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RESEARCH LETTER

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Effective use of computerized insulin dose adjustment algorithms on continuous glucose monitoring results by a clinical pharmacist - Proof-of-concept

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Highlights

A clinical pharmacist using recommendations of Food and Drug Administration-cleared computerized insulin dose adjustment algorithms based on analyses of glucose readings from continuous glucose monitoring (Abbot Free Style Pro) in 13 poorly controlled insulin-requiring diabetic patients increased time in target range of 3.9 to 10.0 mmol/L from 29% to 51% and decreased time in range of >13.9 mmol/L from 43% to 23% (both $P = 0.01$) after 3 months. Glycated hemoglobin (HbA1c) levels (±SD) fell from 102 (±15) to 67 (±10) mmol/mol ($P < 10^{-6}$).

To the Editor

Ninety percent of diabetic patients are cared for by primary care providers (PCPs).[1] Currently, approximately 30% take insulin.[2] Unfortunately, many studies show that PCPs are challenged when it comes to using insulin.[3] The largest barriers for appropriate adjustments of insulin doses for PCPs are time constraints and lack of experience.[4] For patients, it is providing enough glucose values through self-monitoring of blood glucose (SMBG). Continuous glucose monitoring (CGM) effectively meets the patient challenge. However, the very large number of glucose readings compounds the time constraints, as does the lack of experience, because few PCPs are familiar with CGM outputs.

This observational, proof-of-concept report examines whether Food and Drug Administration-cleared computerized insulin dose adjustment algorithms written to analyze much fewer SMBG readings can also effectively work with CGM outputs. Within 15-30 seconds of downloading glucose meters, these algorithms[5] generate a report containing a scatterplot of glucose readings, their organization into before and after meals and before bedtime values, an analysis of the results, and recommendations for adjusting insulin doses (if necessary) that the clinician can modify or accept. The new insulin doses serve as the basis for subsequent reports. If the algorithms are effective with the CGM glucose readings, both the PCP and patient challenges are easily met with resultant better control in insulin-requiring patients.

1 | METHODS

Poorly controlled (glycated hemoglobin [HbA1c] levels >75 mmol/mol), minority, underresourced, diabetic patients in a Federally Qualified Health Center (FQHC) are often referred to a clinical pharmacist (CP) specially trained in diabetes care who routinely uses the

TABLE 1 Glycemic responses

	Initial report	Final report	*P* value
Time in Range (% ± SD)			
<3.0 mmol/L	0.2 ± 0.7	0.6 ± 1.4	0.32
3.0–3.8 mmol/L	0.5 ± 1.3	1.6 ± 2.3	0.15
3.9–10.0 mmol/L	28.8 ± 27.2	50.6 ± 24.9	0.01
10.0-13.9 mmol/L	26.3 ± 11.0	24.2 ± 10.5	0.58
>13.9 mmol/L	44.2 ± .0	22.9 ± 17.7	0.01
HbA1c (mmol/mol ± SD)			
	102 ± 15	67 ± 10	$<10^{-6}$

Abbreviation: HbA1c, glycated hemoglobin.

computerized insulin dose adjustment algorithms in patients taking insulin and performing fingerstick glucose tests. The pharmacy purchased 13 CGMs (Free Style Libre Pro) that were given to the first 13 insulin-requiring patients at referral who agreed to be seen every 2 weeks. The CP transferred glucose readings (date, time, values) to a secure, Health Insurance Portability and Accountability Act-approved cloud on which the computerized insulin dose adjustment algorithms resided. Within 30 seconds of downloading the CGM readings, the CP received the report described previously. The algorithms use the patterns of glucose readings during the 24-hour period and determine if these patterns are consistent throughout multiple days in making insulin dose adjustment recommendations.

The primary outcome was change in HbA1c levels from baseline. Secondary outcomes were time in ranges (TIRs) for glucose concentrations of <3.0 mmol/L (level 2 hypoglycemia), 3.0-3.8 mmol/L (level 1 hypoglycemia), 3.9-10.0 mmol/L (target range), 10-13.9 mmol/L and ≥ 13.9 mmol/L. Results were analyzed by a two-tailed, paired *t* test with significance accepted at $P < 0.05$. Because patient data in this observational, retrospective study were de-identified, informed consents were not required.

This was a retrospective observational study in which data had already been collected and were in an electronic health record. The institutional review boards in the United States do not require informed consents for the use of such data as long as the patients are de-identified, that is, there is no way that they can be identified, which is the case here.

