Mann Whitney U tests. Multivariate analyses were performed using multiple linear regression for glycaemic control and logistic regression for predictors of hypertension. Explanatory variables included in the models were country, gender, age, duration of diabetes, BMI, insulin regimen, insulin dose and frequency of HbA<sub>1c</sub> measurements, home blood glucose monitoring and clinic visits. Results are reported as co-efficient and 95% confidence intervals (CI) for multiple regression or odds ratio (OR) and 95% CI for logistic regression and chi squared analysis.

## Results

### Clinical characteristics

Of the 346 youth with type 2 diabetes recruited, 15 were excluded from the statistical analyses because they did not fulfil the inclusion criteria (older than 18 years), or had multiple missing fields including date of visit and birth date, leaving 331 eligible patients comprising the analysis population. Characteristics of participants are shown in Table 1.

**Table 1.** Characteristics of youth with type 2 diabetes in the Western Pacific Region

Country	N	%	Age (years)*	Diabetes duration (years)*	Age of diabetes onset (years)*	Male (%)	Overweight (%)	Obese (%)	FPG (mmol/L)*	HbA <sub>1c</sub> (%)*
Region	331	100	14.9 (13.2–16.4)	2.3 (1.4–3.6)	12.0 (10.7–13.5)	45.0	41	32	7.4 (5.7–11.4)	7.0 (5.9–9.9)
Australia	11	3	16.1 (14.9–16.8)	2.2 (1.6–3.1)	14.1 (12–14.2)	27.3	27	64	5.8 (5.1–9.5)	6.4 (5.7–8.5)
China	25	8	14.1 (12.7–15.1)	1.3 (1.0–1.9)	12.3 (11.3–13.1)	52.0	46	9	7.0 (5.7–8.1)	7.8 (7.0–10.4)
Hong Kong	15	4	15.1 (14.3–17.3)	1.9 (1.1–3.0)	13.2 (12.3–15.4)	53.3	13	60	6.0 (5.6–13.3)	7.3 (6.0–11.7)
Indonesia	7	2	13.5 (10.8–14.9)	1.6 (0.5–3.1)	10.7 (10.3–12.0)	42.9	33	50	5.5 (5.2–14.7)	7.7 (5.3–12.6)
Japan	113	34	15.0 (13.6–16.5)	2.7 (1.4–4.0)	12.0 (10.5–13.7)	42.5	34	38	7.0 (5.6–9.8)	6.6 (5.8–7.7)
South Korea	45	14	14.3 (12.9–15.8)	2.1 (1.4–3.2)	11.9 (10.9–12.6)	40.0	48	17	8.9 (6.4–11.2)	7.4 (6.4–11.9)
Malaysia	23	7	14.1 (12.5–15.4)	2.0 (1.2–2.7)	11.2 (10.7–12.6)	34.8	44	30	12 (6.3–14.6)	9.3 (5.9–11.8)
Philippines	19	6	14.4 (12.1–16.3)	2.6 (1.8–3.8)	10.8 (9.1–12.9)	42.1	47	16	8.8 (7.2–13.6)	6.8 (5.8–10.7)
Singapore	21	6	16.3 (14.5–17.4)	3.3 (2.2–5.0)	11.7 (11–13)	42.9	68	16	6.9 (6.6–12.8)	6.6 (5.9–9.2)
Taiwan	32	10	15.5 (13.8–17.6)	2.1 (1.2–4.4)	12.6 (11–14.1)	62.5	47	28	8.0 (6.0–13.8)	7.8 (6.6–11)
Thailand	20	6	15.5 (13.9–15.9)	2.7 (2.3–4.1)	11.6 (10.2–13.3)	55.0	40	45	6.0 (5.2–11.5)	6.9 (5.4–9.7)

\*Data are median (interquartile range)

The median age was 14.9 (13.2–16.4) years, age of diabetes onset 12.0 (10.7–13.5) years and diabetes duration 2.3 (1.4–3.6) years. There was a slight preponderance of females to males (1:1.2). Forty-four per cent had at least one parent with type 2 diabetes, while 8% had an affected sibling. The frequency of parental diabetes was highest in Thailand (65%) and Malaysia (70%), while 14% of Japanese and 13% of Malaysian participants respectively had an affected sibling. Amongst the Australian patients, the majority were Aboriginal ( $n = 7$ ), with the remaining patients Caucasian ( $n = 3$ ) or Samoan ( $n = 1$ ).

