Glycemic control in children with Type 1 diabetes in Wales: the influence of the Pediatric Diabetes Specialist Nurse

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Short running title: Pediatric nurse and glycemic control

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**Objective** - To determine if glycemic control is improving in diabetic children in Wales; to identify factors associated with improvement.

**Research design and methods** – Data collected in 2001 and 2006.

**Results** - Over time HbA1c reduced from 9.08±1.66 to 8.88±1.63% (p=0.012). There were differences between centers (p<0.001) and differential change over time (interaction p<0.001). Since 2001 five centres had appointed a pediatric diabetes specialist nurse (PDSN). These centres improved HbA1c from 9.59±1.88 to 8.72±1.61% (p<0.001). Glycemic control was worse in children aged >10y compared to younger patients (p<0.001). Improvement occurred in those aged >10y. Age (p=0.003) and insulin dose (p<0.001) were positively and independently associated with HbA1c. Thus any influence of PDSNs was not achieved through increased insulin prescription.

**Conclusions** - Improvement in glycemic control has occurred. Worse control is seen associated with greater prescribed insulin dose in older children. Appointing PDSNs was associated with improved glycemic control amongst adolescents.
Whether glycemic control in children with type 1 diabetes (T1DM) is improving with modern management is controversial. We aimed to determine if control has improved in Wales and identify factors related to improvement. Between 2001 and 2006 five centers appointed a pediatric diabetes specialist nurse (PDSN) allowing examination of changes associated with this service development. We assessed glycemic control over time by center, age group, insulin regime and gender.

**RESEARCH DESIGN AND METHODS**

Twelve of 14 pediatric diabetes units in Wales supplied data collected at routine clinic visits within 3 months of November 2001 and November 2006. Patients were >99% white caucasian aged up to 18 years. Age standardized weight measurements are from UK National Growth standards (1). Five centers appointed PDSNs after 2001 having not had one previously. The remaining seven except the smallest already had PDSNs. Ascertainment calculation denominator data came from the Brecon Group register: an all-Wales register of diabetic children.

Influence of center, age group and appointment of PDSN on HbA1c over time were analysed in separate ANOVA models (Tukey’s HSD post hoc). Comparing centers HbA1c data were adjusted for age, gender and body weight. Multilinear regression (backwards stepwise) was used to assess the influence of age, gender, PDSN, insulin dose (units/kg/day) and number of daily doses on HbA1c. Since the last of these parameters was only available for the 2006 dataset initial analysis was undertaken using 2006 data only (N=795) then a second analysis without number of daily doses performed with 2001 and 2006 data (N=1689). Data are reported as mean±SD.

**RESULTS**

The proportion of Welsh diabetic children included was 80% in 2001 and 88% in 2006. In 2006 patients were heavier but HbA1c was lower (table). Diabetic children were 0.60SD above mean weight for age in 2001 increasing to 0.72 in 2006. Insulin dose increased in proportion to weight. HbA1c was not different by gender (males 8.96±1.63, females 9.05±1.67%, p=0.21).

Adjusted HbA1c from the 12 centers varied from 8.45±1.57 to 10.33±1.57% in 2001 and from 8.10±1.56 to 9.30±1.58% in 2006. ANOVA demonstrated differences between centers (p<0.001), over time (p=0.001) and differential change between centres over time (interaction p<0.001). Four centres showed improvement, one borderline (p=0.053), five no change and in two HbA1c deteriorated.

Glycemic control was worse in children aged >10y compared to 5-9y (p<0.001) and <5y (p<0.001) (table). In 3 way ANOVA (year, new DSN, age< or >10y) there was interaction between year and age group (F=3.96, p=0.047) indicating children aged >10y showed improvement in 2006 compared with 2001.

In centers appointing a PDSN, HbA1c improved versus those with no staffing change (centre v time interaction p=0.001). Centers which appointed a PDSN were those with highest mean HbA1c raising the possibility that regression to the mean contributed to reduced HbA1c in this subgroup. Therefore, expected regression to the mean was calculated from the variance in 2001 center HbA1c means (2). Repeating analysis with 2001 center means corrected for expected regression to the mean confirmed centre v time interaction (p=0.007). Using individual patient data also showed centre v time interaction (p<0.001) (table). Appointment of PDSN did not affect body weight or insulin dose (U/kg/day).
None of the five new appointments was associated with additional pediatrician clinics. Three appointees started nurse-led clinics seeing patients between doctor appointments. All reported increased telephone contacts, home and school visits with more frequent insulin dose adjustments, change of regime and diabetes education. Few patients were on insulin pumps (approximately 1% in 2006). Formal “Dose adjustment for normal eating” (DAFNE type) programmes were not then in use.

