Technology: Continuous Glucose Monitors and Insulin Pumps with Automatic Insulin Delivery (AID)

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Objectives

- Become familiar with professional CGM
- Become familiar with personal CGM
- Understand the use of insulin pumps with Automatic Insulin Delivery (AID) systems

Dr. Horowitz has no disclosures related to this lecture

Commercial Technologies

Original GameBoy
1989

Motorola Flare
1995

SuperNintendo Entertainment System
1990

Nokia 3310
2000

Original iPhone
2007

Sony PlayStation 3
2006

Sony PlayStation 4
2013

Sony PlayStation VR
2016

Nintendo Switch
2017

iPhone XS
2018

1980

2019

Diabetes Technologies

AccuCheck bG
model 750
1984

NovoPen
1985

MiniMed 502
1992

MedTronic Guardian REAL-time
2004

Gulcowatch Biographer
1999

MedTronic
MiniMed 515
2008

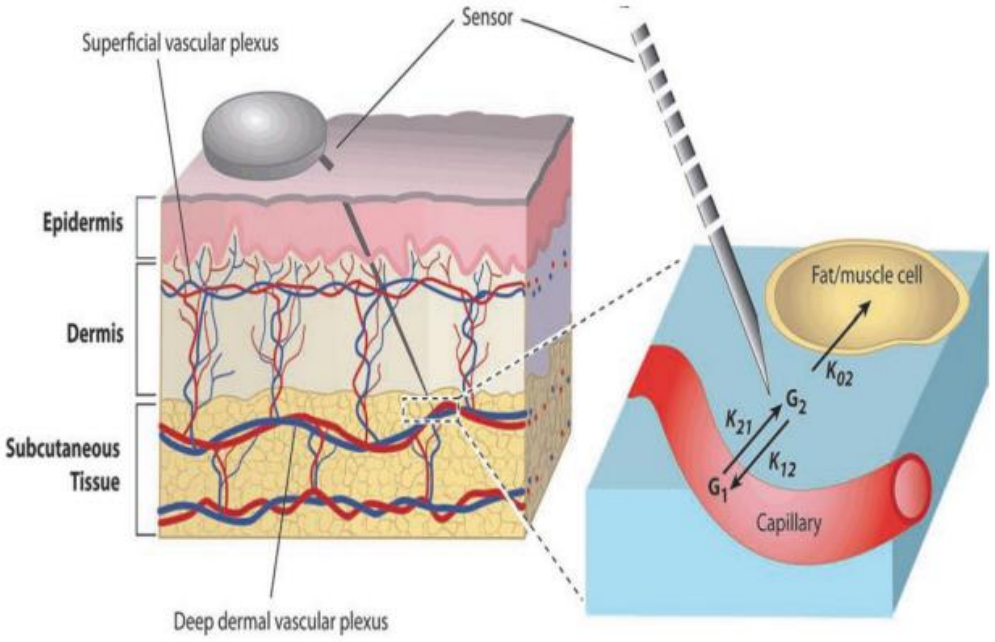
OpenAPS
2015

NightScout
2014

Dexcom G5
2015

FreeStyle Libre
2017

Monitoring Glycemic Control: Continuous Glucose Monitoring (CGM)

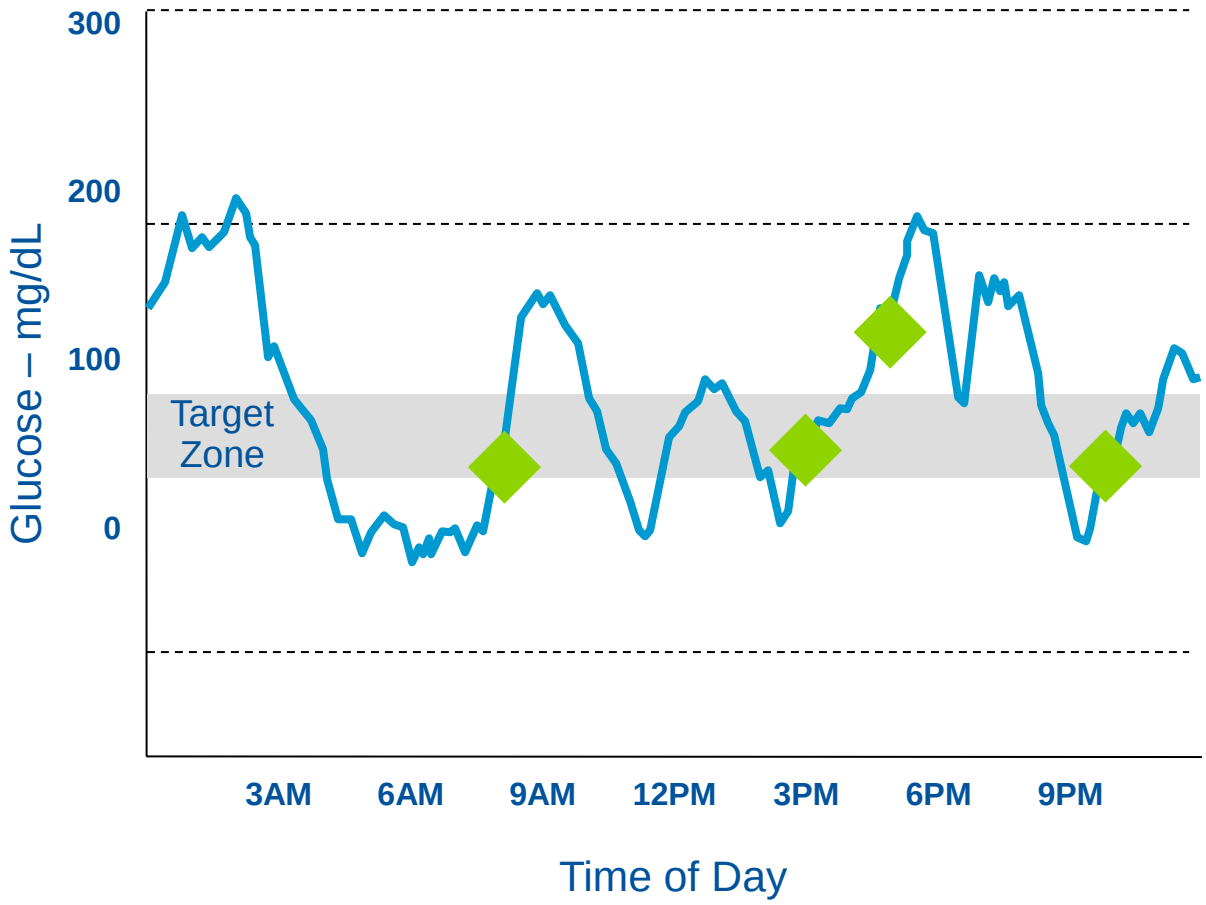


- A1C cannot capture glycemic variability or glucose excursions, including hypoglycemic events[1]
- With CGM, a small sensor is placed under the skin, to measure the interstitial glucose levels in intervals of 5 to 15 minutes[1]
- CGM provides a more comprehensive assessment of glycemic control
- CGM can inform patients of impending glucose excursions using glucose trend arrows and influence treatment decisions[2]
- CGM devices continue to become easier to use, more accurate, and more accessible to patients[2]

Figure: Cengiz and Tamborlane. Diabetes Technol Ther. 2009. Jun;11 (Suppl 1)

1. Bergenstal et al. *Diabetes Care*. 2018 Nov;41(11):2275-2280.
2. Ajjan et al. *Adv Ther*. 2019 Mar;36(3):579-596.

CGM Reveals Insights Beyond Fingerstick Testing

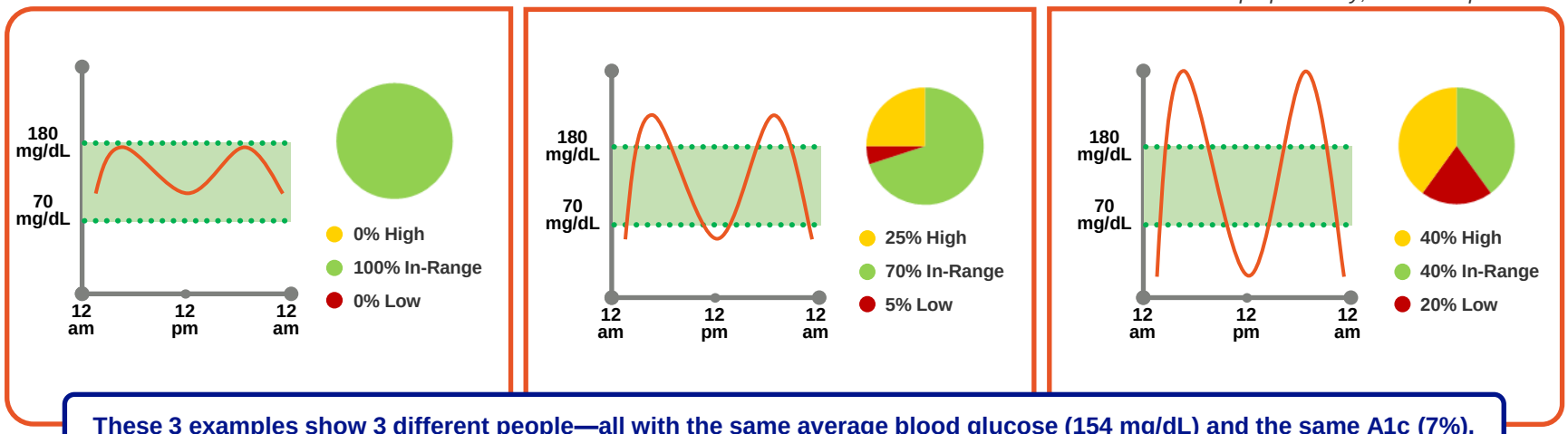


Medtronic Advance

Though A1c is the primary metric for assessing glycemic control, relying on A1c alone may not provide a complete assessment[1,2]

While it reflects 3-month glucose averages, A1c doesn't track glycemic excursions or hypoglycemia, so patients with an acceptable level (<7%) may still not be in control[1,3,4]

For educational purpose only, not actual patients



These 3 examples show 3 different people—all with the same average blood glucose (154 mg/dL) and the same A1c (7%).

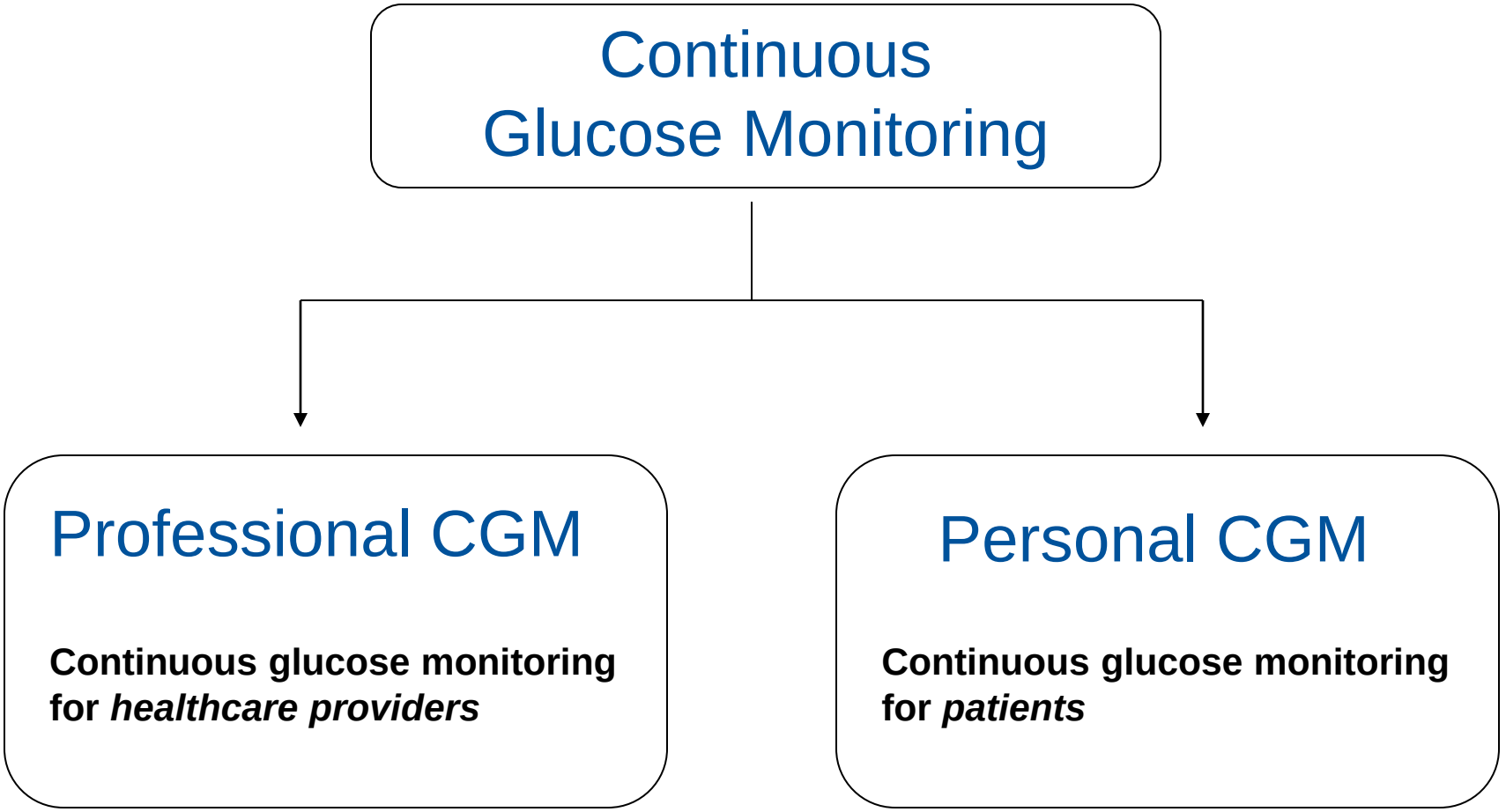
Adapted from diaTribe. "Time in Range Infographic." Accessed April 2022. https://diatribe.org/sites/default/files/TIR%20V12%20Infographic_0.pdf.

1. American Diabetes Association. "Glycemic Targets: Standards of Medical Care in Diabetes—2022." *Diabetes Care* 45(suppl 1)(January 2022): S83-S96. https://doi.org/10.2337/dc22-S006. **2.** Chandran, Suresh Rama, et al. "Beyond HbA1c: Comparing Glycemic Variability and Glycemic Indices in Predicting Hypoglycemia in Type 1 and Type 2 Diabetes." *Diabetes Technology and Therapeutics* 20, no. 5 (March 2019): 353-362. https://doi.org/10.1089/dia.2017.0388. **3.** Battelino, Tadej, et al. "Clinical Targets for Continuous Glucose Monitoring Data Interpretation: Recommendations From the International Consensus on Time in Range." *Diabetes Care* 42, no. 8 (August 2019): 1593-1603. https://doi.org/10.2337/dci19-0028. **4.** Beck, Roy W. "The Fallacy of Average: How Using HbA1c Alone to Assess Glycemic Control Can Be Misleading." *Diabetes Care* 40, no. 8 (August 2017): 994-999. https://doi.org/10.2337/dc17-0636.

Customize Diabetes Management Based Upon the Needs of Your Practice and Patients

	Professional CGM	Personal CGM
Device Ownership	HCP or Healthcare institution	Patient
Application or Purpose	Assess glucose patterns and treatment options	Make own therapy adjustments
Duration or Frequency of Use	Periodic, episodic use	Ongoing use

Customize Diabetes Management Based Upon the Needs of Your Practice and Patients



PATIENT SELECTION FOR PROFESSIONAL CGM

AACE Guidelines for Professional CGM Candidates:

Patients with type 1 or type 2 diabetes who:

- *Are not at their A1C target*
- *Have recurrent hypoglycemia or hypo unawareness*

Pregnant women with:

- *Type 1 diabetes*
- *Type 2 diabetes*
- *Gestational diabetes requiring insulin*

Youth with type 1 diabetes who are:

- *Changing their diabetes regimen*
- *Experiencing nocturnal hypo*
- *Dawn phenomenon*
- *Hypo unawareness*
- *Post-prandial hyperglycemia*

AACE CGM Task Force. *Endocrine Practice*. 2010;16(5):730-44.

Patients with T2D may not report hypoglycemia[1]

In a study of patients with T2D on insulin, fewer than half reported severe hypoglycemic events

Among patients without severe hypoglycemia in the last 6 months

ONLY

28% (61/231)

consulted their physician/nurse following a non-severe hypoglycemic event*[1]

Among patients with severe hypoglycemia in the last 6 months

ONLY

48% (28/60)

Consulted their physician/nurse following a severe hypoglycemic event†[1]

*Defined in this study as events managed by the patient alone. †Defined in this study as any hypoglycemic event requiring assistance of another person to actively administer carbohydrate, glucagon, or other resuscitative actions.

1. Lamounier, Rodrigo, et al. "Hypoglycemia Incidence and Awareness Among Insulin-Treated Patients with Diabetes: the HAT Study in Brazil." *Diabetology & Metabolic Syndrome* 10, no. 83 (November 2018): 1-10. https://doi.org/10.1186/s13098-018-0379-5.