Across the region 41% of participants were overweight and 32% obese, with the highest incidence of overweight found in Singapore (41%) and obesity in Australia (64%). More than one third of patients had acanthosis nigricans (38%).

The majority of patients were diagnosed with type 2 diabetes by clinical judgment (97%), while the diagnosis was confirmed by negative type 1 diabetes-associated autoantibodies in 56% and elevated c-peptide or insulin in 61%.

### Glycaemic control

The median HbA<sub>1c</sub> was 7.0% (5.9–9.9) and 40% had a level above the current target HbA<sub>1c</sub> for type 1 diabetes of 7.5%<sup>22,23</sup>. There was significant variation in HbA<sub>1c</sub> between countries after adjustment for other variables in the multiple regression model ( $p = 0.02$ ), while higher insulin dose was associated with higher HbA<sub>1c</sub> (estimate 3.7, 95% CI 2.0–5.4,  $p < 0.0001$ ) and more frequent home blood glucose testing was associated with lower HbA<sub>1c</sub> (–0.04, 95% –0.06 to –0.01,  $p = 0.005$ ). The median fasting plasma glucose of the study population was 7.4 mmol/L (5.7–11.4) and 54% had a level above  $\geq 7.0$  mmol/L<sup>21</sup>.

### Biochemical measurements

The median fasting total cholesterol was 4.7 (4.1–5.5) mmol/L, HDL 1.3 (1.1–1.5) mmol/L, LDL 2.9 (2.2–3.5) mmol/L and triglyceride 1.3 (0.9–1.9) mmol/L. In the study population 12% had a poor TC control ( $\geq 6$  mmol/L), 10% had poor HDL control ( $< 0.9$  mmol/L), 12% had a poor LDL control ( $> 4$  mmol/L) and 16% had a poor TG control ( $\geq 2.2$  mmol/L). Overall 9% of patients had at least three criteria for the metabolic syndrome (excluding waist circumference, which was not measured)<sup>24</sup>. Lipid lowering medication was used in only 2.6%.

### Clinical care and monitoring

Home blood glucose monitoring was performed by 65% of participants across the region (range 33–96% by country, Table 2) and was performed on average 32.2 times per month (range 14–45). The rates were lowest in Malaysia (14 per month) and China (18 per month). Urine glucose monitoring was performed in 5% of patients overall (range 0–57% by country). Four or more clinic visits in the previous year were reported by 77% of participants, with the highest rate in Taiwan (94%) and the lowest in China (29%, Table 2). The frequency of local HbA<sub>1c</sub> measurements in the previous year varied across the region: most had at least one local HbA<sub>1c</sub> assessment within the last 12 months (97%) while 52% had a minimum of four HbA<sub>1c</sub> measurements.

### Diabetes therapy

Three quarters of the patients were treated with either oral antidiabetic drugs (OADs) and/or insulin, with 25% receiving dietary management or no treatment. The

**Table 2.** Diabetes management and clinical care of youth with type 2 diabetes in the Western Pacific Region

Country	Therapy				Clinic visits $\geq 4$ (%)	$> 3$ HbA <sub>1c</sub> tests (%)	Blood glucose monitoring (%)
	OAD only (%)	Insulin only (%)	OAD and insulin (%)	None (%)			
Region	48.9	10.9	15.4	24.8	77.3	52.0	64.6
Australia	36.4	0.0	18.2	45.5	54.6	45.5	80.0
China	28.0	28.0	16.0	28.8	28.6	8.7	80.0
Hong Kong	33.3	13.3	0.0	53.3	78.6	0.0	92.9
Indonesia	14.3	14.3	28.6	42.9	57.2	16.7	57.1
Japan	36.3	8.0	13.3	42.5	89.4	90.2	33.0
South Korea	53.3	15.6	31.1	0.0	88.9	23.3	95.6
Malaysia	65.2	4.4	8.7	21.7	73.9	65.2	81.8
Philippines	57.9	15.8	26.3	0.0	68.5	28.6	88.2
Singapore	66.7	9.5	9.5	14.3	52.4	47.6	90.0
Taiwan	84.4	3.1	9.4	3.1	93.7	43.8	65.6
Thailand	65.0	15.0	10.0	10.0	65.0	21.1	61.1

