

Research Article

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Sensitivity Study of HbA1C Range Using Big Data Analytics Based on Five Different Models (GH-Method: Math-Physical Medicine)

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Received: April 21, 2020; **Accepted:** April 27, 2020; **Published:** April 30, 2020**Introduction**

In spite of some built-in variance of lab tested HbA1C results which include operational, environmental, chemical and other factors, this paper further describes a clinical case study about a rational range of HbA1C for type 2 diabetes (T2D) conditions. The dataset is provided by the author, who uses his own type 2 diabetes metabolic conditions control, as a case study via the “math-physical medicine” approach of a non-traditional methodology in medical research.

Math-physical medicine (MPM) starts with the observation of the human body’s physical phenomena (not biological or chemical characteristics), collecting elements of the disease related data (preferring big data), utilizing applicable engineering modeling techniques, developing appropriate mathematical equations (not just statistical analysis), and finally predicting the direction of the development and control mechanism of the disease.

Methods

The author used the following five different methods (models or sources) to establish a range for HbA1C:

1. Lower glucose bound from finger-piercing and testing strip method (Finger).
2. Higher glucose bound from a sensor-based continuous glucose monitoring device (Sensor).
3. American Diabetes Association’s (ADA) conversion equation of glucose and HbA1C estimated average glucose (eAG).
4. EclaireMD derived mathematical A1C based on actual measured finger glucoses (actual).
5. EclaireMD derived mathematical A1C based on artificial intelligence (AI) predicted glucoses (predicted).

The author conducted four glucose measurements per day by using the Finger method over the past 7.5 years, 2,745 days from 1/1/2012 - 7/7/2019 with 10,980 measured glucose data. Furthermore, by applying a Sensor on his upper arm and measuring 74 times per day, he has collected additional 31,672 measured glucose data over 428 days (5/5/2018 - 7/7/2019).

The ADA is recommending the use of a new term known as the “estimated average glucose” or “eAG” for diabetes management (see following quotes from ADA literature).

“Health care providers can now report A1C results of patients by using the same units (mg/dl or mmol/l) that patients routinely see in blood glucose measurements.....

Although the A1C test is an important tool, it can’t replace the daily self-monitoring of blood glucose (SMBG). A1C tests don’t measure a person’s day-to-day control. People with diabetes can’t adjust their insulin on the basis of their A1C tests. That’s why blood glucose checks and log results are so important to stay in good control. From 1994, the goal for most people with diabetes has been less than 7%.....

ADAG Study was conducted by ADA, EASD, and IDF with 507 recruited people, including 268 patients with type 1 diabetes (53%), 159 with type 2 diabetes (31%), and 80 people without diabetes (16%) from 10 international centers.”

He then conducted a detailed big data analytics of glucose results comparison with both Finger and Sensor data (Figures 1 & 2).