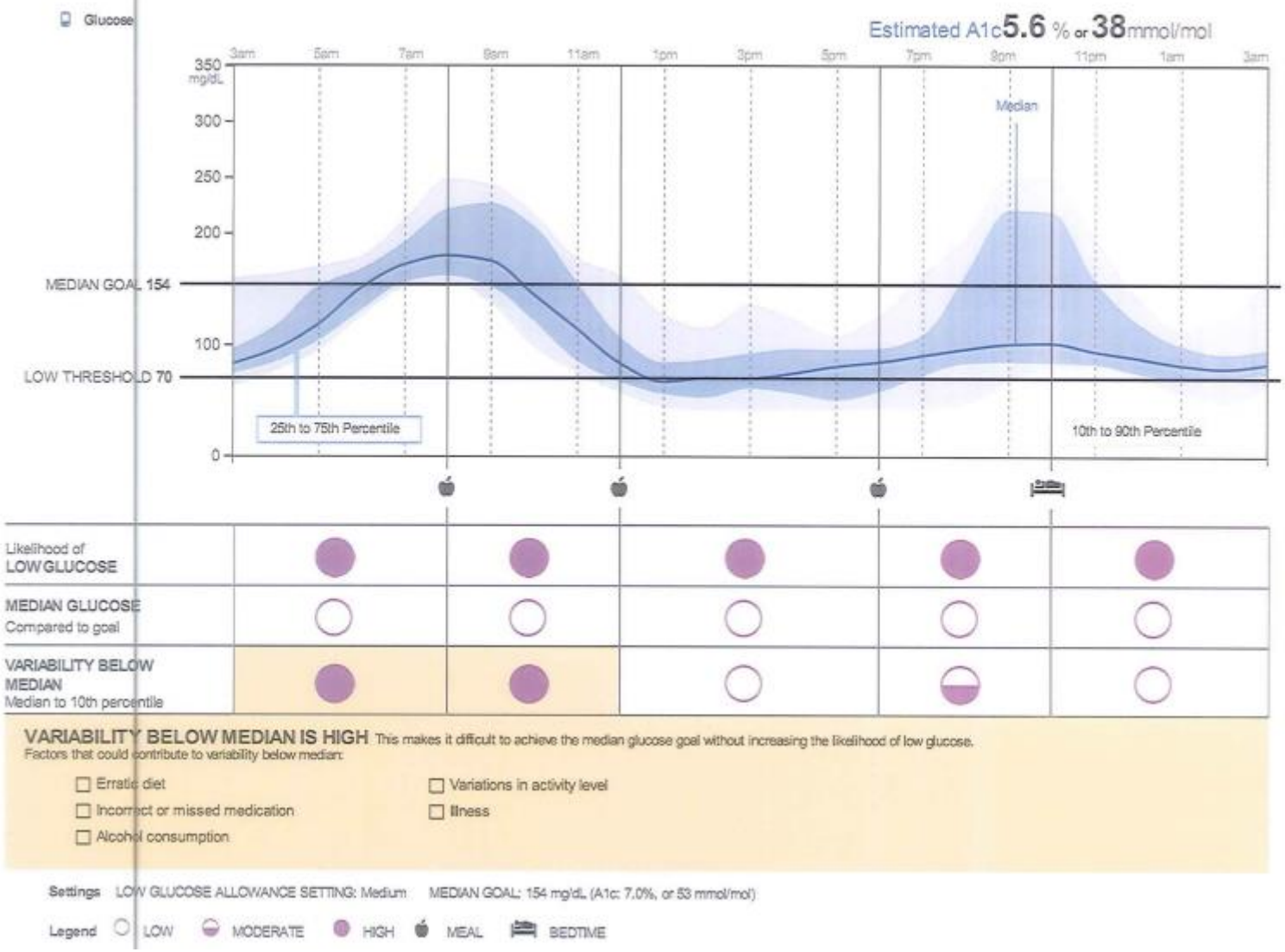
PATIENT CASE: BB

- 48 yo male with type 2 diabetes for 7 years
- On several oral agents
- Checks sugars at home infrequently and when he does reports they are in the low to mid 100 range
- Poorly compliant with lifestyle
- A1c has been increasing from 6.7% to 7.8%

Glucose Pattern Insights

March 21, 2018 - March 28, 2018 (8 Days)

LibreView



VARIABILITY BELOW MEDIAN IS HIGH This makes it difficult to achieve the median glucose goal without increasing the likelihood of low glucose.

Factors that could contribute to variability below median:

- ☐ Erratic diet
- ☐ Incorrect or missed medication
- ☐ Alcohol consumption
- ☐ Variations in activity level
- ☐ Illness

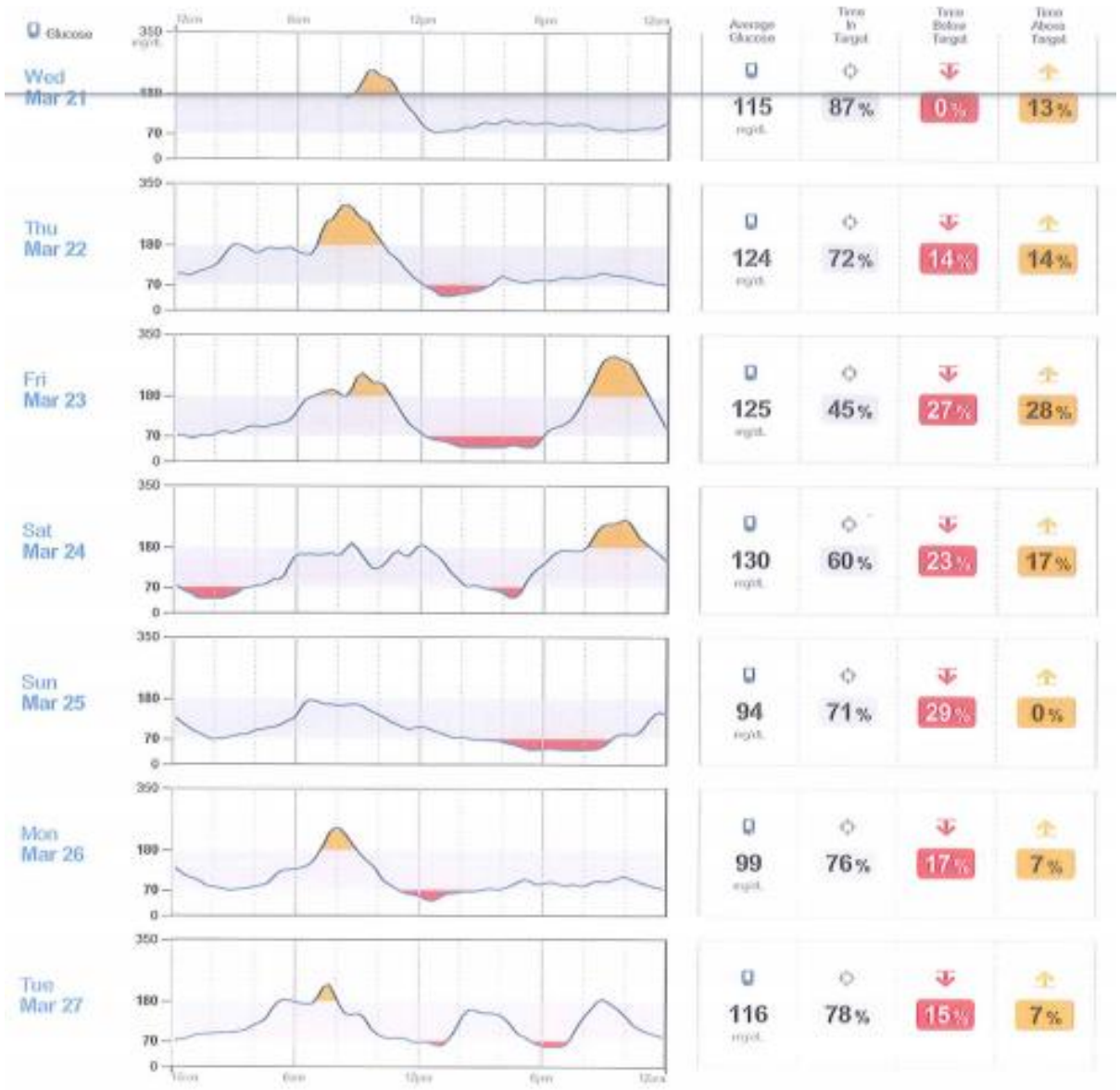
Settings LOW GLUCOSE ALLOWANCE SETTING: Medium MEDIAN GOAL: 154 mg/dL (A1c: 7.0%, or 53 mmol/mol)

Legend ○ LOW ◒ MODERATE ● HIGH MEAL BEDTIME

Daily Glucose Summary

March 21, 2018 - March 28, 2018 (8 Days)

LibreView



Day & Date	Breakfast	Lunch	Dinner	Bedtime
1	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: COFFEE CEREAL STRAWBERRYS	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: CHICKEN NOODLE COLD SLAW 2 HD CANDY	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: BANANA 1/2 A SHEET	Time / Insulin Glucose mg/dL Comments:
2 3/22	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: COFFEE, CEREAL, STRAWBERRYS EGG TOAST	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: CHICKEN NOODLE COLESLAW	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: ORANGE	Time / Insulin Glucose mg/dL Comments:
3 3/23	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: COFFEE CEREAL STRAWBERRYS	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: SALAD HD CANDY	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: ORANGE FISH PRETZELS	Time / Insulin Glucose mg/dL Comments:
4 3/24	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: BLUEBERRY PANCAKES STRAWBERRY SAUSAGE SUGAR SYRUP	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: 4HD CANDY	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: CHICKEN & CHEESE TACOS ORANGE PRETZELS	Time / Insulin Comments:
5 3/25	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: NOVA ORANGE EGG ORANGE	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: 2 HD CANDY	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: PRIME RIB PARCEL POTATOE ICE CREAM	Time / Insulin Comments:
6 3/26	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: CEREAL STRAWBERRY	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: 2 HD CANDY	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: PRIME RIB BAKE POTATO	Time / Insulin Comments:
7 3/27	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: CHEESE STRAWBERRYS	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: POTATO SALAD 2 HD CANDY	Before / After / Insulin Time : : Glucose mg/dL mg/dL U Food & activity: PRIME RIB ORANGE PRETZELS	Time / Insulin Comments:

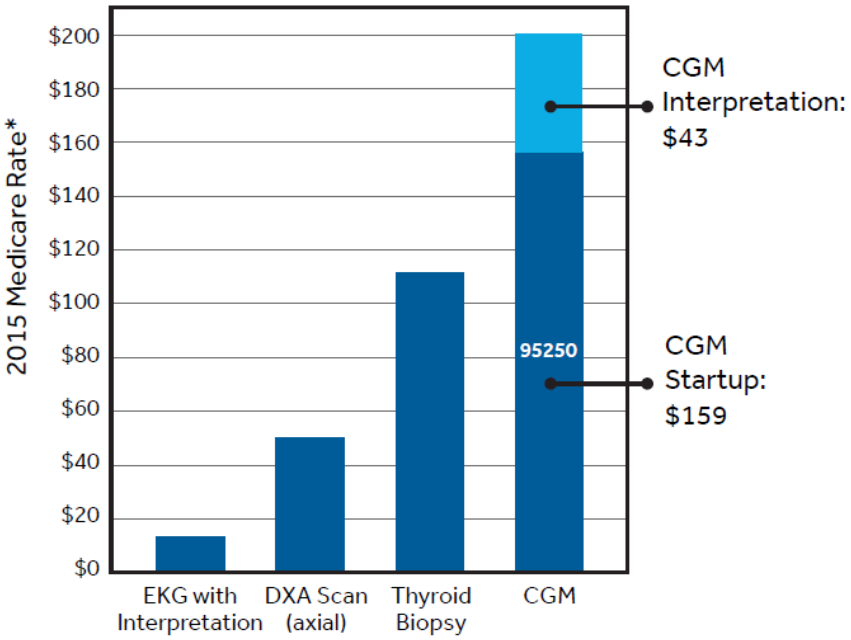
CGM Reimbursement Facts

Approximately 92% of commercial covered lives in the U.S. are covered by an insurer with a written policy for Personal and Professional CGM.

All local Medicare contractors currently cover Professional CGM.

Sources: Internal Data on File.

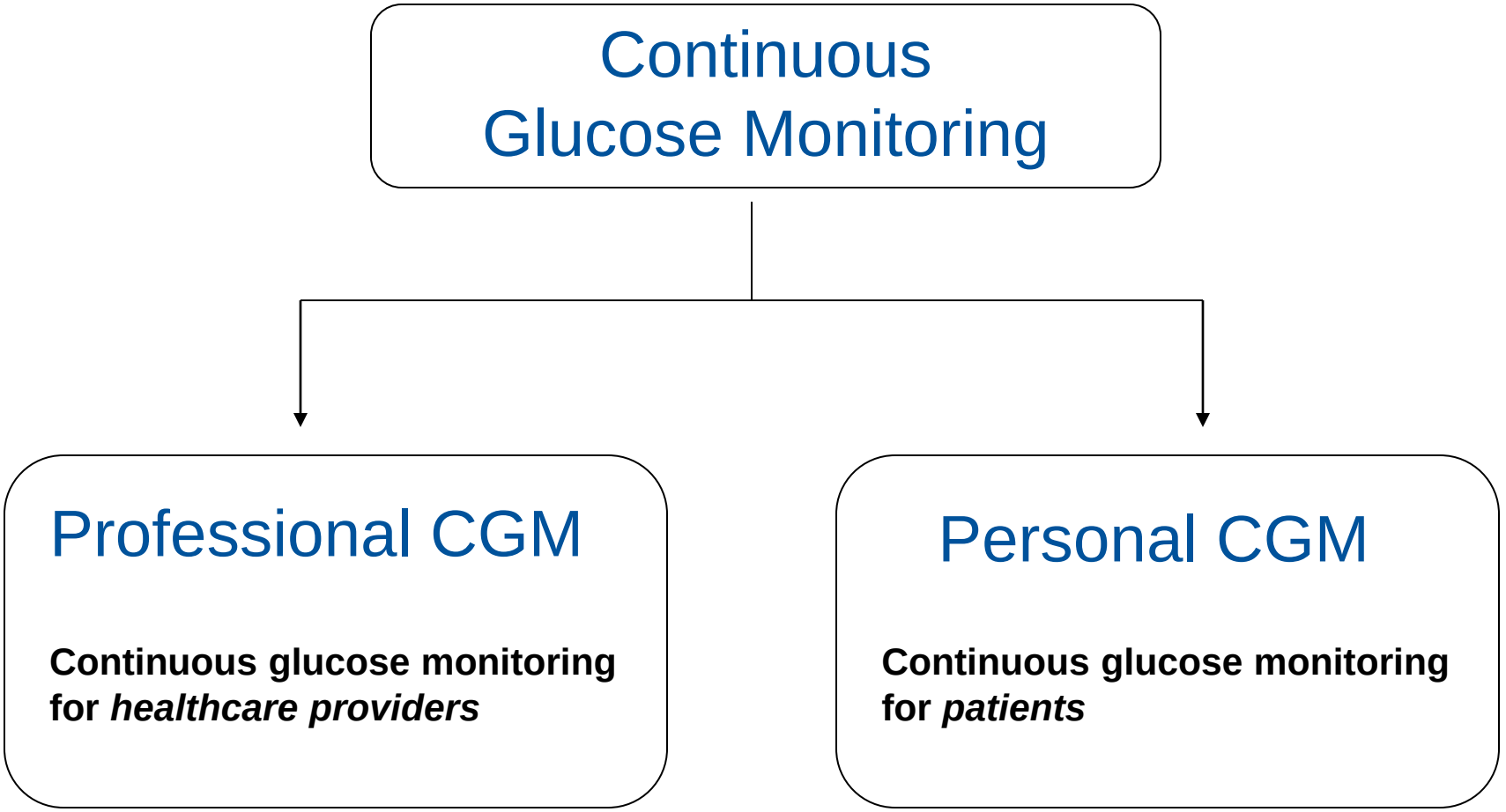
Medicare Rates for Common Procedures



* 2015 Medicare national average fee schedule amount for office procedures. Note: Medicare rates only apply to Professional CGM; Personal CGM is not covered by Medicare and does not meet Medicare Benefit Category requirements. Source: Medicare Physician Fee Schedule, December, 2014.

Reimbursement coverage for Continuous Glucose Monitoring (CGM) is continuing to expand. This document provides general guidance on billing for Professional and Personal CGM.

Customize Diabetes Management Based Upon the Needs of Your Practice and Patients



Indications for CGM Therapy

International Consensus:[1]
- All patients with T1D
- T2D treated with intensive insulin therapy, not meeting glycemic goals
- Those with problematic hypoglycemia

AACE:[3]
- T1D with hypoglycemia/unawareness or not meeting glycemic goals
- T2D on intensive insulin therapy, high risk for hypoglycemia, or unappreciated hyperglycemia

American Diabetes Association:[2]
- T1D not meeting glycemic goals (consider in T2D)
- Hypoglycemia/unawareness
- Sensor-augmented pump therapy
- Consider in pregnancy

1. Danne et al. *Diabetes Care* 2017; 40:1631-1640.
2. ADA. *Diabetes Care*. 2019 Jan;42(Suppl 1):S71-S80.
3. Handelsman et al. *Endocr Pract*. 2015 Apr;21 Suppl 1:1-87.