class of OAD most frequently prescribed was biguanide (54%), followed by sulphonylurea (14%). OADs were used alone in 49%, in combination with insulin in 15% and insulin alone in 11% (Table 2). In those receiving insulin, the mean daily insulin dose was  $0.6 \pm 0.4$  units/kg body weight. There was significant variation in choice of treatment between countries ( $p = 0.01$ ). In four countries, a large proportion of patients were receiving dietary management or no treatment (Hong Kong 53%, Australia 46%, Indonesia and Japan 43%), while all patients from South Korea and the Philippines were treated with OAD and/or insulin. Glycaemic control varied significantly between the three main treatment types ( $p < 0.0001$ ): median (IQR) HbA<sub>1c</sub> 6.0 (5.4–6.9) for diet alone or no treatment, 6.9 (5.9–9.7) for OAD and 9.1 (7–10.9) for insulin.

### Diabetes complications

Complications screening was performed in the majority of patients, although 20% had not been screened for microalbuminuria in the preceding 12 months. Microalbuminuria was the most common diabetic complication (8% of those screened), as compared to neuropathy (1.2%) and retinopathy (0.6%) (Table 3). Hypertension was present in 24% of patients across the region (28% males, 21% females) while only 4% were treated with anti-hypertensive medication. There was significant variation in frequency of hypertension between countries ( $p = 0.02$ ), while higher BMI was significantly associated with hypertension (OR 1.16, 95% CI 1.09–1.24,  $p < 0.0001$ ).

### Discussion

This was a clinic-based study of 331 youth with type 2 diabetes from 56 centres throughout the Western Pacific region, whose glycaemic control and diabetes care varied significantly. Almost half were not achieving a target HbA<sub>1c</sub> level of 7.5% or less<sup>22,23</sup>, while worse glycaemic control was associated with fewer home blood glucose measurements and higher insulin

dose/kg. Biguanides were used most commonly for treatment (54%), while in one quarter of participants management consisted of diet alone or no therapy. Hypertension was found in 24% and microalbuminuria in 8%, but only 4% of patients were treated with antihypertensive medication. In a region where resources are lacking and rates of diabetes are rising, the care of youth with type 2 diabetes is suboptimal.

The sample size was sufficient to allow a comparison of diabetes care, glycaemic control and complications and exploratory analyses of these outcomes. Despite the reasonable number recruited, however, the study results may be influenced by selection bias. Firstly, it was not feasible to conduct a population based study due to the large target population living in the wide area covered by the Western Pacific Region and although incidence data are lacking, only a small proportion of youth from the region would have been captured by the study. To address this, the study protocol specified recruitment at routine clinic visits with the aim of obtaining a typical clinic-based sample of youth with type 2 diabetes from that centre; however, patients who do not access paediatric diabetes clinics, including undiagnosed cases, will have been missed. Secondly, patients who attend diabetes centres regularly may be more likely to achieve better control due to economic, educational or other factors. Indeed, it was somewhat surprising to find that 77% of the patients reported four or more clinic visits in the last 12 months, implying that the audit captured regular clinic attendees. It can be speculated, therefore, that children who did not participate in the study may have poorer rather than better glycaemic control, putting them at greater risk of microvascular complications.

Participants came from a wide range of ethnic groups across the region, but comparison of diabetes rates by ethnicity was not possible due to the clinic-based nature of the study. There was a preponderance of patients from Japan (34%), which likely reflects the established screening and relatively high incidence of type 2 diabetes in Japanese youth<sup>8,25</sup>. The majority of Australian patients were of Aboriginal origin, in keeping with other studies of youth onset type 2

**Table 3.** Results of screening for diabetes complications

	Number screened	Frequency (%)	Not screened (%)
Neuropathy	283	1.2	13
Cataract	293	0.6	9.7
Retinopathy	284	0.6	12.4
Microalbuminuria	251	8.0	20.4
Macroalbuminuria	247	0.6	20.5
Hypertension	265	8%	20.0
Acanthosis	295	37.6	8.9*

\*Not reported

diabetes in Caucasian populations, in which the case load is greatest in those from indigenous and minority groups<sup>6,7,26</sup>. Factors contributing to the rise in adult-onset diabetes in the Western Pacific Region, such as industrialization, urbanization and mechanization, are also likely to have contributed to increased rates of diabetes in youth, and the marked increase in obesity is recognized as a significant factor in many countries across the region<sup>8,10</sup>. Indeed one third of participants were obese, although waist to hip ratio (not collected in this study) may be a more sensitive measure of obesity and is a better predictor of future cardiovascular disease in adults<sup>27</sup>.