Multivariate analysis indicated number of insulin doses per day bore no relation to HbA1c. Age ($\beta=0.15$, $p<0.001$), insulin dose in units/kg/day ($\beta=0.16$, $p<0.001$) and presence of PDSN ($\beta=-0.12$, $p<0.001$) were independently associated with HbA1c (adjusted $R^2=0.07$, $F=43.1$, $p<0.001$) whereas gender was not. Simple linear regression showed no correlation between number of patients seen at a centre and mean HbA1c either in 2001 ($r=0.18$, $p=0.58$) or 2006 ($r=0.26$, $p=0.41$).

DISCUSSION

Missing data were distributed amongst contributing centers and patient subgroups at random with no systematic bias. A high proportion of diabetic children were included. We therefore feel the aggregate data is representative of glycemic control in Welsh children with T1DM. HbA1c here was similar to Northern Ireland: 8.8%, Scotland: 8.9%, France: 9.0% and Denmark: 8.7% (3-6). We identified modest improvement in glycemic control over time.

We found no effect of gender on glycemic control. The Hvidore study found higher HbA1c in girls (7) but others did not (8,9). Adolescent girls have more ketoacidosis (10,11) but overall the gender difference is minimal. In 2006 more insulin was prescribed in proportion to children being heavier. Body weight in our cohort was above the 50th centile for UK children in 2001, greater in 2006 and is cause for concern. Elevated BMI has previously been demonstrated in diabetic children (12).

The differences in HbA1c between centers were striking. The Hvidore study also identified differences between centers which were persistent and largely unexplained (13). As in that study our data does not indicate multiple injection regimes are superior (13,14). We included small and large centers but numbers seen did not relate to HbA1c achieved. However, improved glycemic control occurred in centers where a PDSN had been appointed. Greater prescribed insulin dose associated with worse control independently of age and PDSN. Thus PDSNs did not gain improved control through advising more insulin. It seems likely that prescribers recommended more insulin in response to rising HbA1c from reduced compliance. Nurses generated increased contacts between clinic and child/family. Their supportive and educational role may achieve better glycemic control. Their application of other developments in care might also contribute. It was children aged >10y that showed improvement. PDSNs may influence adverse behavioural factors operative in adolescence.

In 2001 Welsh centers without PDSNs mostly had sessions of time from adult diabetes nurses. PDSNs reduce median length of stay for newly diagnosed children and reduce clinic non-attendance (15). Our study suggests influence on HbA1c. We speculate benefit occurred from improved self-care in older children.

**Author contributions:** M.O’H. conceived the project, liaised with pediatric units to collect data and undertook initial analysis. J.N.H. carried out the analysis presented here and drafted the manuscript.

**Disclosure.** The authors have no conflict of interest to disclose.
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<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>N</th>
<th>2006</th>
<th>N</th>
<th>p</th>
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<tr>
<td>Age (years)</td>
<td>12.0±3.8</td>
<td>863</td>
<td>12.3±3.8</td>
<td>1033</td>
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<tr>
<td>Proportion male (%)</td>
<td>51.3</td>
<td>873</td>
<td>52.6</td>
<td>1035</td>
<td>NS</td>
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<tr>
<td>HbA1c (%)</td>
<td>9.08±1.7</td>
<td>821</td>
<td>8.88±1.63</td>
<td>1031</td>
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<tr>
<td>Body weight (kg)</td>
<td>46.7±17.3</td>
<td>792</td>
<td>49.2±19.1</td>
<td>966</td>
<td>0.005</td>
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<tr>
<td>Insulin dose (U/day)</td>
<td>46.5±25.2</td>
<td>770</td>
<td>49.3±29.7</td>
<td>952</td>
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<tr>
<td>Insulin dose (U/kg/day)</td>
<td>0.96±0.33</td>
<td>770</td>
<td>0.99±0.77</td>
<td>951</td>
<td>NS</td>
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<tr>
<td>Standardized weight (SD)</td>
<td>0.60±1.13</td>
<td>783</td>
<td>0.72±1.16</td>
<td>966</td>
<td>0.044</td>
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</table>

**Table.** Characteristics of the study population in 2001 & 2006: data is given as mean±SD or proportion, number in each group and significant differences. HbA1c in 2001 & 2006 in the analysis of age groups is adjusted for gender. ANOVA shows glycemic control was worse in children aged >10y compared to 5-9y (p<0.001) and compared to under age 5 (p<0.001). HbA1c of patients where a new PDSN had been appointed is adjusted for age and gender. A center versus time interaction (p<0.001) indicates glycemic control improved in centers which appointed a new PDSN compared with centers which did not.