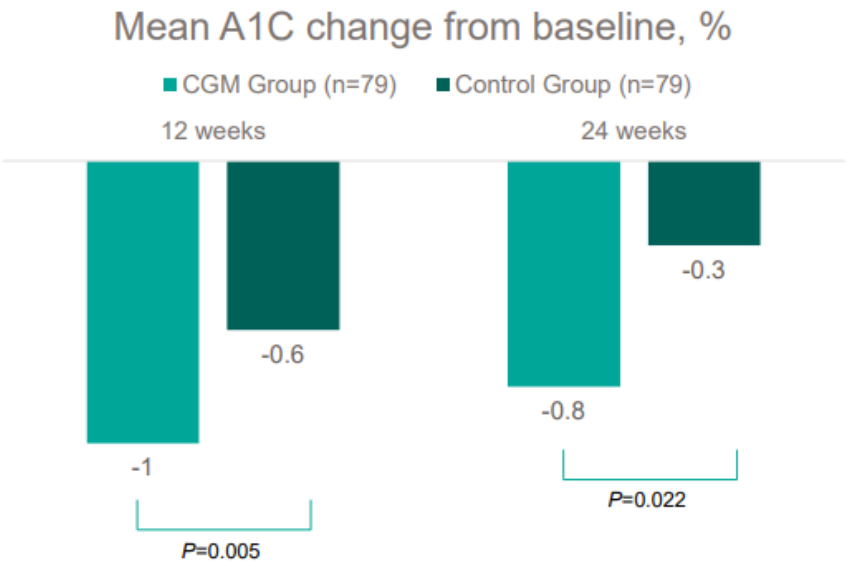
Multiple studies have demonstrated the clinical benefit of CGM

- Reduction in A1c levels without increased hypoglycemia [1,2,5,6]
- Significant decrease in A1c in patients aged 25 or older [2]
- Reduced glucose variability [3,4]
- Increased time in target range [1,2,4]
- Reduced hypo- and hyperglycemic excursions [2,3,4]
- Consistent accuracy over days of use [1,5]
- Reduction in A1c in both MDI and CSII patients [1,2,5,6]

1. Garg S, et al. *Diabetes Care,* 2006; 29(12): 2644-2649.
2. JDRF Continuous Glucose Monitoring Study Group. *N Engl J Med*, 2008; 359(14): 1464-1476
3. Garg S, et al. *Diabetes Care,* 2006; 29(1): 44-50.
4. Garg S, et al. *Diabetes Care,* 2007; 30(12): 3023-3025.
5. Bailey TS, et al. *Diabetes Technol Ther.* 2007; 9(3): 203-210.
6. Deiss D, et al. *Diabetes Care*, 2006; 29(12): 2730-2732.
7. Hirsch IB, et al. *Diabetes Technol Ther*. 2008; 10(5): 377-383

CGM vs SMBG in T2D

- **Prospective RCT in adults with T2D comparing the effect of CGM to SMBG on glycemic control**
- Enrollment criteria: Age ≥25 years, T2D on MDI ≥1 year, A1C 7.5%-10.0%, stable medication regimen and weight over past 3 months, SMBG ≥2 per day, without significant renal dysfunction
- **Primary outcome:** A1C reduction at 24 weeks. Secondary outcomes: hypoglycemia, QOL, and CGM satisfaction
- **Results**: Mean adjusted change in A1C of -1.0% from baseline to 24 weeks in CGM group compared with control group change of -0.6% (*P*=0.005) with adjusted difference of -0.3% (*P*=0.022)
- No difference in hypoglycemia or QOL; high CGM satisfaction scores



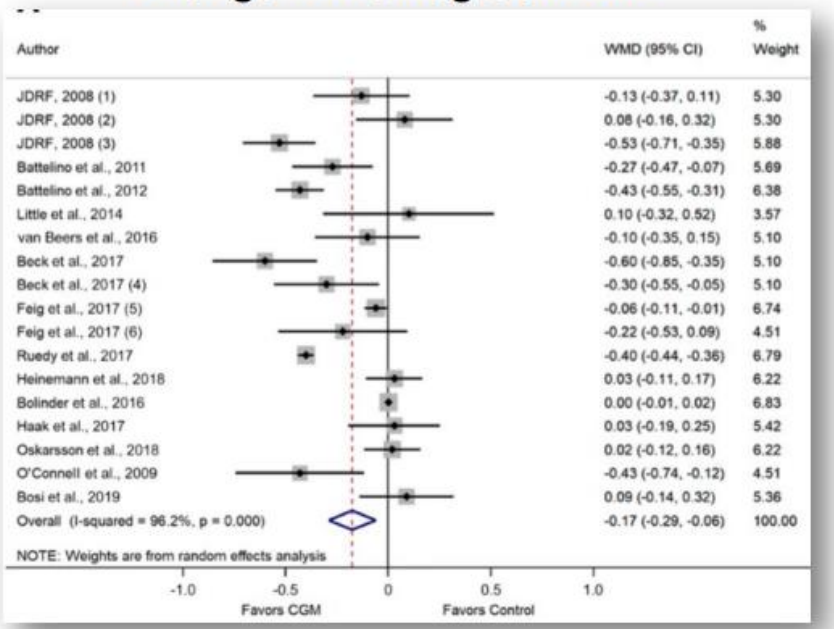
	Mean A1C, %		
	Baseline	12 Weeks	24 Weeks
CGM Group	8.5	7.5	7.7
Control Group	8.5	7.9	8.0

Beck R et al. *Annals of Internal Medicine*. 2017; 167 (4).

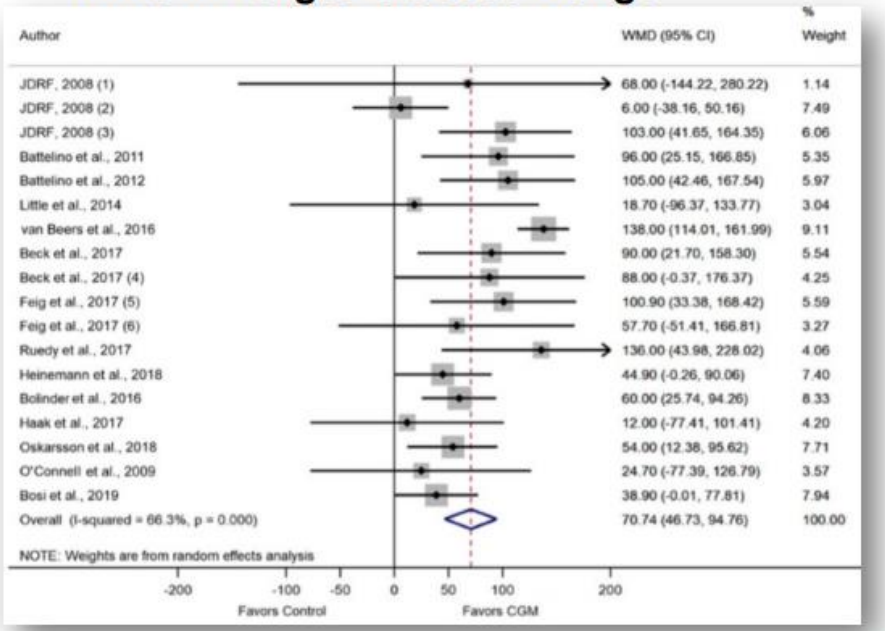
Legend: RCT, randomized controlled trial; SMBG, self-monitoring of blood glucose; T2D, type 2 diabetes; A1C, hemoglobin A1C; QOL, quality of life

Meta-analysis of CGM trials in T1D and T2D

Change in Hemoglobin A1C



Time in Target Glucose Range



Maiorino et al. *Diabetes Care*. 2020;43:1146–1156.

Using a combination of metrics allows for a more complete glucose profile[1-4]

Time in range (TIR) is an important CGM metric of glycemic control and glucose patterns, as it correlates well with A1c in most studies[5-10]

For most adults, ADA guidelines[1] recommend

A1c		TIR
<7%	or	>70%

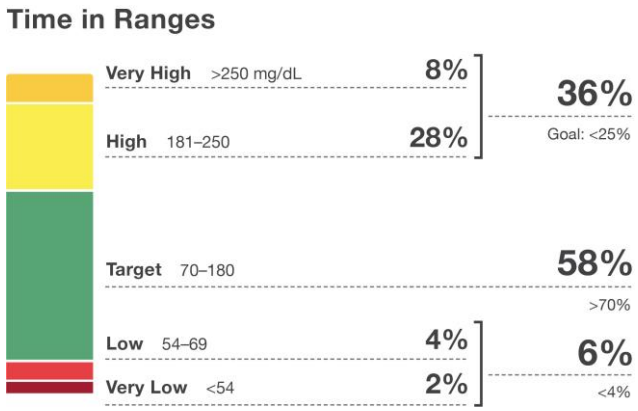
TIR has added value beyond the accepted gold standard of A1c[11]

With CGM, each 10% increase in TIR leads to a 0.8% reduction in A1c[7]

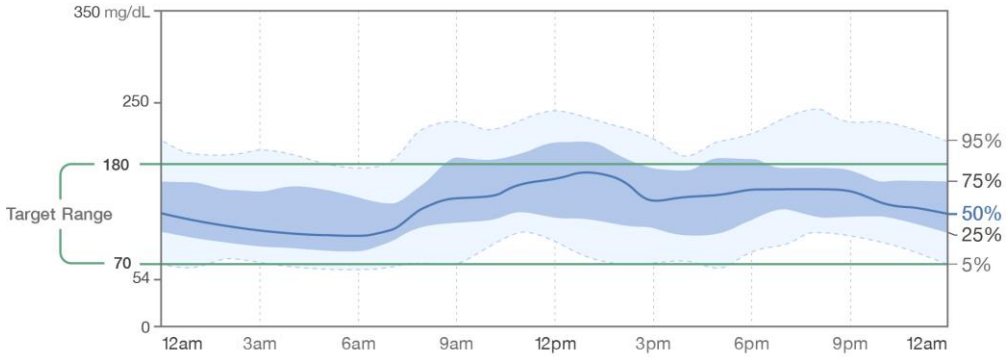
1. American Diabetes Association. "Glycemic Targets: Standards of Medical Care in Diabetes—2022." *Diabetes Care* 45(suppl 1)(January 2022): S83-S96. https://doi.org/10.2337/dc22-S006. **2.** Battelino, Tadej, et al. "Clinical Targets for Continuous Glucose Monitoring Data Interpretation: Recommendations From the International Consensus on Time in Range." *Diabetes Care* 42, no. 8 (August 2019): 1593-1603. https://doi.org/10.2337/dci19-0028. **3.** Danne, Thomas, et al. "International Consensus on Use of Continuous Glucose Monitoring." *Diabetes Care* 40, no. 12 (December 2017):1631–1640. https://doi.org/10.2337/dc17-1600. **4.** Dovc, Klemen and Tadej Battelino. "Time in Range Centered Diabetes Care." *Clinical Pediatric Endocrinology* 30, no. 1 (January 2021): 1-10. https://doi.org/10.1297/cpe.30.1. **5.** Advani, Andrew. "Positioning Time in Range in Diabetes Management." *Diabetologia* 63, no. 2 (February 2020): 242-252. https://doi.org/10.1007/s00125-019-05027-0. **6.** Avari, Parizad, et al. "Differences for Percentage Times in Glycemic Range Between Continuous Glucose Monitoring and Capillary Blood Glucose Monitoring in Adults With Type 1 Diabetes: Analysis of the REPLACE-BG Dataset." *Diabetes Technology & Therapeutics* 22, no. 3 (March 2020): 222–227. https://doi.org/10.1089/dia.2019.0276. **7.** Vigersky, Robert A., and Chantal McMahon. "The Relationship of Hemoglobin A1c to Time-in-Range in Patients with Diabetes." *Diabetes Technology & Therapeutics* 21, no. 2 (February 2019): 81-85. https://doi.org/10.1089/dia.2018.0310. **8.** Kröger, Jens, Andreas Reichel, Thorsten Siegmund, and Ralph Ziegler. "Clinical Recommendations for the Use of the Ambulatory Glucose Profile in Diabetes Care. *Journal of Diabetes Science and Technology* 14, no.3 (May 2020):586–594. https://doi.org/10.1177/1932296819883032. **9.** Livingstone, Rachel, James G. Boyle, John R. Petrie. "How Tightly Controlled do Fluctuations in Blood Glucose Levels Need to Be to Reduce the Risk of Developing Complications in People with Type 1 Diabetes?" *Diabetic Medicine* 37, no. 4 (April 2020): 513–521. https://doi.org/10.1111/dme.13911. **10.** Messer, Laurel H., et al. "Real World Hybrid Closed-Loop Discontinuation: Predictors and Perceptions of Youth Discontinuing the 670G system in the first 6 months." *Pediatric Diabetes* 21, no. 2 (March 2020): 319–327. https://doi.org/10.1111/pedi.12971. **11.** Hirsch, Irl B., Jennifer L. Sherr, and Korey K. Hood. "Connecting the Dots: Validation of Time in Range Metrics with Microvascular Outcomes." *Diabetes Care 42*, no. 3 (March 2019): 345–348. https://doi.org/10.2337/dci18-0040.

Time in range (TIR) is a complement to A1c that provides more actionable information than A1c alone[1]

TIRs show how much time your patient has spent in or out of their target range and compares it to recommendations from the International Consensus[1]



Monitoring an Ambulatory Glucose Profile (AGP) may provide insight into glucose variability and shows how closely readings of an individual patient fall within target range[2]



AGP is a summary of glucose values from the report period, with median (50%) and other percentiles shown as if occuring in a single day.

Not actual patient data; for illustrative purposes only.

1. Battelino, Tadej, et al. "Clinical Targets for Continuous Glucose Monitoring Data Interpretation: Recommendations From the International Consensus on Time in Range." *Diabetes Care* 42, no. 8 (August 2019): 1593-1603. https://doi.org/10.2337/dci19-0028.
2. American Diabetes Association. "Glycemic Targets: Standards of Medical Care in Diabetes—2022." *Diabetes Care* 45(suppl 1)(January 2022): S83-S96. https://doi.org/10.2337/dc22-S006.

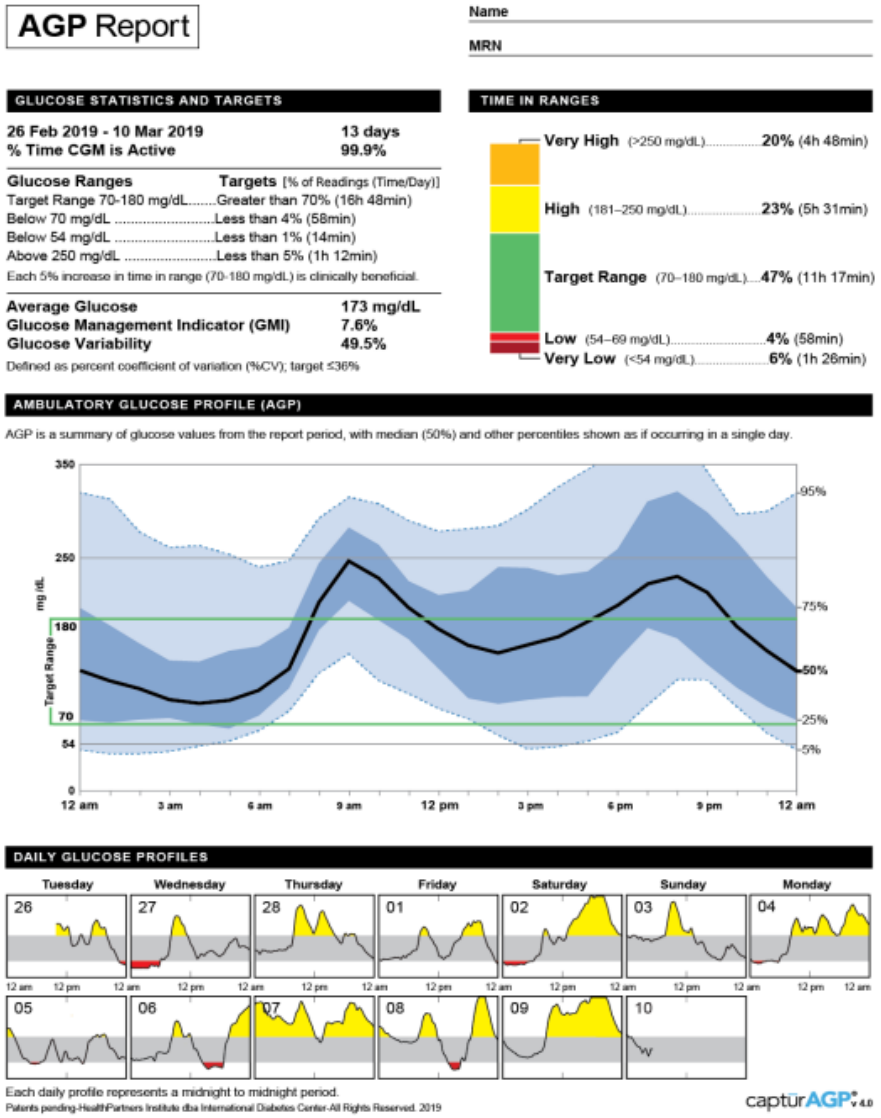
Standardized Metrics for Clinical Care

International Consensus on TIR

Metric	Comment
# Days reported	Goal 14 days
% time with data	Goal >70%
Mean glucose	
Glucose management indicator (GMI)	Estimated A1c
Glycemic variability (%CV)	Goal ≤36%
Time above Range (TAR): % of time • >250 mg/dl • 181-250 mg/dl	Goals vary
Time in Range (TIR): % of time 70-180 mg/dl	Goals vary
Time below Range (TBR): % of time • 54-69 mg/dl (Level 1 hypoglycemia) • <54 mg/dl (Level 2 hypoglycemia)	Goals vary

CV (coefficient of variation)=SD/mean

Electronic AGP Report with Key CGM Metrics



AGP Report

Name

MRN

GLUCOSE STATISTICS AND TARGETS

26 Feb 2019 - 10 Mar 2019	**13 days**
% Time CGM is Active	**99.9%**

Glucose Ranges	**Targets** [% of Readings (Time/Day)]
Target Range 70-180 mg/dL	Greater than 70% (16h 48min)
Below 70 mg/dL	Less than 4% (58min)
Below 54 mg/dL	Less than 1% (14min)
Above 250 mg/dL	Less than 5% (1h 12min)

Each 5% increase in time in range (70-180 mg/dL) is clinically beneficial.