Reported use of home blood glucose monitoring varied widely and was only performed in 65% of patients overall. Lower frequency of blood glucose testing was significantly associated with higher HbA<sub>1c</sub> in multivariate analysis, in keeping with studies in children with type 1 diabetes demonstrating that greater frequency of self-monitoring is associated with lower HbA<sub>1c</sub> values<sup>28-30</sup>. More testing enables more adjustment of medication or insulin doses; therefore, the inverse relationship between frequency of testing and glycaemic control may be associated with affordability of test strips, although other factors such as patient motivation are also likely to be important. Frequency of clinic visits did not influence glycaemic control in the present study, while in a study of adolescents with type 1 diabetes, 3-4 clinic visits per year was associated with better glycaemic control compared with two or less<sup>31</sup>.

Smaller surveys of children with type 2 diabetes have demonstrated worse glycaemic control than the median HbA<sub>1c</sub> of 7% in the present study: 9.7% in a study of urban Asian-Indian<sup>32</sup>, 9.5% in a study among Thai children<sup>10</sup> and 10% in a study among children living in Toronto<sup>6</sup>. Whilst the median HbA<sub>1c</sub> in the region is lower, there was wide variation with a range of 4.3-19% using a standardized method. This suggests a heterogeneous study population, who are likely to have varying degrees of insulin resistance and beta cell failure, in addition to variable care and availability of resources.

Overall 25% of patients were only receiving dietary management or no therapy and in four countries approximately half of patients were not treated with insulin or OAD. In a placebo-controlled study of 82 children, only 8% of the children managed with diet and exercise gained blood glucose goals in 16 weeks<sup>33</sup>, suggesting that insulin and/or OAD should be considered early in the course of the disease. In a survey of 130 paediatric endocrinology practices in the USA and Canada, approximately 44% of children with type 2 diabetes were treated with one or more OAD, with Metformin the most commonly used<sup>34</sup>. Despite this, there are limited studies addressing the safety and

efficacy of OAD in children with type 2 diabetes<sup>33,35</sup>. Further controlled studies in which adverse events are closely monitored are required to improve the therapeutic options available to treat children with type 2 diabetes.

Insulin usage was low (11% were treated with insulin alone and 15% in combination with OAD) compared with 48% of children in North America<sup>34</sup>. It was remarkable that higher insulin doses were associated with higher HbA<sub>1c</sub> levels, but the same positive relationship has been reported in two studies among children and adolescents with type 1 diabetes in New South Wales and Boston<sup>29,36</sup>. Higher insulin doses may reflect the insulin resistance associated with type 2 diabetes and puberty, but the insulin treated patients are more likely to have a greater degree of beta cell failure. Although the study's cross-sectional design limits the conclusions that can be drawn, it is possible that insulin doses had recently been increased in those with elevated blood glucose levels.

Microalbuminuria was found in 8% of youth with type 2 diabetes in the present study after a relatively short median duration of 2.8 years, and one quarter were hypertensive. The estimated prevalence of microalbuminuria may be influenced by different laboratory methods used across the region, and it is of concern that 20% of participants had not been screened in the previous 12 months. Recent studies confirm that children with type 2 diabetes are at risk of developing microvascular complications and the onset may be earlier than in type 1 diabetes<sup>14,26,37</sup>. Persistent microalbuminuria was observed in 18% of Korean patients with youth onset type 2 diabetes after a mean duration of 5 years<sup>38</sup>. Among Pima Indians with childhood onset type 2 diabetes, microalbuminuria was found in 22% at diagnosis and in 58% at 10-year follow-up, indicating a high rate of progression<sup>39</sup>. The risk of microalbuminuria increased with longer diabetes duration in the present study, while hypertension was significantly associated with microalbuminuria in several recent studies of youth onset type 2 diabetes<sup>14,26</sup>. Given the high rates of diabetic nephropathy in adults with youth onset diabetes<sup>17,40</sup>, those with microalbuminuria require close follow-up and early treatment should be considered.

