**Glycemic Control in the 12 Months following a Change to SI Hemoglobin A1c Reporting Units**

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**BACKGROUND:** Many countries have implemented, or are considering, a change in hemoglobin A1c (Hb A1c) units from traditional percentage values [Diabetes Control and Complications Trial (DCCT)] to the new Système International d’Unités (SI) unit in millimoles per mole. Concern exists that such a large alteration in numeric values might lead, through confusion, to a deterioration in patients’ glycemia. This study has assessed Hb A1c in the year before and after the change of units in a UK diabetes population.

**METHODS:** The Hb A1c in the 12 months immediately before the unit change (October 2010 to September 2011) was compared with the 12 months after (October 2011 to September 2012). Also, the subsequent change in Hb A1c in patients who had poor glycemic control [Hb A1c >8% (64 mmol/mol)], either before or after the unit change, was compared.

**RESULTS:** Over the 2 years, 44 721 Hb A1c measurements were requested on 13 197 (7247 male, 5950 female) known diabetes patients. The population Hb A1c was no different between years, with a median [interquartile range (IQR)] value of 7.5% (6.6%–8.7%) after the change and 7.5% (6.5–8.7) before (P = 0.34). The subsequent change in Hb A1c, following a raised (>8%) result was the same regardless of whether the initial value was in DCCT or SI units [median (IQR) change in Hb A1c = −0.2% (−0.9% to 0.3%), n = 4316, following a DCCT result, vs = −0.2% (−0.8% to 0.3%), n = 4396, following SI; P = 0.44].

**CONCLUSIONS:** In this UK diabetes population, a move to SI Hb A1c reporting did not lead to any marked short-term deterioration in glycemia or a different Hb A1c outcome in patients with initial poor glucose control.

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A lack of standardization dogged the measurement of hemoglobin A1c (Hb A1c) for decades following its initial discovery as a glycemic marker in 1968 (1). This meant that values in the same patient could vary markedly from one laboratory to another simply depending on the method of measurement used. Several global standardization initiatives were undertaken to help address this issue, including those based in Sweden and Japan (2,3). However, it was studies such as the Diabetes Control and Complications Trial (DCCT) in type 1 diabetes and the United Kingdom Prospective Diabetes Study (UKPDS) in type 2 diabetes which truly helped cement the importance of Hb A1c as a marker of microvascular and macrovascular complication risk and thereby further focus attention on the need for a common means of expressing results (4,5).

Because both the DCCT and the UKPDS used the same method of analysis in their studies, it was felt that one option would be for all methods to harmonize with this one. Subsequently, in the US, the National Glycohemoglobin Standardization Program (afterward renamed the NGSP) made great strides in making Hb A1c results more comparable between different laboratories (6) in a currency which could be directly related to patients who participated in the DCCT and UKPDS. Similar changes were made in other countries such as the UK (7), and as well as having immediate benefits for patients, these developments also made international multicenter diabetes trials more feasible.

Despite these advances, there were still concerns that DCCT results did not represent the true Hb A1c value in a patient sample, but rather the best approximation that 1980s technology could achieve. To address this situation, the IFCC announced their reference method for Hb A1c measurement in 2002 which, given its increased specificity for Hb A1c, reported values between 1.5% and 2% Hb A1c lower than the NGSP results that related to the DCCT (8). As a consequence, the move over to using these numbers was...
resisted in some quarters because of a fear of confusion between the 2 sets of values (9), with some evidence from previous changes in Hb A1c calibration that clinicians may either undertreat or overtreat patients because they were still using older targets (10). In recognition of this, the IFCC decided to change the units for Hb A1c completely, to be expressed as millimoles per mole, which are an order of magnitude greater than if the result had been expressed as their percentage value (11).

On June 1, 2009, the transition to Système International d’Unités (SI) units started in the UK with “dual reporting” of both the old DCCT and new units together (12). This period ended on October 1, 2011, with the removal of the DCCT number, so results were reported solely in millimoles per mole. This current study has aimed to establish, within a mixed primary and secondary care setting, if this move to reporting just SI units subsequently led to a change in Hb A1c values in the year following its introduction.

Patients and Methods

All patients in Hull and East Yorkshire, UK, who were identified by the laboratory computer system as being on the local diabetes register had their Hb A1c values for the period of October 1, 2010, to September 30, 2012, collected regardless of whether they were taken in the community or in the hospital. From July 1, 2009, to September 31, 2011, the laboratory reported Hb A1c in both percentage (NGSP/DCCT) and millimoles per mole (IFCC/SI) units. Subsequently, Hb A1c has been reported only in SI units. It means the data collected represented a full year of results both before and after the change. Hb A1c measurements were performed with the same 2 Menarini HA-8160 analyzers (Menarini Diagnostics Limited) and in the same central laboratory throughout the study period. Both used the same DCCT/NGSP-aligned calibrants, with SI values derived using the recognized “master equation” for conversion (13). The between-assay CV of both instruments averaged 1.65% at 5.4% Hb A1c and 1.3% at 9.3% Hb A1c during the study period. No notifications of poor performance on external quality assessment were received for either analyzer. What instrument was used to analyze a particular Hb A1c sample was purely a matter of chance. Patients reported as having hemoglobin variants during Hb A1c analysis were excluded from the analysis.