Average Glucose	**173 mg/dL**
Glucose Management Indicator (GMI)	**7.6%**
Glucose Variability	**49.5%**

Defined as percent coefficient of variation (%CV); target ≤36%

TIME IN RANGES

Very High (>250 mg/dL)	**20%** (4h 48min)
High (181–250 mg/dL)	**23%** (5h 31min)
Target Range (70–180 mg/dL)	**47%** (11h 17min)
Low (54–69 mg/dL)	**4%** (58min)
Very Low (<54 mg/dL)	**6%** (1h 26min)

AMBULATORY GLUCOSE PROFILE (AGP)

AGP is a summary of glucose values from the report period, with median (50%) and other percentiles shown as if occurring in a single day.

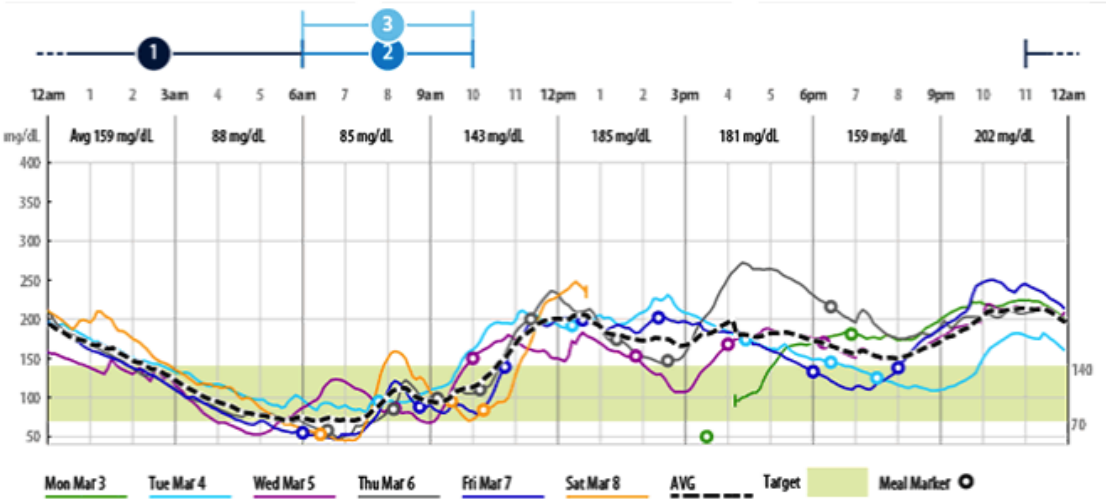
DAILY GLUCOSE PROFILES

Each daily profile represents a midnight to midnight period.

captürAGP® v 4.0

CGM Data: Glucose Management Indicator (GMI)

- Using 10-14 days of data, CGM-derived mean glucose values can be used to find an "estimated A1C" (eA1C)[1]
- GMI has been proposed as a new term to replace eA1C, as this better conveys the use of this metric
  - GMI helps inform or guide diabetes treatment decisions, but is not necessarily a perfect match with A1C levels[1]

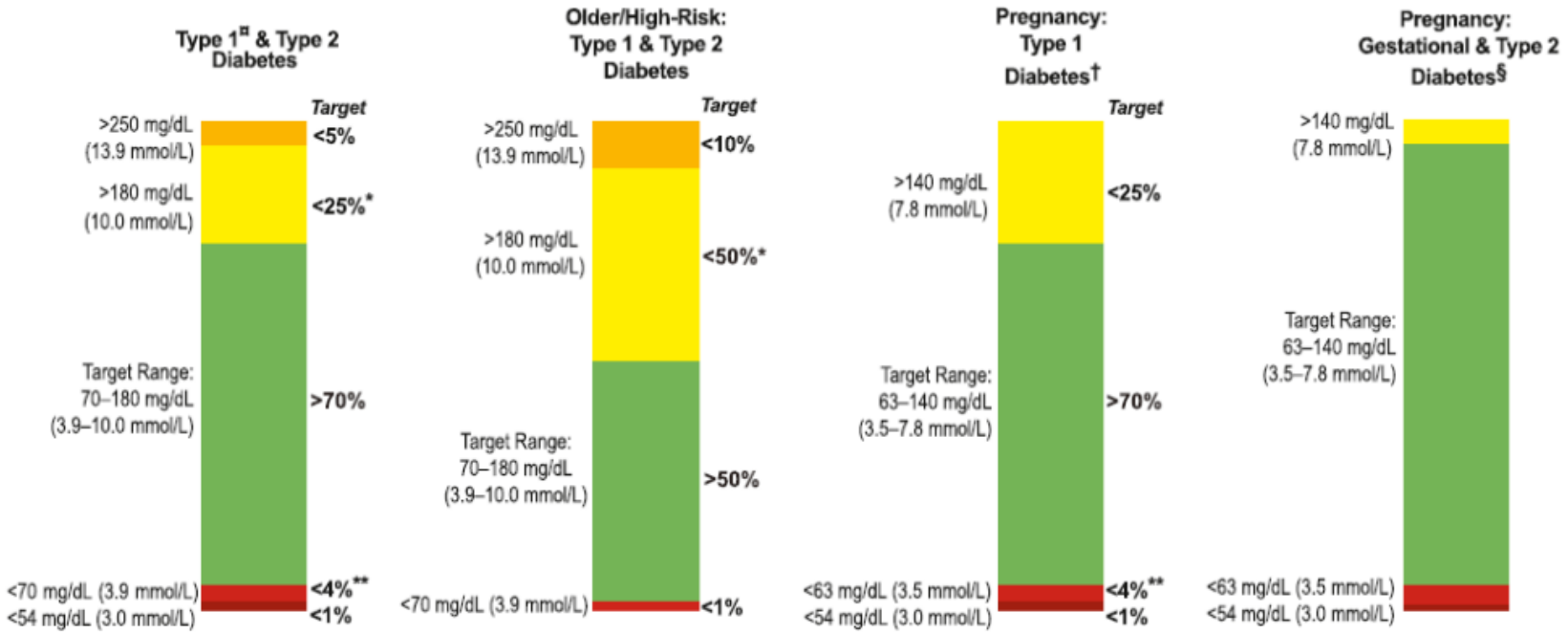


(1) Estimated A1C does not replace Lab measurement and is calculated from limited SG data.
(2) Suggested considerations are limited and do not replace the opinion or advice of the healthcare provider. Please see User Guide on how patterns and possible causes are identified.

Image: https://professional.medtronicdiabetes.com/ipro2-professional-cgm. Accessed on January 9, 2020

1. Bergenstal et al. *Diabetes Care*. 2018 Nov;41(11):2275-2280.

Individualizing Glycemic Control Goals Using CGM Metrics



Battelino T et al. *Diabetes Care*. 2019 Aug;42(8):1593-1603

Abbott

No user calibration required

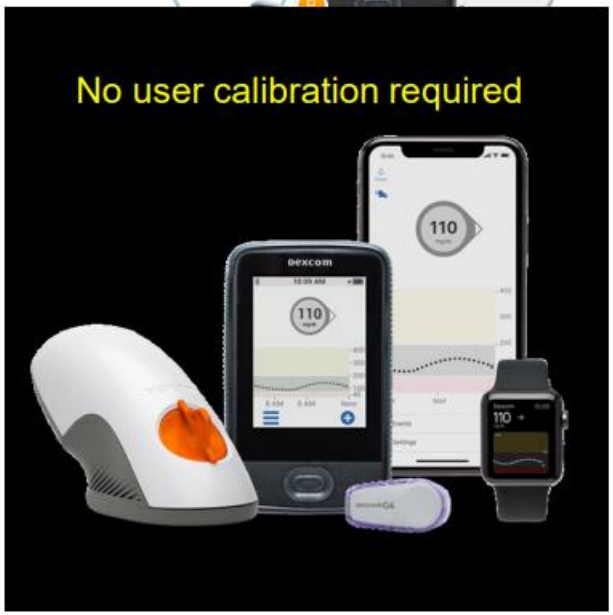
Medtronic

Dexcom

CONTINUOUS GLUCOSE MONITORING

eversense

Continuous Glucose Monitoring System

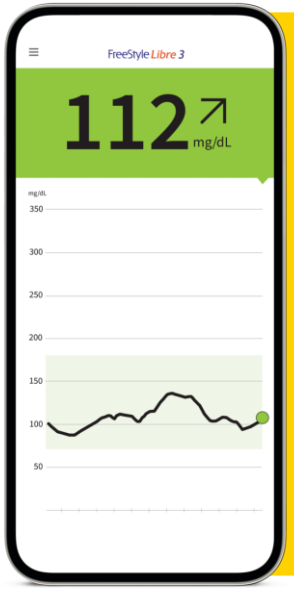


Continuous Glucose Monitors

	Dexcom 7	Eversense 3	Freestyle Libre 3	Medtronic Guardian 3
Sensor Life	10 days + 12 hrs	180 days	14 days	Up to 7 days
Warm-up	30 minutes	24 hours	1 hour	2 hours
MARD	8.2%	8.5%	9.2%	8.7% - 9.1%
Calibrations Required	0 required	2x/d through day 21, then 1x/d	Not available	2x/d
Data Transmission	Smartphone, receiver	Smartphone	Smartphone, receiver	Smartphone, Medtronic 670 & 680 insulin pumps
Medicare Coverage	Yes	Yes	Yes	Yes
Misc	G6 integrated with Tandem & OP5. G7+CSII integration is TBD	Implanted SubQ on upper arm	Libre 2 & 3 FDA cleared for insulin pump integration	Guardian 4 FDA cleared, 0 calibrations

The FreeStyle Libre 3 system

Advanced technology designed to fit into your patients' lives



Performance

- Accurate[1] readings every minute sent directly to your patients' smartphones*
- Real-time alarms† every minute
- Unsurpassed 14-day accuracy, especially in the low-glucose range[1]

Discretion

- The world's smallest, thinnest‡ and most discreet[2] sensor

Easy

- Easy to apply[2] using a 1-piece applicator
- Easy to share§‖[2] glucose readings
- Easy to monitor[3] your patients remotely‖¶

Not actual patient data; for illustrative purposes only.

***The FreeStyle Libre 3 app is only compatible with certain mobile devices and operating systems. Please check our website for more information about device compatibility before using the app. Use of the FreeStyle Libre 3 app requires registration with LibreView. †Notifications will only be received when alarms are turned on and the sensor is within 33 feet unobstructed of the reading device. You must enable the appropriate settings on your smartphone to receive alarms and alerts, see the FreeStyle Libre 3 User's Manual for more information. ‡Among patient-applied sensors. §The FreeStyle Libre 3 app is designed to facilitate data sharing between patients and their healthcare providers and caregivers. ‖The user's device must have internet connectivity for glucose data to automatically upload to Libreview and to transfer to connected LibreLinkUp app users. ¶The LibreView data management software is intended for use by both patients and healthcare professionals to assist people with diabetes and their healthcare professionals in the review, analysis and evaluation of historical glucose meter data to support effective diabetes management. The LibreView software is not intended to provide treatment decisions or to be used as a substitute for professional healthcare advice.

1. FreeStyle Libre 3 User's Manual. **2.** Data on file. Abbott Diabetes Care. **3.** Ajjan, Ramzi A., Neil Jackson, and Scott A. Thomson. "Reduction in HbA1c Using Professional Flash Glucose Monitoring in Insulin-Treated Type 2 Diabetes Patients Managed in Primary and Secondary Settings: A Pilot, Multicentre, Randomised Controlled Trial." *Diabetes and Vascular Disease Research* 16, no. 4 (July 2019): 385-395. https://doi.org/10.1177/1479164119827456.

Introducing Dexcom G7 System

- Small **all-in-one discreet** sensor AND transmitter
- Cleared for use in **pregnancy**
- 10-day sensor wear, with up to 12-hour grace period
- Indicated for wear on the back of the upper arm
- Short **30-minute wait** to view readings after sensor insertion
- **No scanning** or BGM fingersticks* required
- **Glucose alerts** can be individualized for utility and discretion
- **Smart phone**† displays glucose data and Clarity CGM metrics

  A color display receiver is available to those without compatible smart phones† and Medicare beneficiaries

***If your glucose alerts and readings from Dexcom G7 do not match symptoms or expectations, use a blood glucose meter to make diabetes treatment decisions.** †Compatible smart devices sold separately. To view a list of compatible smart devices, visit dexcom.com/compatibility. Users should always confirm readings on the Dexcom G7 app or receiver before making treatment decisions. Dexcom G7 User Guide. BGM, blood glucose meter; CGM, continuous glucose monitoring.

LBL-1003389 Rev001

The Eversense CGM System

Sensor | **Smart Transmitter** | **Mobile App**

Fully implantable sensor **for long term continuous wear**

Transmitter attributes:

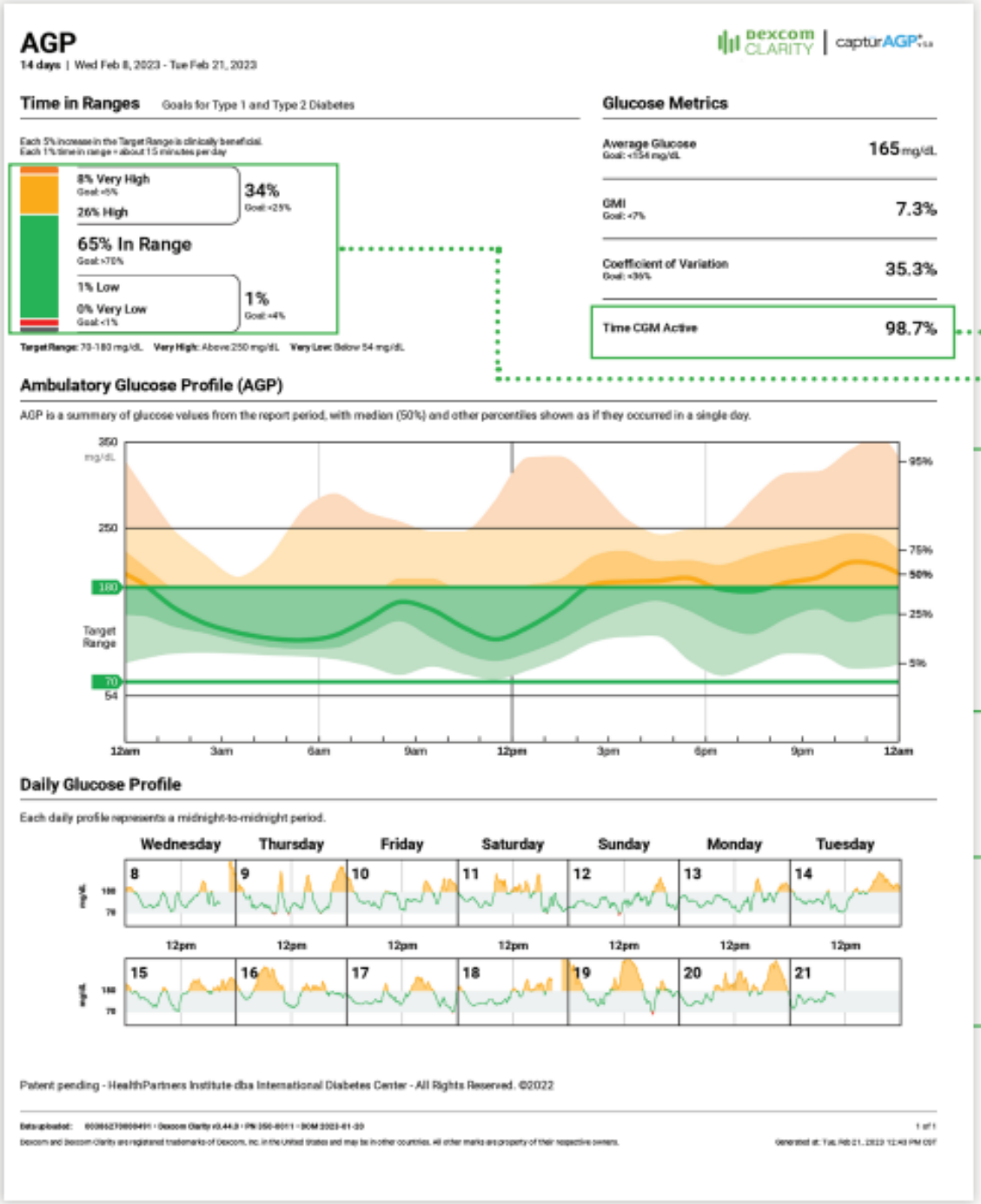
- Powers sensor and calculates glucose
- Can be removed without replacing sensor
- Gentle-on-skin adhesive
- Lightweight and water-resistant
- On-body vibratory alerts for low and high glucose values

MKT-001233

Pattern Management

1. Review medication taking behaviors
2. Assess meal times, snacks, particularly overnight
3. Assess overall control (TIR, mean glucose)
4. Address hypoglycemia first if Time Below Range (TBR) is above target
5. Address AM/*fasting* glucose
6. Assess non-fasting glucose
7. Evaluate patterns related to physical activity or work

Grunberger et al. Endocrine Practice 2021;27:505-37



Patent pending - HealthPartners Institute dba International Diabetes Center - All Rights Reserved. ©2022

Before getting started, assess if there is **enough data to be analyzed?**

- Consensus recommendation is > 70% time CGM active during 14 days.[2]

1 What is the problem?

- Review standard CGM metrics
- Look for hypoglycemia and hyperglycemia
- Are time in range (TIR) goals met?[2]

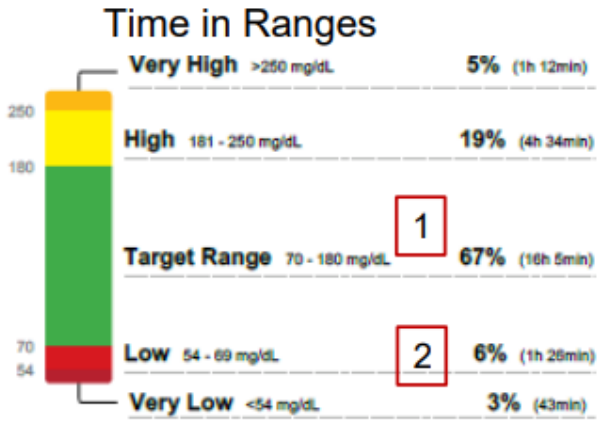
2 Where is the problem?