## Conclusions

The results from this study provide further evidence that type 2 diabetes is an emerging problem in youth from the Western Pacific Region. Many are not achieving adequate glycaemic control, placing them at high risk for microvascular complications, including hypertension and microalbuminuria. These are common, appear early in the disease course compared

with type 1 diabetes, and may be present prior to diagnosis. Strategies to target obesity, even in the early years of life<sup>41</sup>, are urgently required to prevent the ongoing rise in youth onset type 2 diabetes. The study also highlights the need to define the prevalence of childhood type 2 diabetes, particularly in at risk populations, and the need to develop evidence based management guidelines<sup>4</sup>.

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## References

1. American Diabetes Association. Type 2 diabetes in children and adolescents. *Diabetes Care* 2000;23:381-9
2. Fagot-Campagna A. Emergence of type 2 diabetes mellitus in children: epidemiological evidence. *J Pediatr Endocrinol Metab* 2000;13(Suppl 6):1395-402
3. Pinhas-Hamiel O, Zeitler P. The global spread of type 2 diabetes mellitus in children and adolescents. *J Pediatr* 2005;146: 693-700
4. Alberti G, Zimmet P, Shaw J, et al. Type 2 diabetes in the young: the evolving epidemic: the international diabetes federation consensus workshop. *Diabetes Care* 2004;27: 1798-811
5. Kitagawa T, Owada M, Urakami T, Yamauchi K. Increased incidence of non-insulin dependent diabetes mellitus among Japanese schoolchildren correlates with an increased intake of animal protein and fat. *Clinical Pediatrics* 1998;37:111-5
6. Zdravkovic V, Daneman D, Hamilton J. Presentation and course of Type 2 diabetes in youth in a large multi-ethnic city. *Diabetic Med* 2004;21:1144-8
7. McMahon SK, Haynes A, Ratnam N, et al. Increase in type 2 diabetes in children and adolescents in Western Australia. *Med J Aust* 2004;180:459-61
8. Urakami T, Kubota S, Nitadori Y, et al. Annual incidence and clinical characteristics of type 2 diabetes in children as detected by urine glucose screening in the Tokyo metropolitan area. *Diabetes Care* 2005;28:1876-81
9. Kim DM, Ahn CW, Nam SY. Prevalence of obesity in Korea. *Obes Rev* 2005;6:117-21
10. Likitmaskul S, Kiattisathavee P, Chaichanwatanakul K, et al. Increasing prevalence of type 2 diabetes mellitus in Thai children and adolescents associated with increasing prevalence of obesity. *J Pediatr Endocrinol Metab* 2003;16:71-7
11. Aylin P, Williams S, Bottle A. Obesity and type 2 diabetes in children, 1996-7 to 2003-4. *Br Med J* 2005;331:1167
12. Klein DJ, Aronson FL, Harlan WR, et al. Obesity and the development of insulin resistance and impaired fasting glucose in black and white adolescent girls: a longitudinal study. *Diabetes Care* 2004;27:378-83
13. Weiss R, Taksali SE, Tamborlane WV, et al. Predictors of changes in glucose tolerance status in obese youth. *Diabetes Care* 2005;28:902-9
14. Ettinger LM, Freeman K, Dimartino-Nardi JR, Flynn JT. Microalbuminuria and abnormal ambulatory blood pressure in adolescents with type 2 diabetes mellitus. *J Pediatr* 2005;147: 67-73
15. Donaghue KC, Craig ME, Chan AK, et al. Prevalence of diabetes complications 6 years after diagnosis in an incident cohort of childhood diabetes. *Diabetic Med* 2005;22:711-8
16. Schultz CJ, Konopelska-Bahu T, Dalton RN, et al. Microalbuminuria prevalence varies with age, sex, and puberty in children with type 1 diabetes followed from diagnosis in a longitudinal study [Oxford Regional Prospective Study Group]. *Diabetes Care* 1999;22:495-502
17. Yokoyama H, Okudaira M, Otani T, et al. Higher incidence of diabetic nephropathy in type 2 than in type 1 diabetes in early-onset diabetes in Japan. *Kidney Int* 2000;58:302-11
18. Chuang LM, Tsai ST, Huang BY, Tai TY. The status of diabetes control in Asia – a cross-sectional survey of 24 317 patients with diabetes mellitus in 1998. *Diabetic Med* 2002;19:978-85
19. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *Br Med J* 2000;320:1240-3
20. National Institutes of Health National Heart LaBI. Update on the Task Force Report (1987) on high blood pressure in children and adolescents: a working group report from the National High