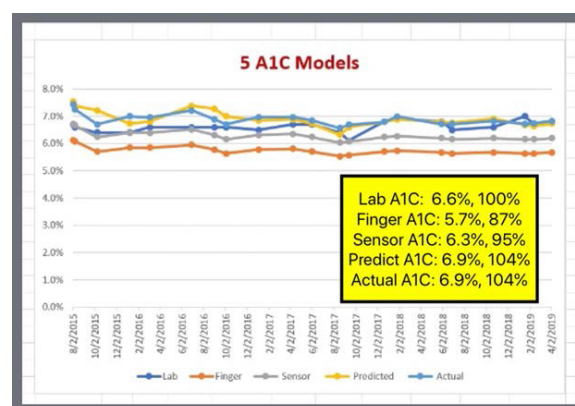


Figure 1: Five HbA1C models with average A1C and accuracy %

	A1C Lab	A1C Finger	A1C Sensor	A1C Predicted	A1C Actual	F vs A1C Lab	S vs A1C Lab	P vs A1C Lab	A vs A1C Lab	eAG	Glucose Finger	Glucose Sensor	F vs eAG	S vs eAG
8/2/2015	6.1%	6.1%	6.7%	7.54%	7.44%	-0%	0%	13%	11%	146	129	146	-11%	0%
8/7/2015	6.6%	6.1%	6.7%	7.38%	7.20%	-8%	1%	12%	10%	143	128	143	-10%	1%
10/9/2015	6.4%	5.7%	6.2%	7.21%	6.70%	-11%	3%	13%	5%	137	117	137	-15%	3%
1/8/2016	6.4%	5.8%	6.4%	6.73%	7.00%	-0%	0%	5%	0%	137	121	137	-12%	0%
3/4/2016	6.4%	5.8%	6.4%	6.80%	6.90%	-11%	3%	3%	5%	143	121	137	-15%	4%
6/29/2016	6.4%	5.9%	6.5%	7.38%	7.21%	-10%	3%	12%	9%	143	124	140	-13%	2%
9/1/2016	6.4%	5.8%	6.3%	7.38%	6.80%	-13%	4%	10%	4%	143	119	139	-17%	4%
10/4/2016	6.4%	5.6%	6.2%	7.00%	6.70%	-15%	-7%	6%	2%	143	115	130	-19%	-9%
1/3/2017	6.3%	5.8%	6.3%	6.84%	6.97%	-11%	3%	5%	2%	140	110	134	-15%	4%
4/9/2017	6.7%	5.8%	6.4%	6.80%	6.97%	-13%	3%	8%	4%	144	120	136	-18%	7%
6/1/2017	6.7%	5.7%	6.2%	6.73%	6.84%	-15%	7%	0%	2%	146	117	132	-20%	-9%
8/1/2017	6.4%	5.5%	6.0%	6.32%	6.57%	-14%	-6%	-1%	3%	137	112	127	-18%	4%
9/12/2017	6.1%	5.0%	6.1%	6.60%	6.69%	-9%	0%	8%	10%	128	113	128	-12%	1%
11/20/2017	6.4%	5.7%	6.2%	6.79%	6.77%	-10%	8%	0%	0%	148	117	132	-21%	11%
3/2/2018	6.0%	5.7%	6.3%	6.89%	6.99%	-17%	-9%	0%	1%	151	118	133	-22%	-12%
5/2/2018	6.8%	5.7%	6.2%	6.78%	6.71%	-17%	-9%	0%	-1%	148	116	131	-22%	-12%
10/29/2018	6.5%	5.0%	6.2%	6.70%	6.71%	-13%	-5%	4%	2%	140	115	130	-18%	7%
10/12/2018	6.4%	5.7%	6.2%	6.81%	6.82%	-14%	0%	0%	3%	143	116	131	-19%	4%
1/1/2019	7.0%	5.6%	6.2%	6.68%	6.72%	-20%	-12%	5%	4%	154	115	130	-25%	-16%
7/13/2019	6.7%	5.6%	6.2%	6.64%	6.74%	-16%	-8%	-1%	1%	146	115	130	-21%	-11%
4/2/2019	6.4%	5.7%	6.2%	6.75%	6.82%	-17%	-9%	-1%	0%	146	116	131	-21%	-12%
Average	6.40%	5.40%	5.70%	6.20%	6.20%	-13%	-5%	6%	4%	143	118	134	-17%	-7%
Conversion										21.645	17.863	20.186		

Figures 2: Lab A1C and other four estimated A1C models

In summary, the average sensor results are 13% higher than the average finger results which include fasting plasma glucose (FPG), postprandial plasma glucose (PPG), and the glucoses in other periods (pre-meal and pre-bed) throughout the day. It is obvious that the finger results serve as the lower bound and the sensor result serve as the upper bound of measured glucoses.

Furthermore, the author applied signal processing, wave theory, energy theory, optical physics to develop an AI-based tool (artificial intelligence) to predict both FPG and PPG with >99% accuracy in comparison with Finger glucose. He then develop a corresponding AI equation to estimate this AI predicted glucose's corresponding HbA1C. Both of these two sets of predicted HbA1C have achieved >96% accuracy during a period of ~4 years (2015 - 2019) with 21 lab-tested A1C values.

The following ADA's equation for the eAG conversion to A1C is also used in this calculation:

$$\text{eAG (mg/dL)} = (\text{A1C} \times 28.7) - 46.7$$

Or

$$\text{A1C (\%)} = (\text{eAG} + 46.7) \div 28.7$$

Results

Figure 1 shows the summarized results of his HbA1C study. It includes the above mentioned five glucose models. Table 1 provides detailed data of these five summarized HbA1C curves.

In summary, his EclairMD tool predicted two A1C mathematical curves with the "upper bound" of the eGA model (both are 4% higher than eAG), whereas both Finger (lowest among five sources with 17% lower than eAG) and Sensor (10% higher than Finger but still 7% lower than eAG) are offered as the "lower bound" of the eGA model.

Conclusion

This big data analytics derived a range of HbA1C values and curves based on five different glucose models. With this rational Range of HbA1C, health care providers can depict a more accurate and rational Picture of T2D patient's conditions [1-4].

References

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