- Ambulatory Glucose Profile (AGP) shows patterns that are present
- Does a pattern exist? What time of day is the pattern?

3 How to adjust therapy?

- Check daily glucose data
- Use shared decision-making to discuss plan
- See figure below for suggested therapeutic modifications for people with type 2 diabetes only[1]

Case Example



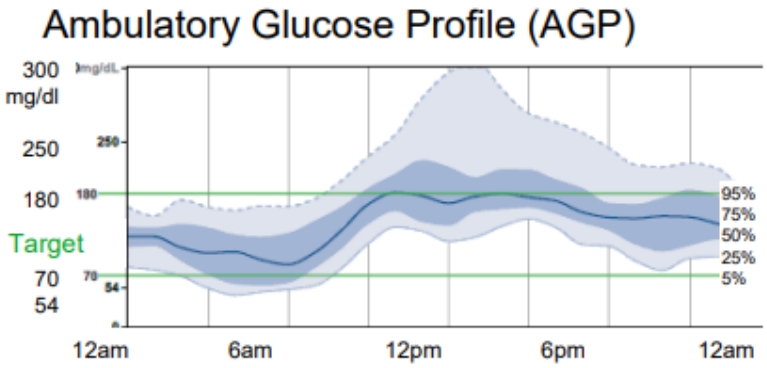
29 year old female with T2D

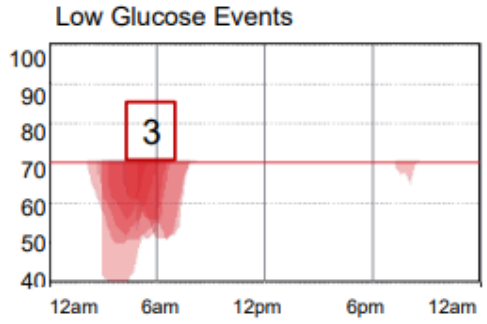
Current Treatment:

- Empagliflozin
- Glargine 45 unit daily
- Lispro correction dosing only
- Intolerance to metformin, GLP-1 RA

Interpretation: (*red boxes* ☐)

1. Overall glucose (TIR) is close to goal
2. Hypoglycemia





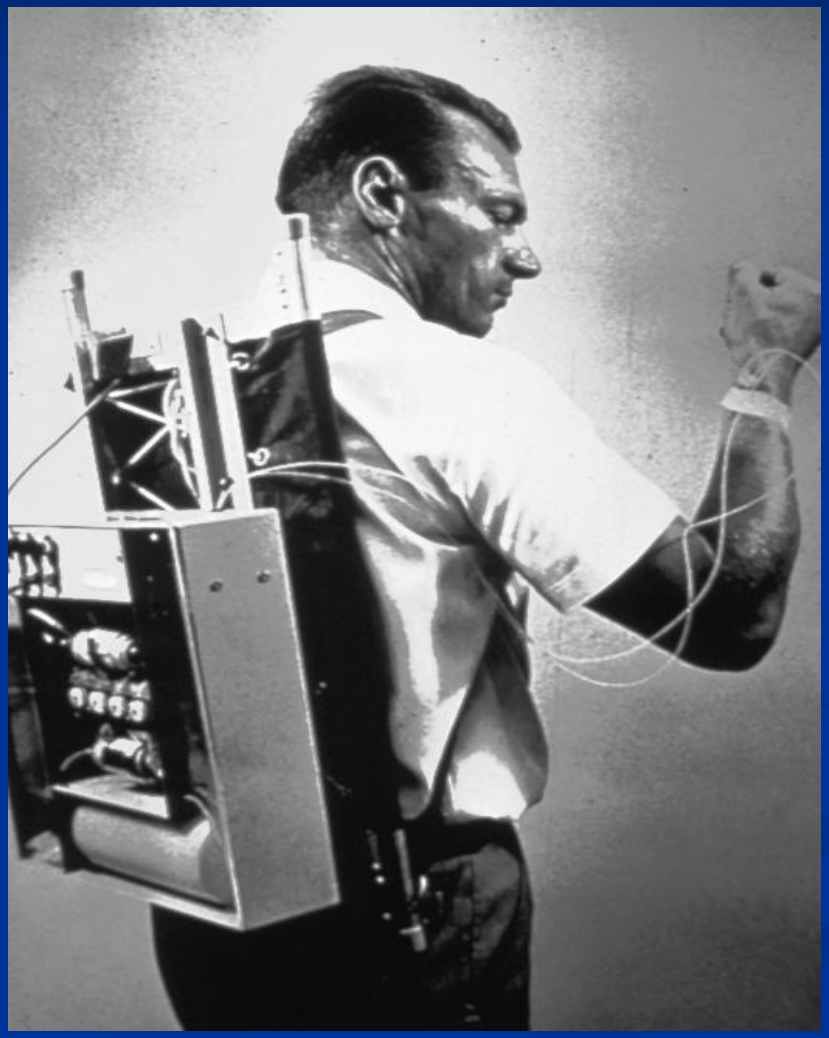
Plan:

- Reduce glargine by 20%
- Add lispro with breakfast

Prescribing CGM

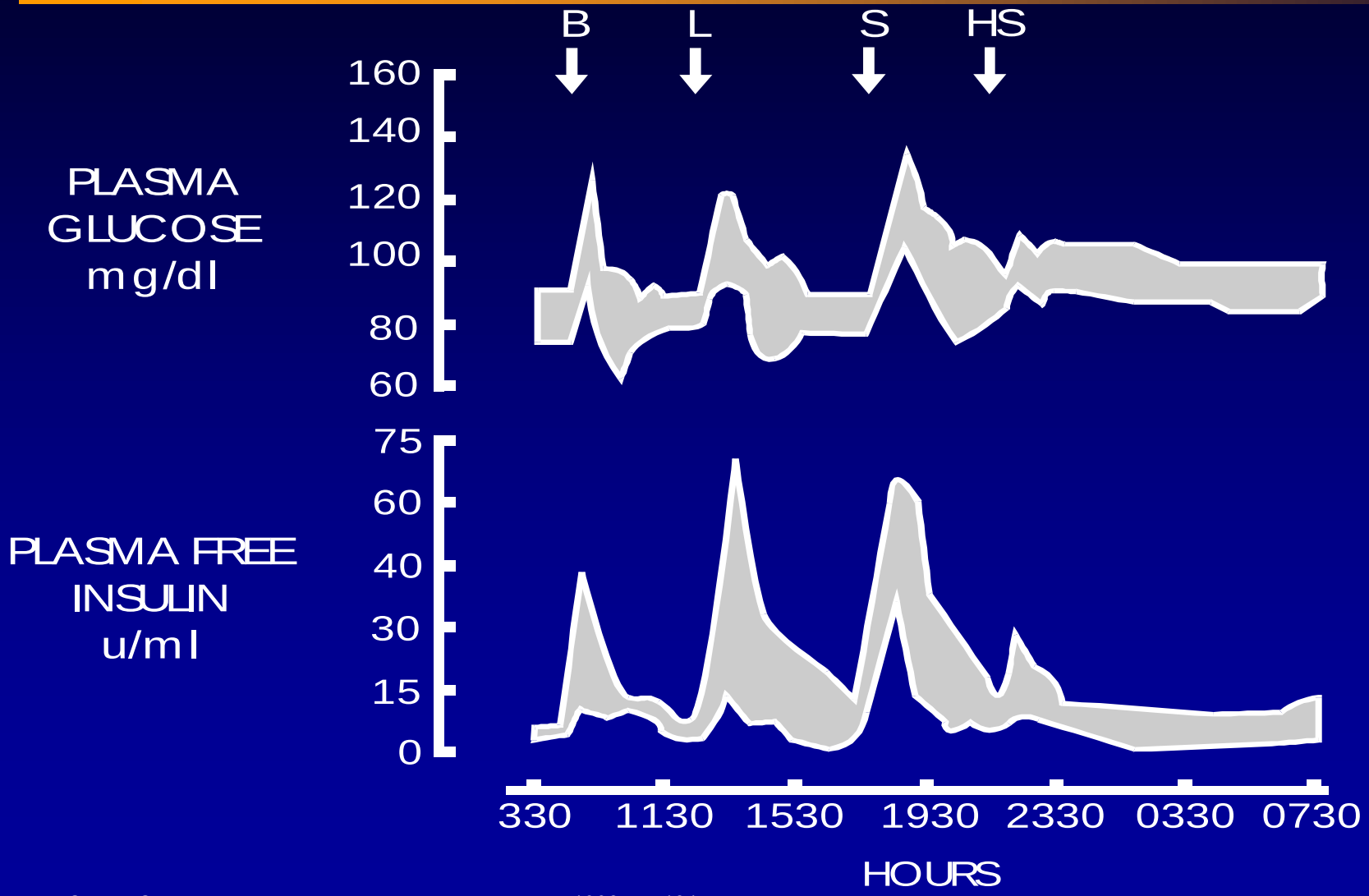
- All commercial plans cover for type 1 patients – CGM is the standard of care!
- Most commercial plans cover for type 2 patients
- In 2016 Florida Medicaid approved CGM for type 1 patients 21 and younger. BIG WIN for CGM
- VA covers CGM for Type 1 and Type 2
- Medicare covers Dexcom and Libre: all type 1's and type 2's on ≥1 shot of insulin and/or having hypoglycemia

First Insulin Pump (early 1970s)



The Goal of Insulin Therapy:

Attempt to Mimic Normal Pancreatic Function



Schade, Skyler, Santiago, Rizza, "Intensive Insulin Therapy," 1993, p. 131.

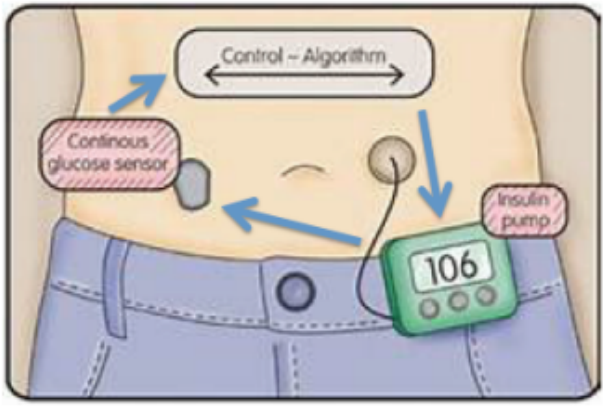
Pharmacokinetics of CSII vs MDI

- Uses only rapidly acting insulin
  - More predictable absorption
- Uses one injection site
  - Reduces variations in absorption
- Eliminates most of the subcutaneous insulin depot
- Closest match with physiologic needs

** Lauritzen: Diabetologia 1983; 24:326-9*

Early Insulin Pumps

Automated Insulin Delivery (AID)



AID Definition:

An insulin pump and CGM system that uses an algorithm to automatically adjust insulin delivery based on CGM values and trends.

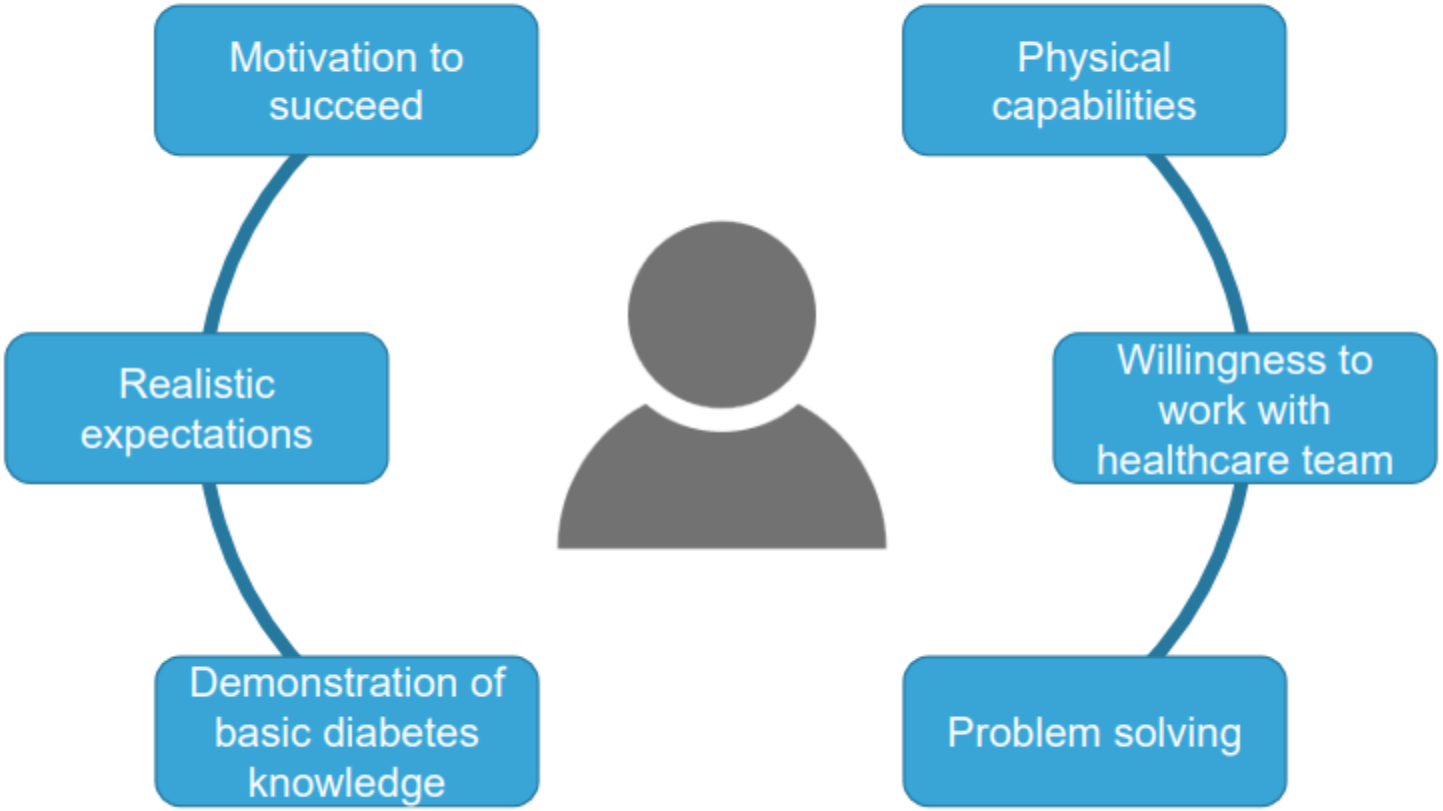
[CGM + insulin pump + algorithm = AID]

What Can AID Accomplish?

EMOTIONAL	NUMERICAL
May alleviate mental burden	Reduce A1c
Less worry about hypoglycemia	Less hypoglycemia
Less need for micromanaging	Increased time in range

Jennifer L. Sherr, Lutz Heinemann, G. Alexander Fleming, Richard M. Bergenstal, Daniela Bruttomesso, Hélène Hanaire, Reinhard W. Holl, John R. Petrie, Anne L. Peters, Mark Evans; Automated Insulin Delivery: Benefits, Challenges, and Recommendations. A Consensus Report of the Joint Diabetes Technology Working Group of the European Association for the Study of Diabetes and the American Diabetes Association.*Diabetes Care* 1 December 2022; 45 (12): 3058–3074. https://doi.org/10.2337/dci22-0018

Ideal Attributes of a Pump Candidate



The American Diabetes Association; Diabetes Care 2023; *Diabetes Care* 2023;46(Supplement_1):S111–S127 doi.org/10.2337/dc23-S007

"Understanding Automated Insulin Delivery Systems." *Association of Diabetes Care & Education Specialist*. Diabeteseducator.org/danatech, Jan 2023.