- Blood Pressure Education Program. NIH publication No 96-3790; 1996
21. Asia Pacific Type 2 Diabetes Policy Group. Type 2 diabetes: practical targets and treatments, 3rd ed. Health Communications Australia Pty Ltd; 2002
  22. Australasian Paediatric Endocrine Group for the Department of Health and Ageing. Clinical practice guidelines: type 1 diabetes in children and adolescents. National Health and Medical Research Council; 2005
  23. National Institute of Clinical Excellence. Type 1 diabetes (childhood): diagnosis and management of type 1 diabetes in children and young people. 2004
  24. Adult Treatment Panel III. Executive summary of the third report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. *J Am Med Assoc* 2001;285:2486-97
  25. Owada M, Hanaoka Y, Tanimoto Y, Kitagawa T. Descriptive epidemiology of non-insulin dependent diabetes mellitus detected by urine glucose screening in school children in Japan. *Acta Paediatrica Japonica* 1990;32:716-24
  26. Eppens MC, Craig ME, Cusumano J, et al. Prevalence of diabetes complications in adolescents with type 2 diabetes compared with type 1 diabetes. *Diabetes Care* [in press]
  27. Yusuf S, Hawken S, Ounpuu S, et al. Obesity and the risk of myocardial infarction in 27 000 participants from 52 countries: a case-control study. *Lancet* 2005;366:1640-9
  28. Haller MJ, Stalvey MS, Silverstein JH. Predictors of control of diabetes: monitoring may be the key. *J Pediatr* 2004;144:660-1
  29. Levine BS, Anderson BJ, Butler DA, et al. Predictors of glycemic control and short-term adverse outcomes in youth with type 1 diabetes. *J Pediatr* 2001;139:197-203
  30. Dorchy H, Roggemans MP, Willems D. Glycated hemoglobin and related factors in diabetic children and adolescents under 18 years of age: a Belgian experience. *Diabetes Care* 1997;20:2-6
  31. Urbach SL, LaFranchi S, Lambert L, et al. Predictors of glucose control in children and adolescents with type 1 diabetes mellitus. *Pediatr Diabetes* 2005;6:69-74
  32. Ramachandran A, Snehalatha C, Satyavani K, et al. Type 2 diabetes in Asian-Indian urban children. *Diabetes Care* 2003;26:1022-5
  33. Jones KL, Arslanian S, Peterokova VA, et al. Effect of metformin in pediatric patients with type 2 diabetes: a randomized controlled trial. *Diabetes Care* 2002;25:89-94
  34. Silverstein JH, Rosenbloom AL. Treatment of type 2 diabetes mellitus in children and adolescents. *J Pediatr Endocrinol* 2000;13(Suppl 6):1403-9
  35. Benavides S, Striet J, Germak J, Nahata MC. Efficacy and safety of hypoglycemic drugs in children with type 2 diabetes mellitus. *Pharmacotherapy* 2005;25:803-9
  36. Craig ME, Handelsman P, Donaghue KC, et al. Predictors of glycaemic control and hypoglycaemia in children and adolescents with type 1 diabetes from NSW and the ACT. *Med J Aust* 2002;177:235-8
  37. Singh R, Shaw J, Zimmet P. Epidemiology of childhood type 2 diabetes in the developing world. *Pediatr Diabetes* 2004;5:154-68
  38. Yoo EG, Choi IK, Kim DH. Prevalence of microalbuminuria in young patients with type 1 and type 2 diabetes mellitus. *J Pediatr Endocrinol Metab* 2004;17:1423-7
  39. Fagot-Campagna A, Knowler WC, Pettitt DJ. Complications among Pima Indians diagnosed during childhood. *Diabetes* 1998;47(Suppl 1):605
  40. McGrath NM, Parker GN, Dawson P. Early presentation of type 2 diabetes mellitus in young New Zealand Maori. *Diabetes Res Clin Pract* 1999;43:205-9
  41. Reilly JJ, Armstrong J, Dorosty AR, et al. Early life risk factors for obesity in childhood: cohort study. *Br Med J* 2005;330:1357

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