2 | RESULTS

Ten of the 13 patients (seven female) were on basal insulin alone and three were on basal/bolus regimens. Twelve had type 2 diabetes and 1 had type 1 diabetes. Mean (±SD) ages were 52.7 ± 9.2 years and mean body mass indices were 31.6 ± 7.8. Reports were generated at each visit. The mean number of CGM reports was 4.7 per patient covering a mean period of 97 days or one every 3 weeks. Glycemic responses are shown in Table 1. Time spent with glucose concentrations >13.9 mmol/L decreased from 44% to 23% with a concomitant increase in time in the target range of 3.9-10.0 mmol/L from 29% to 51%. HbA1c levels (±SD) markedly fell from 102 ± 15 to 67 ± 10 mmol/mol. There were no significant differences in time spent at hypoglycemia levels 1 or 2 nor any episodes of severe hypoglycemia (assistance required for treatment). The total daily baseline dose of insulin was 47 units, which increased to 67 units, a 42% rise. Because insulin regimens were not changed, the increase was because of simply raising insulin doses.

3 | COMMENT

The major finding of this proof-of-concept observational study is that the computerized insulin dose adjustment algorithms used to analyze fingerstick glucose readings can also effectively analyze values measured every 15 minutes. A CP using the Abbott Free Style Libre Pro markedly improved glycemia in poorly controlled patients over a short period of time without significantly increasing hypoglycemia. CGM successfully meets the patient challenge of providing enough glucose readings. The organization and analysis of the readings with subsequent recommendations for dose adjustments that can be modified or accepted are provided by these computerized insulin dose adjustment algorithms to PCPs within a minute, successfully meeting their time constraints and providing guidance for adjusting insulin doses. Furthermore, not only do PCPs have time challenges at visits, they also face difficulties in scheduling these patients frequently enough to have much effect on diabetes control. For instance, the mean HbA1c level in

patients receiving insulin is 69 mmol/mol[6-9] with two-thirds[10] failing to meet the American Diabetes Association's target HbA1c level of <53 mmol/mol. Yet a clinical trial showed that if insulin doses were adjusted every 1-4 weeks, 88% of patients reached that goal.[10] CGM readings can also be sent remotely, which would allow more frequent dose adjustments without face-to-face visits.

In conclusion, combining CGM with computerized insulin dose adjustment algorithms meets two of the biggest challenges of controlling diabetes in insulin-requiring patients. Using these two innovations together, especially if the glucose monitoring results can be more frequently provided remotely, should improve diabetes control with subsequent beneficial effects on diabetes complications and resultant lowering of health care costs.

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CONFLICT OF INTEREST

Mayer B. Davidson is the Chief Medical Officer and S. J. Davidson is the Chief Products Officer of Mellitus Health, Inc. The authors have no conflicts of interest.

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REFERENCES

1. Davidson JA. The increasing role of primary physicians in caring for patients with type 2 diabetes mellitus. *Mayo Clin Proc*. 2010;85(suppl 12):S3-S4.
2. Selvin E, Porrinello CM, et al. Trends in insulin use and diabetes control in the U.S.: 1988-1994 and 1999-2012. *Diabetes Care*. 2016;39:e33-e35.
3. Davidson MB. An effective method for adjusting insulin doses. http://openaccessbooks.com/an-ebook-on-diabetes.html. Accessed dd mm, yyyy.
4. Ellis K, Mulnier H, Forbes A. Perceptions of insulin use in type 2 diabetes in primary care: a thematic synthesis. *BMC Fam Pract*. 2018;19:70. https://doi.org/10.1186/s12875-018-0753-2.
5. Food and Drug Administration (FDA). Regulation number 21 CFR 868 1890: submission # k160673.
6. Khunti K, Wolden MI, Thorsted BL, Andersen M, Davies MJ. Clinical inertia in people with type 2 diabetes: a retrospective cohort study of more than 80,000 people. *Diabetes Care*. 2013;36:3411-3417.
7. Mata-Cases M, Franch-Nadal J, Real J, et al. Therapeutic inertia in patients treated with two or more antidiabetics in primary care: factors predicting intensification of treatment. *Diabetes Obes Metab*. 2018;20:103-112.
8. Harris SB, Kapor J, Lank CN, Willan A, Houston T. Clinical inertia in patients with T2DM requiring insulin in family practice. *Can Fam Physician*. 2010;56:e418-e424.
9. Home P, Naggar NE, Khamseh M, et al. An observational non-interventional study of people with diabetes beginning or changed to insulin analogue therapy in non-Western countries: the A1chieve study. *Diabetes Res Clin Pract*. 2011;94:352-363.
10. Bashan E, Herman WH, Hodish I. Are glucose readings sufficient to adjust insulin dosage? *Diabetes Technol Therap*. 2011;13:85-92.

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