Any overall difference in Hb A1c values for the whole population for the year after the unit change was compared with that from the year before. To understand more clearly whether healthcare staff were responding any differently to an SI result compared to one that included a DCCT value, the change in Hb A1c following an unequivocally raised result (Hb A1c ≥8%) was compared before and after the units were redefined. The time between the raised result and the next Hb A1c measurement was also compared between years.

The Mann–Whitney U-test was used to compare all before and after measurements with STATA (Statacorp LP). An arbitrary level of 5% statistical significance (2-tailed) was assumed.

Results

There were 21 880 Hb A1c measurements in the year to October 1, 2011, (dual reporting of results) and 22 841 taken in the following year (only IFCC results reported) on 13 197 patients without known hemoglobin variants [7247 male, 5950 female, median age 67 years, interquartile range (IQR) 55–77 years, median Hb A1c 7.5% (58 mmol/mol), IQR 6.6%–8.7% (49–72 mmol/mol)].

Fig. 1 shows the monthly mean Hb A1c values over the 2 years. There was no difference in the overall glycemic control of the population before and after the change of unit reporting (Table 1). Among those patients with an initial Hb A1c value above 8% who had 2 or more measurements in the year before the unit switch, the subsequent change in their Hb A1c result was no different from the change in Hb A1c following a result which was reported in only SI units (Table 1).

Discussion

This study has shown that changing Hb A1c units to being reported solely in the SI (mmol/mol) format has made little change to the glycemic control of a large population of patients with diabetes. The population distribution of Hb A1c did not change in the year following implementation of the use of SI units alone, and the improvement in Hb A1c among poorly controlled patients with initial Hb A1c values of >8% (64 mmol/mol) was the same whether or not a DCCT/NGSP number was included alongside an SI/IFCC result. These poorly controlled patients also had a repeat Hb A1c measured after a similar period of time, irrespective of the units being just SI or not. Taken together, it means the way healthcare workers (and perhaps patients) act on an Hb A1c result does not appear to have changed markedly as a consequence of changing reporting units.

Given the concern generally expressed about the effect that changing Hb A1c units could have on clinical care, it is perhaps surprising that there was not a larger detrimental effect on glycemia than has been demonstrated here. There are several possible reasons for this. One is that the wide distribution of information on the
new units to healthcare and laboratory professionals in the UK (12), as well as to patients themselves, before and during the period of dual result reporting may have been successful in making them more accustomed to SI. Another possible reason is that the ability of healthcare staff (comprising predominantly physicians, diabetes specialist nurses, and primary care nurses) to adapt to the new numbers was underestimated, or that they are exercising greater care with the unfamiliar units. Certainly, serious patient safety issues were not reported during the simultaneous major change in several common tests to SI units in the 1970s (14, 15). Related to this, the decision by the IFCC to change the numeric index for Hb A1c completely may indeed have helped in avoiding confusion following the unit change. Lastly, at least some healthcare staff may have demonstrated their ingenuity in being able to readily convert the new units back to the old ones.

There were limitations to this study. First, the data collected from the laboratory computers did not in-
clude information on other aspects of the patients’ diabetes, such as the type, duration, and treatment. Second, the data provided information only for the 12-month period after the change to reporting only SI units, so any long-term changes in Hb A1c may not yet have become apparent. However, the influence that seasonal variability can have on Hb A1c (16) (as demonstrated in Fig. 1) means that the only feasible times to assess any future change in glycaemia will be following each anniversary of implementation. Third, it is not possible from this analysis to establish with certainty if any confusion with units may have occurred when dual reporting was started rather than, as here, when the DCCT/NGSP value was removed.

In this study’s favor, all the samples from Hull and East Yorkshire were analyzed in the same laboratory and the data set is sufficiently large to detect subtle changes in population glycemia. Also, knowing that patients were recorded on the database as already having confirmed diabetes excluded the influence that using Hb A1c for diabetes diagnosis may otherwise have had on the findings.

Most of Europe and Australasia have moved, or are currently in the process of transferring, to SI Hb A1c units, whereas countries such as the US and Canada have stated their intention to continue with DCCT/NGSP values, for now at least (17, 18). This study gives reassurance to those nations having already changed to SI, or planning to do so, that with proper education the move can be made with little detriment to patient care.

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References


4 Clinical Chemistry 59:10 (2013)