Insulin Pumps with AID

Omnipod 5

Tandem Control IQ

Medtronic 780G

iLet Bionic Pancreas

	Omnipod 5	Tandem Control IQ	Medtronic 780G
Integrated CGM	Dexcom G6	Dexcom G6/G7;Libre 3	Guardian 4
Algorithm Insulin Adjustment	60 minute predictive based on CGM	30 minute predictive based on CGM	100-120 mg/dL
Baseline Basal Pattern	Adaptive basal rate based on insulin delivery history	Programmed settings	Insulin delivery updates q6d (basal, CF)
Algorithm Target Bolus Calc Target	Customizable 110 to 150 mg/dL	112.5 – 160 mg/dL 110 mg/dL	100, 110, 120 mg/dL
Temporary Override Options	Activity 150 mg/dL	Exercise 140 – 160 mg/dL Sleep 112.5 – 120 mg/dL	Exercise 150 mg/dL
CGM trend used in bolus calculator	↑ up to 30% ↓ up to 100%	-	Bolus automation, every 5 minutes
Insulin Action	2 – 6 hours	5 hours	2 – 8 hours

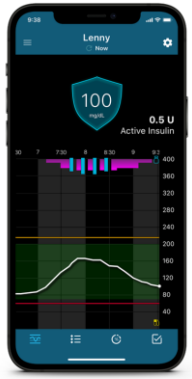
The MiniMed™ 780G system

System components and smart device connectivity

MiniMed™ 780G pump
with smart device connectivity
Age indication: 7+ years

Guardian™ 4 sensor and transmitter*

MiniMed™ Mobile
smartphone app** and Apple watch



CareLink™ Connect app
for care partner

ACCU-CHEK® Guide Link
blood glucose meter

Indications: Patients with type 1 diabetes ages 7 and older

- The MiniMed™ 780G system algorithm includes technology developed by DreaMed Diabetes.
- *The system can also be used with the Guardian™ 3 sensor and the Guardian™ Link transmitter
- **The Blue adapter is available for manual CareLink uploads if the MiniMed™ mobile app is not used

Smart devices sold separately. For a list of compatible devices, visit user guide.

dreamed diabetes ai

Roche

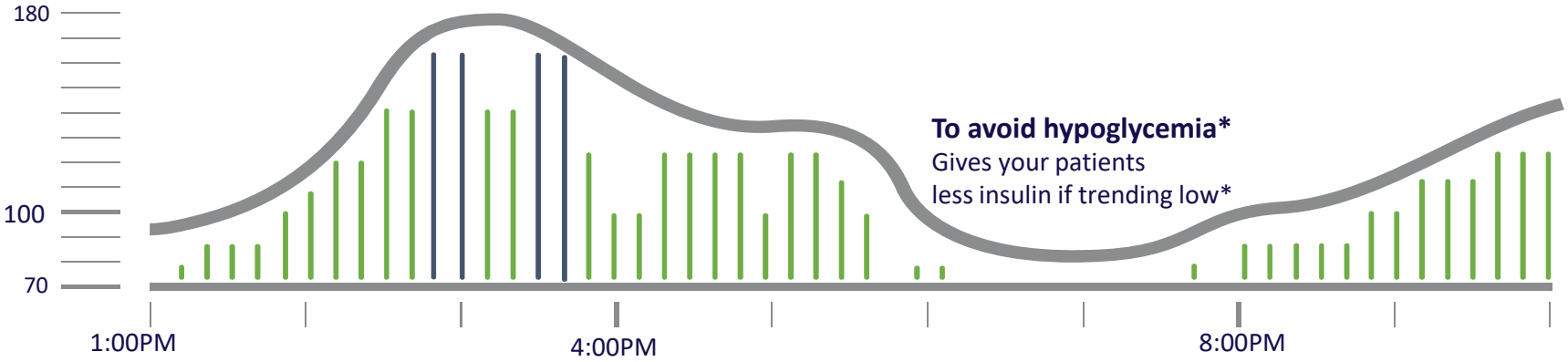
Adjusts and Auto corrects

SmartGuard™ technology automatically delivers basal insulin and auto correction doses every five minutes, based on sensor glucose readings.*

Up to 288 automatic adjustments and/or corrections per day*

Lowest set target
The only pump that offers the target of 100 mg/dL

To avoid hyperglycemia*
Gives your patients more insulin if trending high*



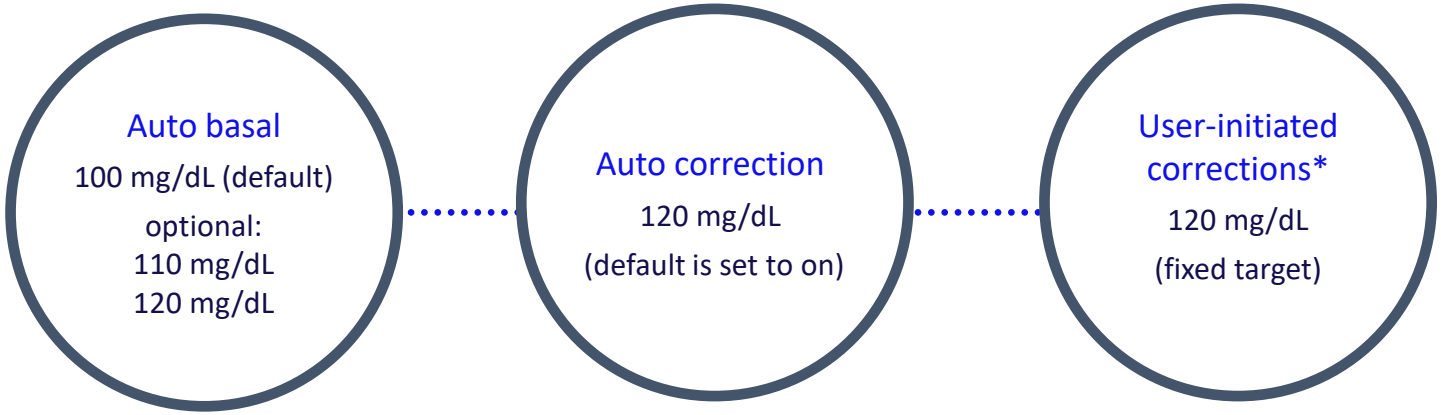
To avoid hypoglycemia*
Gives your patients less insulin if trending low*

Auto corrections automatically correct highs every 5 minutes, as needed

Glucose levels mg/dL
Background insulin
Auto correction bolus

For illustrative purposes only.
*Refers to SmartGuard™ feature. Individual results may vary.

SmartGuard™ Targets



150 mg/dL when Temp Target is set

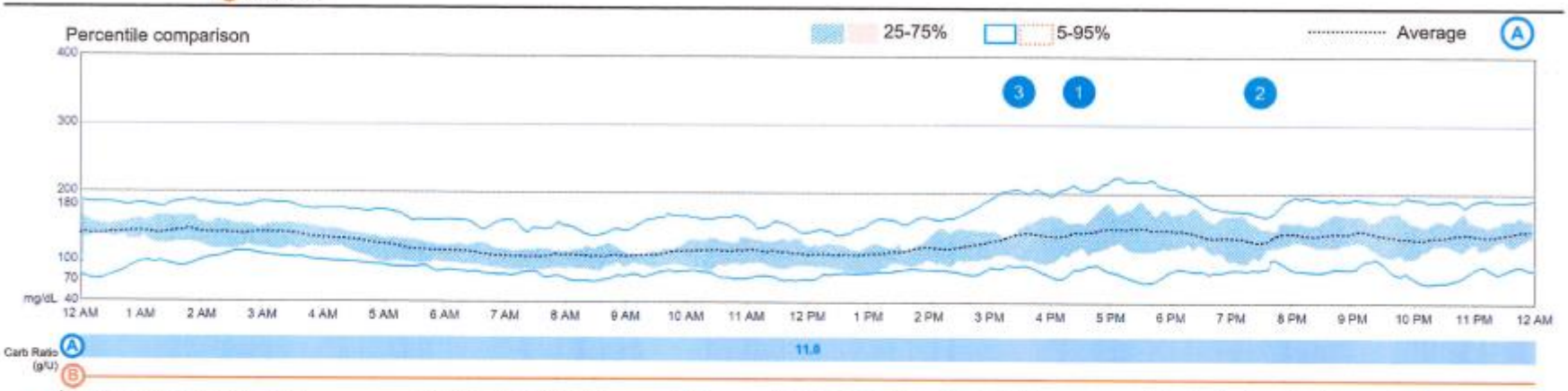
No auto corrections when Temp target is set

150 mg/dL fixed target when Temp target is set

A temp target of 150 mg/dL is available to use for exercise or any other time less insulin is desired. It can be set for 30 minutes up to 24 hours

*Non-Auto correction boluses are delivered by the patient.

Percentile comparison



Hypoglycemic patterns (0)

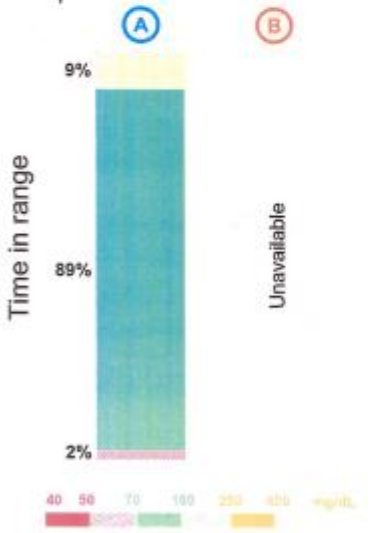
Episodes (per day): 0.4

None

Hyperglycemic patterns (4)**

Episodes (per day): 1.1

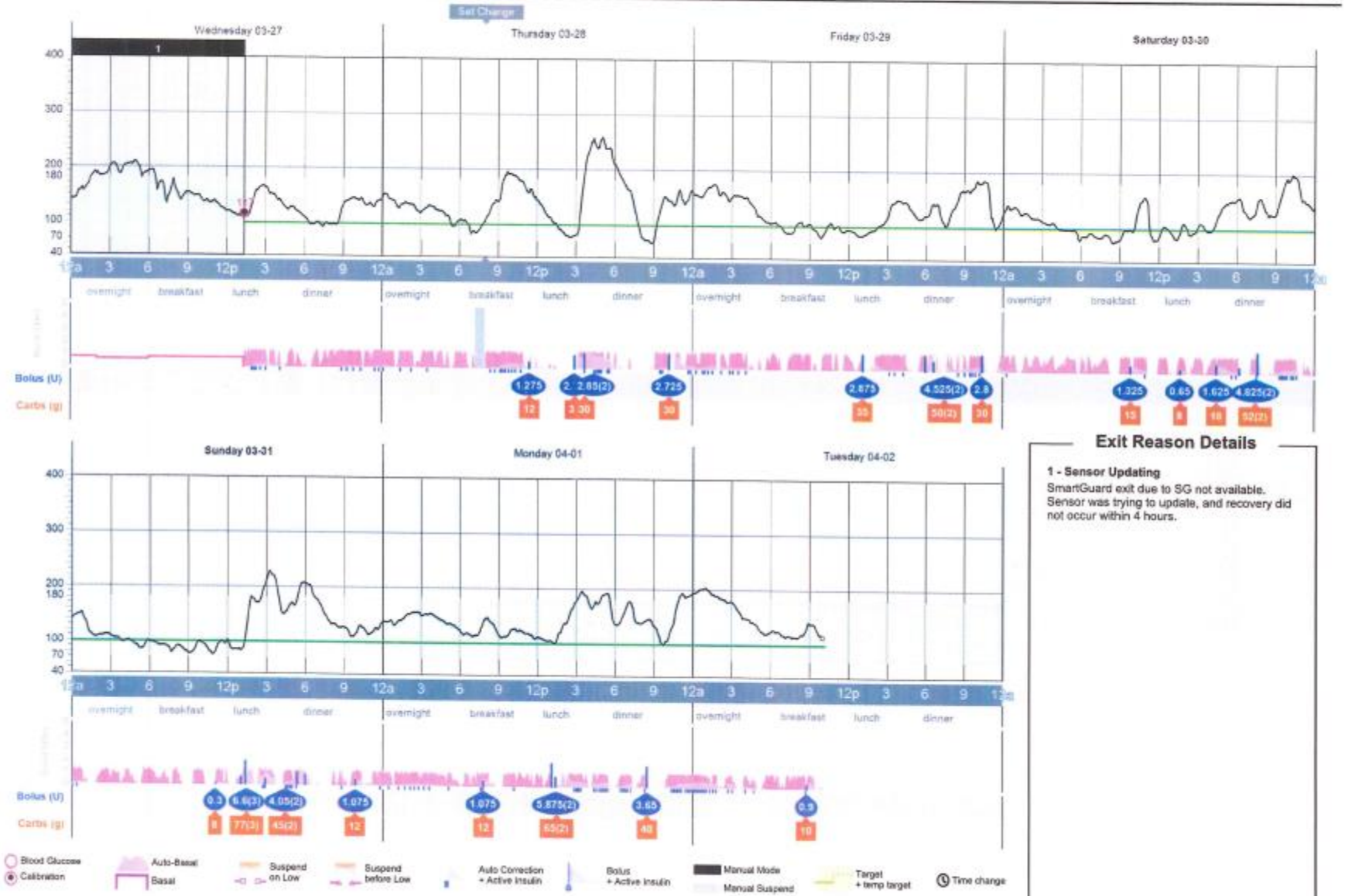
1. 4:00 PM - 4:59 PM (3 occurrences)
2. 7:00 PM - 7:59 PM (3 occurrences)
3. 3:00 PM - 3:59 PM (2 occurrences)



SmartGuard Exits	A	B
No Calibration	0	--
SmartGuard max delivery	0	--
SmartGuard min delivery	0	--
BG required for SmartGuard	0	--
Sensor Algorithm Underread	0	--
Sensor Updating	• 1	--
No SG values	0	--
Sensor Expired	0	--
SmartGuard disabled by user	0	--
Prolonged Suspend	0	--
SmartGuard Warm Up	0	--
Unidentified	0	--

Statistics	A	B
SmartGuard (per week)	86% (6d 01h)	--
Manual Mode (per week)	10% (17h)	--
Sensor Wear (per week)	91% (6d 10h)	--
Average SG ± SD	129 ± 34 mg/dL	--
GMI***	6.4%	--
Coefficient of Variation (%)	26.7%	--
Low / High SG Alerts (per day)	3.2 / 0.6	--
Average BG	150 ± 46 mg/dL	--
BG / Calibration (per day)	0.1 / 0.1	--
Total daily dose (per day)	33.3 units	--
Bolus amount (per day)	12.9U (39%)	--
Auto Correction amount (per day)	3.8U (29%)	--
Auto Basal / Basal amount (per day)	20.4U (61%)	--
Set Change	Every 8.0 days	--
Reservoir Change	Every 2.7 days	--
Meal (per day)	3.9	--
Carbs entered (per day)	99 ± 56 g	--
Active Insulin time	2:00 hrs	--

** Only highest priority shown.
*** Glucose Management Indicator



Exit Reason Details

1 - Sensor Updating
SmartGuard exit due to SG not available. Sensor was trying to update, and recovery did not occur within 4 hours.

t:slim X2 Automated Insulin Delivery System

1

T:SLIM X2 INSULIN PUMP

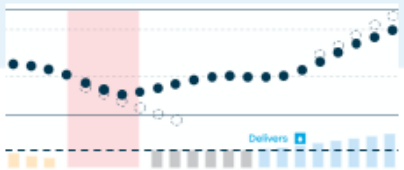
- Remote software updates
- Holds 300 units
- Rechargeable battery
- All data on **one** user-friendly touchscreen device

2

DEXCOM CGM

- 10-day wear
- Zero fingersticks†
- 9.0% MARD[1]
- More than a decade of collaboration together

3

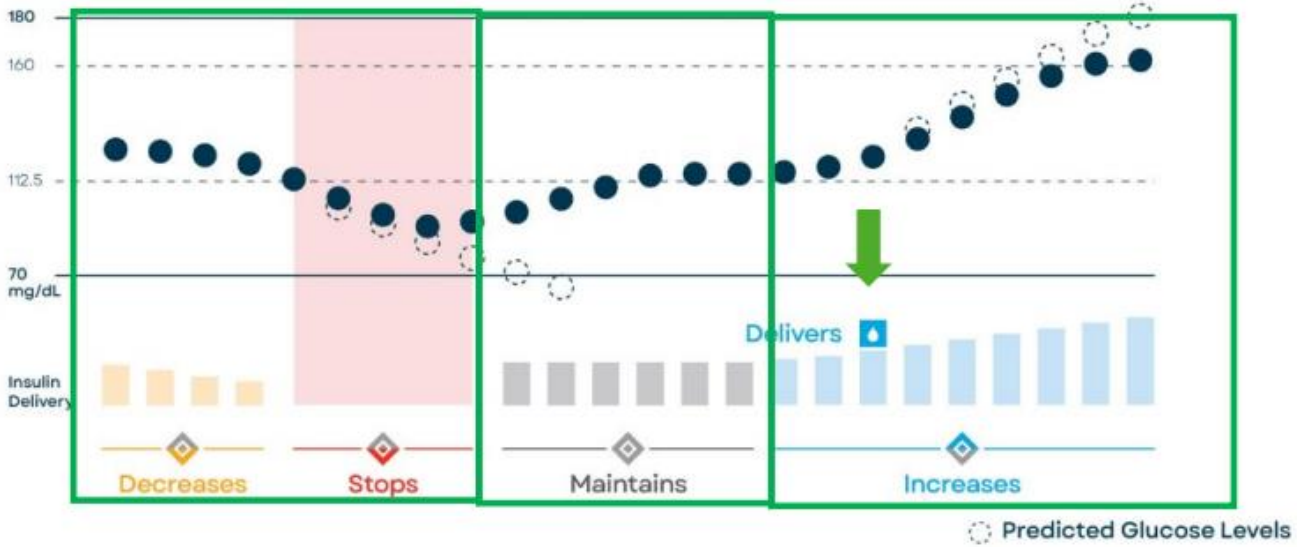


CONTROL-IQ ALGORITHM

- Advanced Hybrid Closed Loop
- 30-minute predictive algorithm
- Designed to increase TIR[2]

†If your glucose alerts and readings from the G6 do not match symptoms or expectations, use a blood glucose meter to make diabetes treatment decisions. References: 1. Dexcom G6 User Guide; 2. Brown SA, Kovatchev BP, Raghinaru D, et al. Six-month randomized, multicenter trial of closed-loop control in type 1 diabetes. *N Engl J Med*. 2019;381(18):1707-1717.

Control-IQ technology



HOW IT WORKS

Control-IQ technology **predicts glucose levels 30 minutes ahead** and automatically adjusts insulin every five minutes.

Predicted Glucose Levels

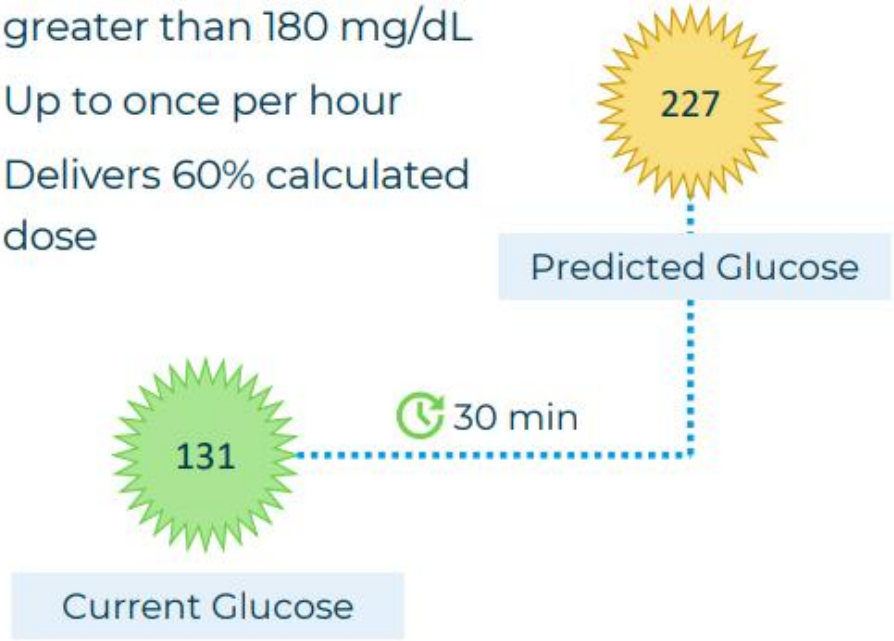
Helps Prevent Lows
Decreases or stops basal insulin if sensor glucose is predicted to be low.

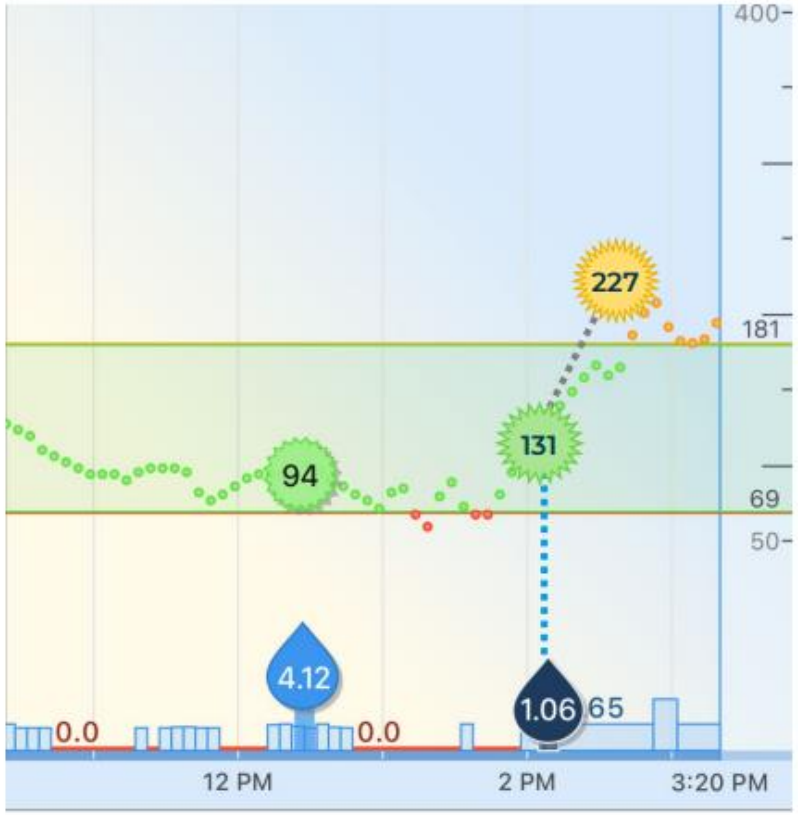
Helps Prevent Highs
Increases basal insulin and delivers automatic correction boluses* ( ) if sensor glucose is predicted to be high.

HOW IT WORKS

Automatic Correction Bolus

- When predicted to be greater than 180 mg/dL
- Up to once per hour
- Delivers 60% calculated dose





CGM Data by Dexcom

Time in Range
Past 24 hr (70-180 mg/dL)
85%

Tandem Source | Overview Apr 23 - May 6, 2024

Important Therapy Information

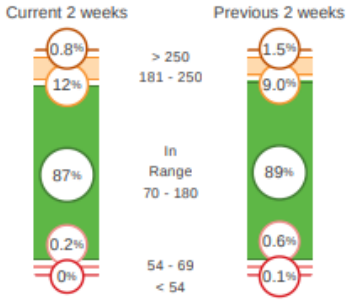
- This date range contains one or more incomplete therapy days. Data from the affected day(s) is excluded from daily averages. Affected day(s): May 6.

CGM Data by Dexcom

CGM summary

Average reading	142 mg/dL
Time in range	87 %
Time CGM in use	100 %
Standard deviation	34 mg/dL
Coefficient of variation	24 %
GMI	6.7 %

Time in range comparison

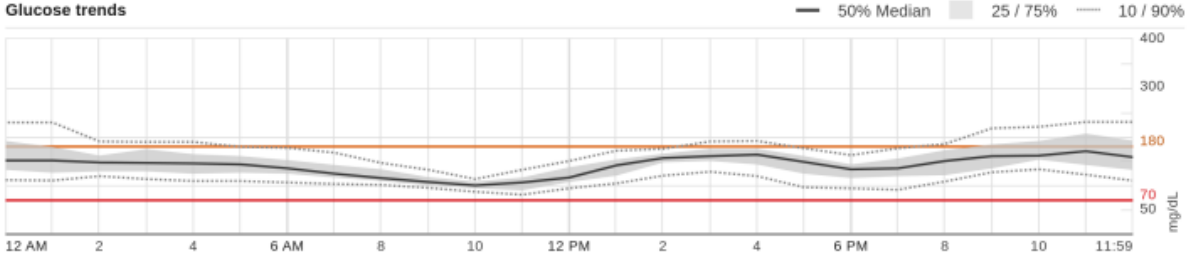


Control-IQ summary

Time active	98 %	13 d 5 hr
Control-IQ off	0 %	0 hr
CGM inactive	1 %	4 hr
Pump inactive	0 %	1 hr

Average sleep		Average exercise	
Duration	10 hr	Duration	0 hr
Weekly	7 times	Weekly	0 times

Glucose trends



Insulin summary

Average daily dose		35.94 u
Basal	69 %	24.79 u
Bolus	31 %	11.16 u
Average daily boluses		7 boluses
Manual	63 %	5 boluses
Control-IQ	37 %	3 boluses
Average daily carbs		17 g

Bolus review (daily average)

Type		
Food	30 %	3.36 u
Correction	11 %	1.21 u
Override	28 %	3.08 u
Control-IQ	31 %	3.51 u
Delivery Method		
Standard	69 %	7.65 u
Extended	0 %	0.00 u
Quick	0 %	0.00 u
Control-IQ	31 %	3.51 u

Load activity

Cartridge change	every	3.6 d
Tubing fill	every	3.6 d
Cannula fill	every	3.6 d

Tandem Source | Daily Timeline Apr 23 - May 6, 2024

Important Therapy Information

- This date range contains one or more incomplete therapy days. This may result in an incomplete graph. Affected day(s): May 6.

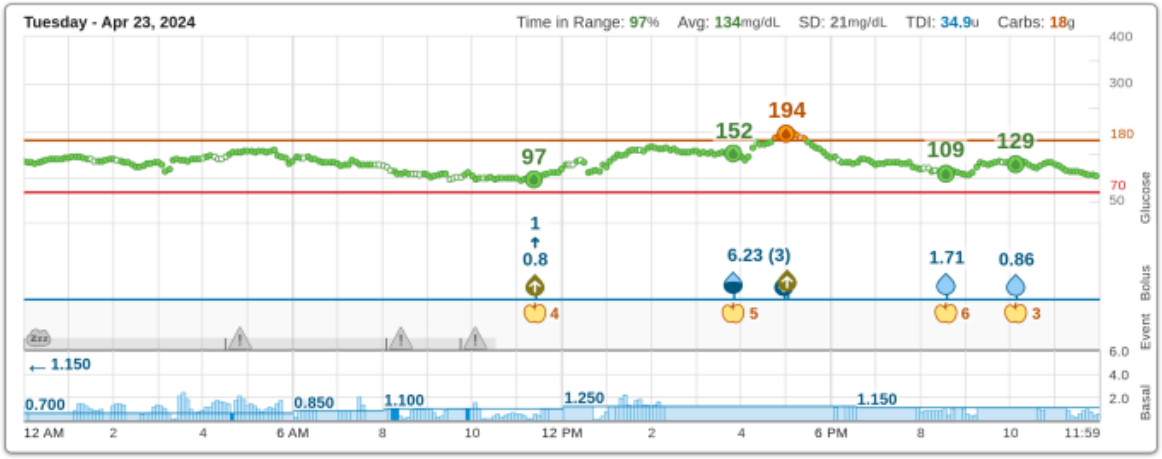
Glucose (mg/dL): BG High, BG In Range, BG Low, Auto Populated BG, CGM High, CGM In Range, CGM Low, CGM Backfill

Bolus (u): Food, Correction, Food + Correction, Extended, Override Increase, Override Decrease, Quick, Auto

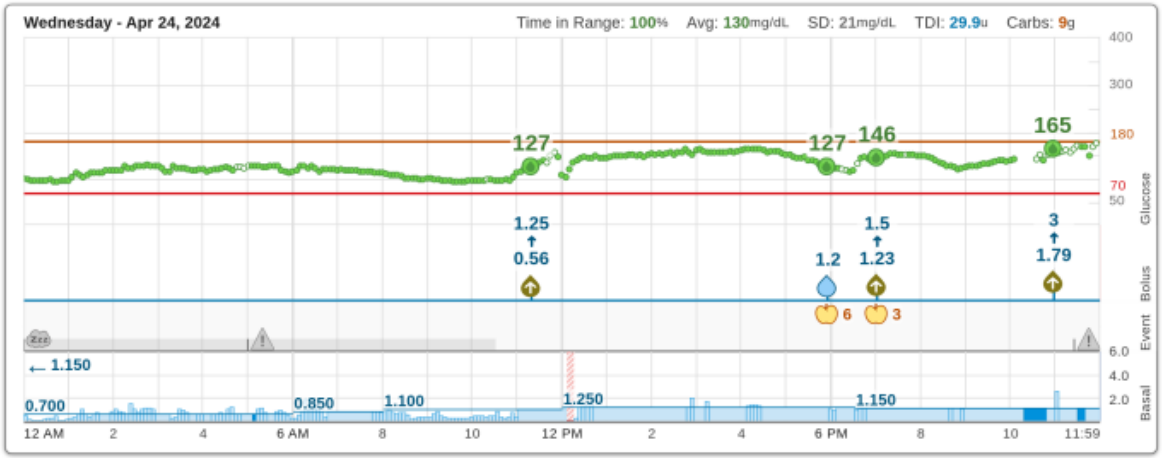
Basal (u/hr): Profile Delivered, Profile Setting, Temporary, Control-IQ, 0 u/hr, 0 u/hr Temp., Auto Suspend

Event: Carbs (g), Sleep, Exercise, Cartridge/Site Change, Event Duration, Lost CGM Connection, CGM Alert, Pump Alarm, Manual Stop, Shutdown

CGM Data by Dexcom



CGM Alerts: 4:30 AM - CGM Out of Range; 8:05 AM - CGM Out of Range; 9:45 AM - CGM Out of Range.



CGM Alerts: 5:00 AM - CGM Out of Range; 11:26 PM - CGM Out of Range.

Omnipod 5: The Best of Both Worlds

Simple

- No tubes
- No multiple daily injections
- No fingersticks*

Effective

- More time in range: 74%[1]
- Lower A1c: - 0.38%[1]
- Less time low: 46% reduction[1]

Pod shown without the necessary adhesive.
*Fingersticks required for diabetes treatment decisions if symptoms or expectations do not match readings.
1. Study in 128 people with T1D aged 14 - 70 years involving 2 weeks standard diabetes therapy(ST) followed by 3 months Omnipod 5 use in Automated Mode. Average time in Target Glucose range (from CGM), average A1c, median time with low blood glucose (from CGM): ST vs Omnipod 5 in adults/adolescents = 64.7% vs. 73.9%, & 7.16% vs 6.78%, & 2.0% vs. 1.1%. Brown S. et al. Diabetes Care (2021).

Simple

- Tangle-proof tubeless system
- Waterproof*
- Up to 72 hours of continuous insulin delivery
- Virtually painless, automatic insertion
- Indicated for Type 1 Diabetes in ages 2+

Pod shown without necessary adhesive.
*The Pod is waterproof for depths up to 25 feet (7.6 meters) for up to 60 minutes (IP28).

The Omnipod 5 System

Dexcom G6 CGM

Reports glucose values to the Pod, so you can get real-time data‡ without the fingersticks.§

Pod

Automatically adjusts insulin delivery based on the glucose value, trend, and total daily insulin.

Omnipod 5 App

Monitors and controls the Pod's operations including Pod activation, bolusing, and displaying alerts.

Pod and Dexcom G6 shown without the necessary adhesive. A separate prescription is required for the Dexcom G6 CGM. The Dexcom G6 is sold separately and must be used with the Dexcom G6 mobile app. The Dexcom G6 receiver is not compatible.
‡ Shah VN, et al. Diabetes Technol and Ther. 2018;20(6).
§ Fingersticks required for diabetes treatment decisions if symptoms or expectations do not match readings.
* For a list of compatible smartphone devices, visit omnipod.com/compatibility.

DOB: Jun 21, 1988 Diabetes: Type 1

Mar 1, 2024 - Mar 14, 2024 (14 days)
Today: March 14, 2024

Glucose - Time In Range

3%	Very High	> 250 mg/dL
21%	High	181-250 mg/dL
75%	Target Range	70-180 mg/dL
1%	Low	54-69 mg/dL
0%	Very Low	< 54 mg/dL

Summary

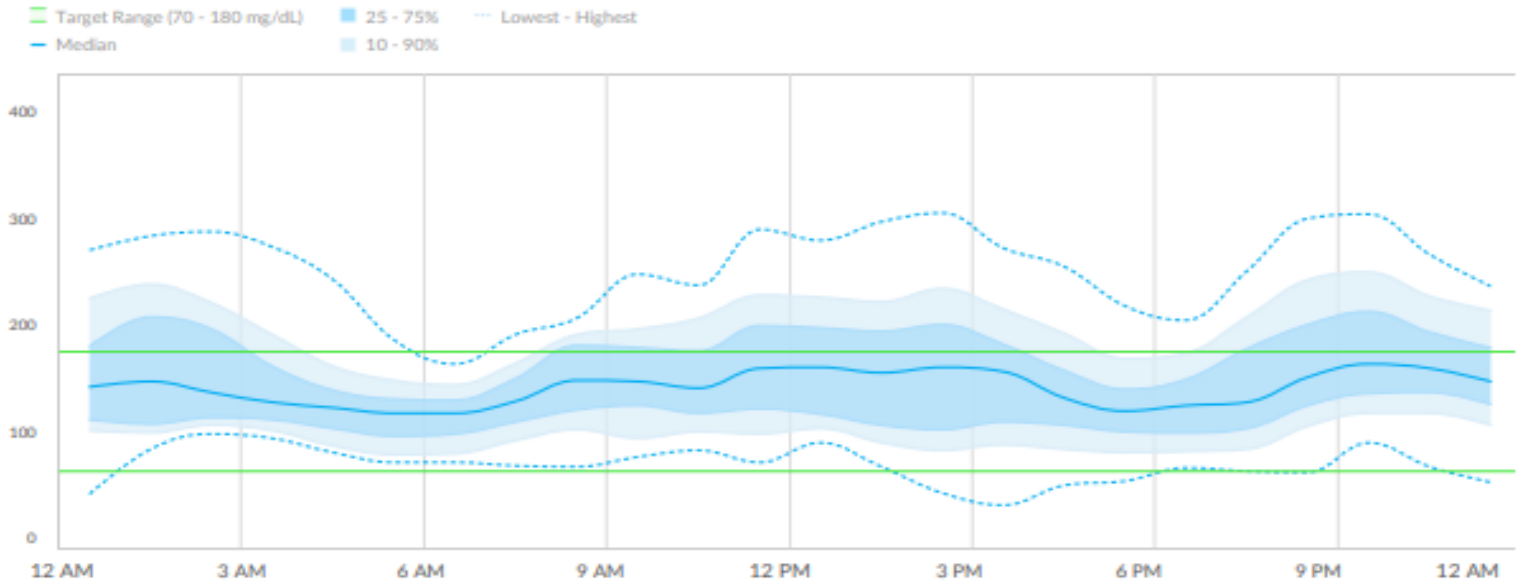
GMI
6.9% (52 mmol/mol)

Average
150 mg/dL

% Time CGM Active
88.7% (12.4 days)

SD	47 mg/dL
CV	31%
Median	141 mg/dL
Highest	306 mg/dL
Lowest	LO mg/dL

Ambulatory Glucose Profile (AGP)



Insulin - Device

From Insulin Pump

- 70% 26.5 units Basal/Day
- 30% 11.2 units Bolus/Day

Insulin/Day	37.6 units
Overrides (%)	11% (12 boluses)
# Bolus/Day	7.6

System Details

Insulet Omnipod® 5 System (13d 3h)

Automated Mode	16% (2d 4h)
Automated: Limited	0%
Automated: Activity	0% (1h)
Manual Mode	84% (10d 23h)

Diet

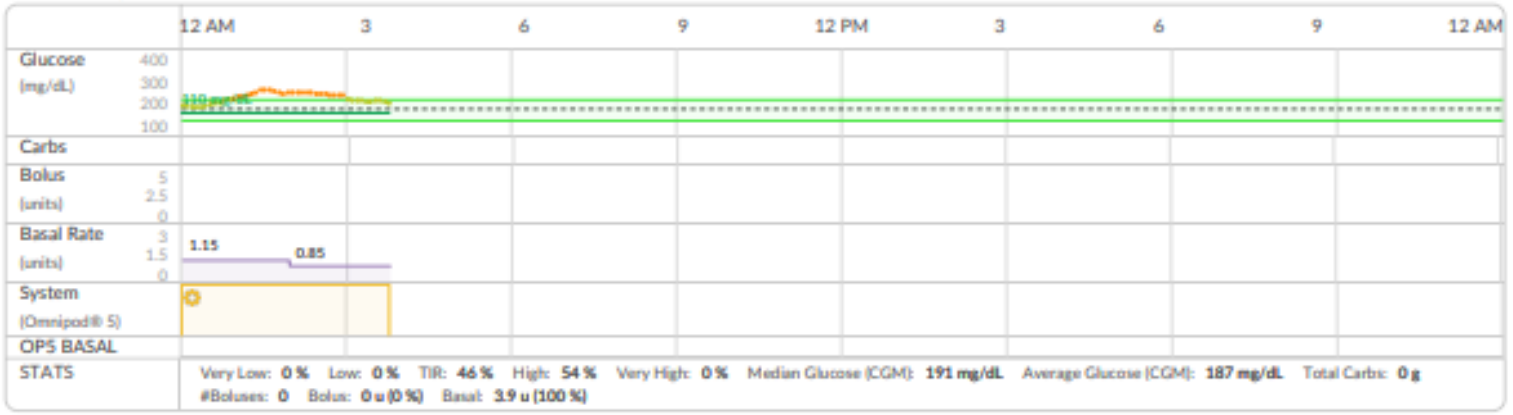
Carbs/Day	124.2 g
Entries/Day	4.3

Fitness

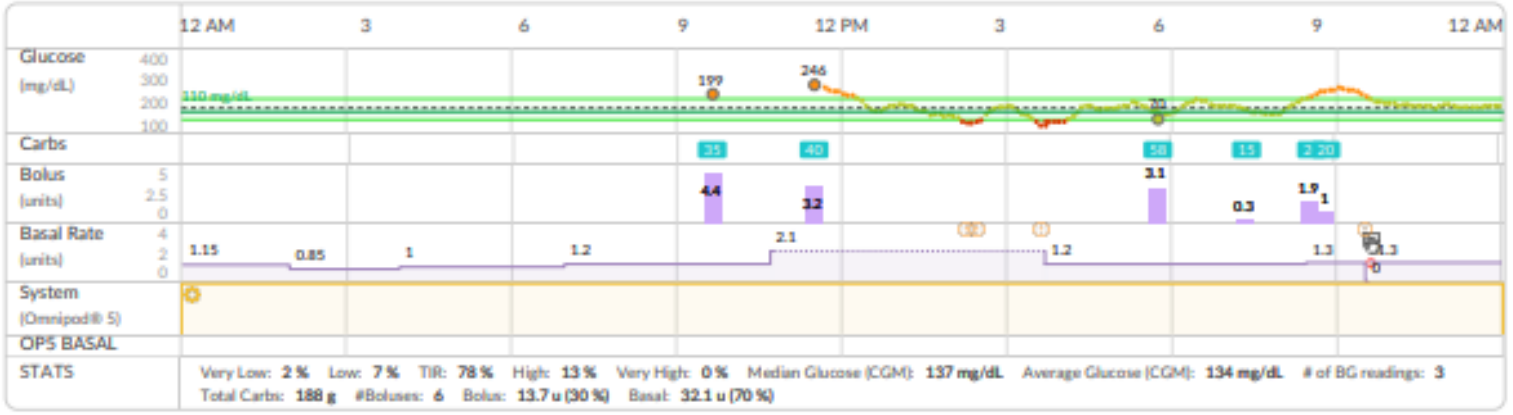
No fitness tracker connected

Comments

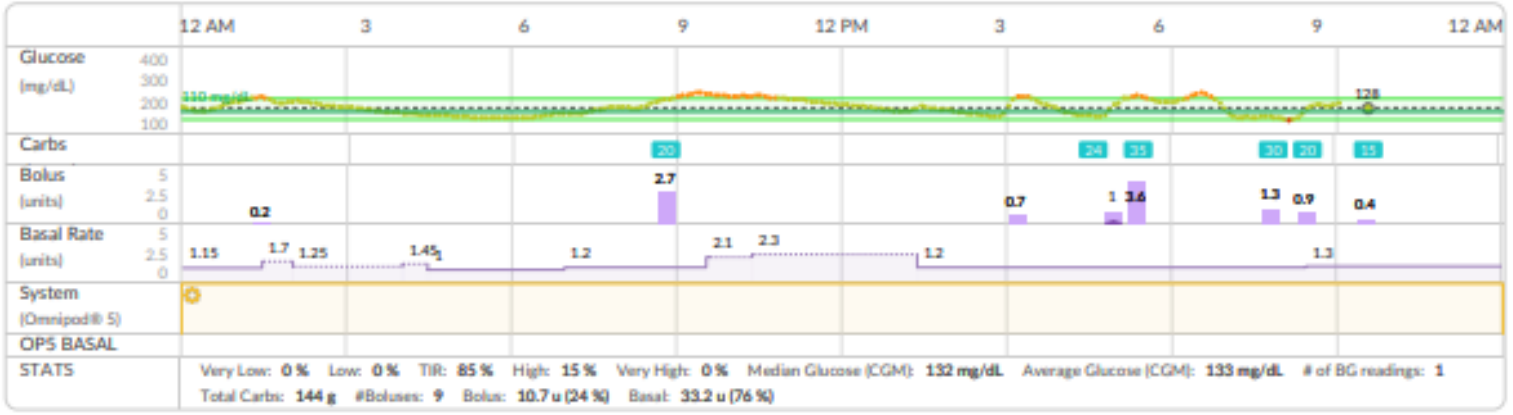
March 14, 2024



March 13, 2024



March 12, 2024



Benefits of AID

Improvements in

- HbA1c (adults, children & adolescents)[1]
- TIR [2,3,4]
- Decreased TAR [4]
- Quality of life - sleep, reducing anxiety, and relieving some diabetes management burden [5]

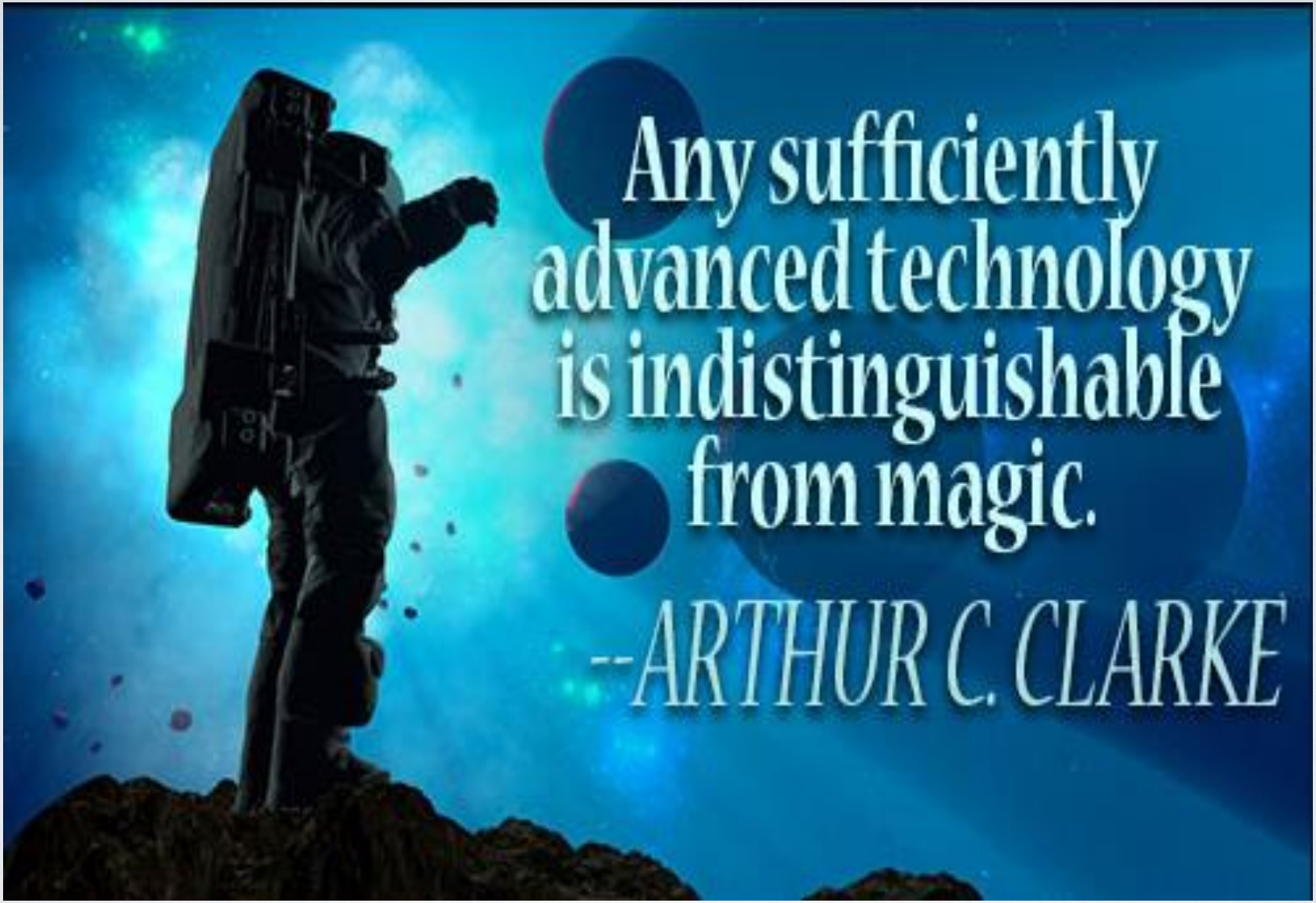
1. Karageorgiou V et al. Effectiveness of artificial pancreas in the non-adult population: a systematic review and network meta-analysis. Metabolism 2019;90:20–30
2 . Weisman A et al. Effect of artificial pancreas systems on glycemic control in patients with T1D: a systematic review and meta-analysis of outpatient randomized controlled trials. Lancet Diabetes Endocrinology 2017;5:501–512
3. Bekiari E, Kitsios K, Thabit H, et al. Artificial pancreas treatment for outpatients with T1D: systematic review and meta-analysis. BMJ 2018;361:k1310
4. Amer BE, Yaqout YE, Abozaid AM, et al. Does fully closed-loop automated insulin elivery improve glycemiac control in patinets with type 2 diabetes? A meta-analysis of randomized controlled trials. Diabet Med 2023:00e15196.
5. Farrington C. Psychosocial impacts of hybrid closed-loop systems in the management of diabetes: a review. Diabet Med 2018;35:436–449

AID Limitations

- It's not perfect
- User must be prepared to use pump without AID
- Pumps and CGMs can fail
- Reporting software may have glitches
- DKA can happen due to site issues
- Must have Dexcom mobile app compatibility for OP5
- Cost

Connected Pens

	InPen	Tempo
Compatible CGM	Dexcom G6 w iPhone only	Dexcom G6
Insulin Options	Humalog, Novolog, Fiasp	Humalog, Lyumjev, Basaglar
Bolus Calculator	Yes	No
Pair >1 pen	Yes	No


Any sufficiently
advanced technology
is indistinguishable
from magic.
--ARTHUR C. CLARKE

5M Diabetes

MD, EMHA, CDCES

Justyna graduated from Columbia University with a Master's Degree in Health Administration, and from Poznan University with her MD, becoming a Certified Diabetes Educator during her four years working at Palm Beach Diabetes. She started 5M Diabetes because of her strong desire to help serve diabetes patients who lack access to health care.

Meet
Monitor
Mentor
Motivate
Manage

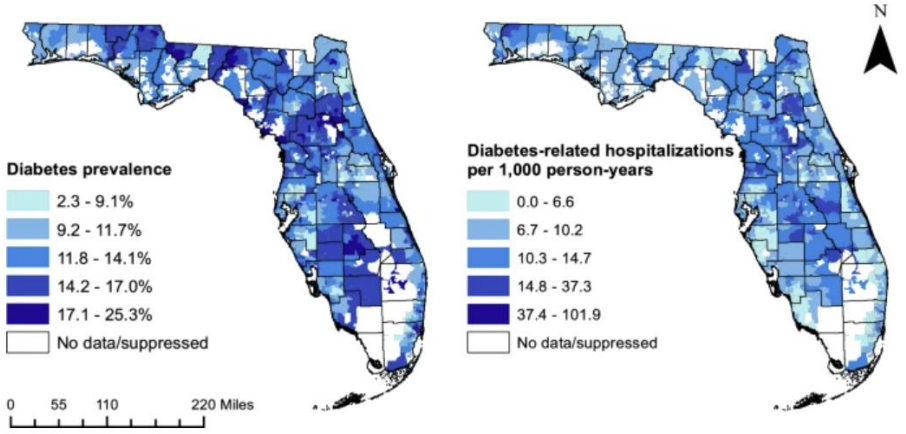
Justyna Stachnik
Founder and CEO

5M Diabetes Mission

- For Florida residents affected by diabetes to achieve their full potential of health and well-being through screening, preventing complications, educating, administering medical devices and improving patient-provider relationships.
- We focus on showing patients with diabetes, the relationship food, exercise and emotions have on blood glucose.

The Rising Epidemic of Type 2 Diabetes

- The CDC classified diabetes as an epidemic in 1994, and disease incidence has continued to rise.
- Today, 37.3 million Americans are living with diabetes, and it is estimated that 2.4 million Florida residents are affected



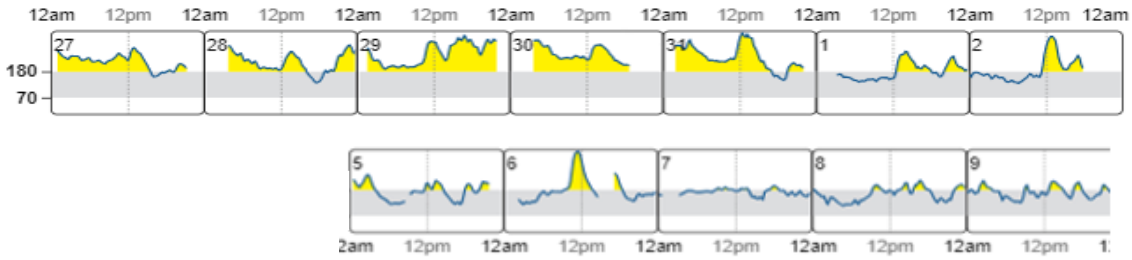
Geographic distribution of ZCTA-level diabetes prevalence estimates and smoothed diabetes-related hospitalization rates in Florida, 2016–2019

5M Diabetes Protocol

- Patients are referred to us by their providers
- Through the kind philanthropy of Elliot Stein and Abbot Laboratories, we provide CGMs to individuals with non optimally controlled diabetes.
- The magic of biofeedback is on our side because when patients see what food causes what BG, it's an amazing self learning experience and creates more interest to be further educated.

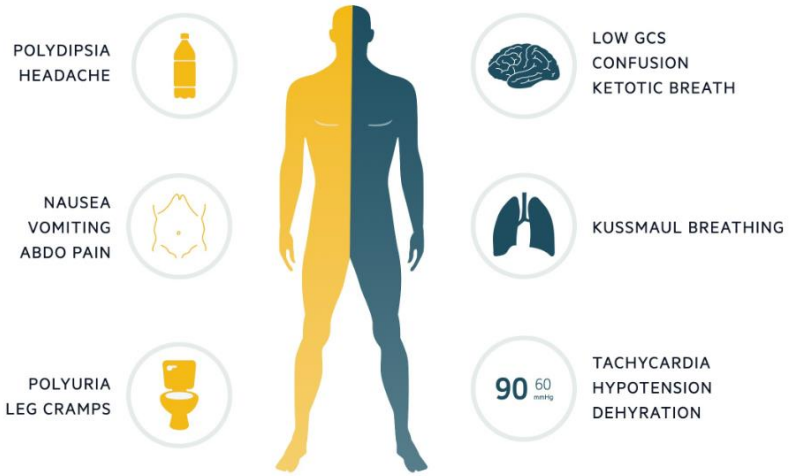
Example of Success Story

- Type 2 Diabetes for 3 years
- Never attended diabetic education
- HbA1c -9.1
- After 4 weeks- Time In Range was 72% and glucose management indicator (GMI) for the last 1 week was 7.2



Our Second Mission is to Screen for T1D

- An estimated **300,000** people in the US are **at risk** for Stage 3 (clinical) T1D
- Approximately **60% of youth** in the US are diagnosed with T1D as a result of a **DKA event**



DKA at diagnosis may have long-term impacts

- Brain changes **and detrimental neurocognitive outcomes**

- Sustained **negative effect of glycemic control** over time, independent of other variables

- **Increased morbidity and mortality** that is associated with **lifelong poor glycemic control**

Multiple Studies Have Found a Lower Rate of DKA Associated with T1D Screening

Screening Study	Setting	DKA Rate	Expected DKA Rate without Screening
ASK	General Population	5%	59%
DAISY	Relative/Genetic Risk	3%	44%
TEDDY	Genetic Risk, Age <5	11%	17-36%

Potential Benefits of T1D Screening

- Lower **the rate of DKA** in research and community settings
- Opportunity to participate in **research**
- Creates opportunities to **provide education and counseling** to individuals and their families about the challenges they may face.
- Allow time to **develop the skills** they will need to **sustain optimal glycemic management**
- Prompts **closer monitoring and management protocols**

T1D Screening Options

T1D AutoAntibody Testing Option	Blood Draw	Autoantibodies Available	Cost
Commercial Lab	Blood draw at local lab	GAD IA-2A Insulin ZNt8A	Cost based on the individual lab
Trail Net	Blood draw of home finger blood test	GAD IA-2A Insulin ZNt8A	Free if individual meets the eligibility criteria
Autoimmunity Screening for Kids (ASK)	Blood draw of home finger blood test	GAD IA-2A Insulin ZNt8A	Free if individual meets the eligibility criteria
Enable Bioscience	Blood draw of home finger blood test	GAD IA-2A Insulin	$10-$89

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Thank you