ADVANCED DIABETES TECHNOLOGY

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Disclosures

- No relationships to disclose

Diabetes Technology

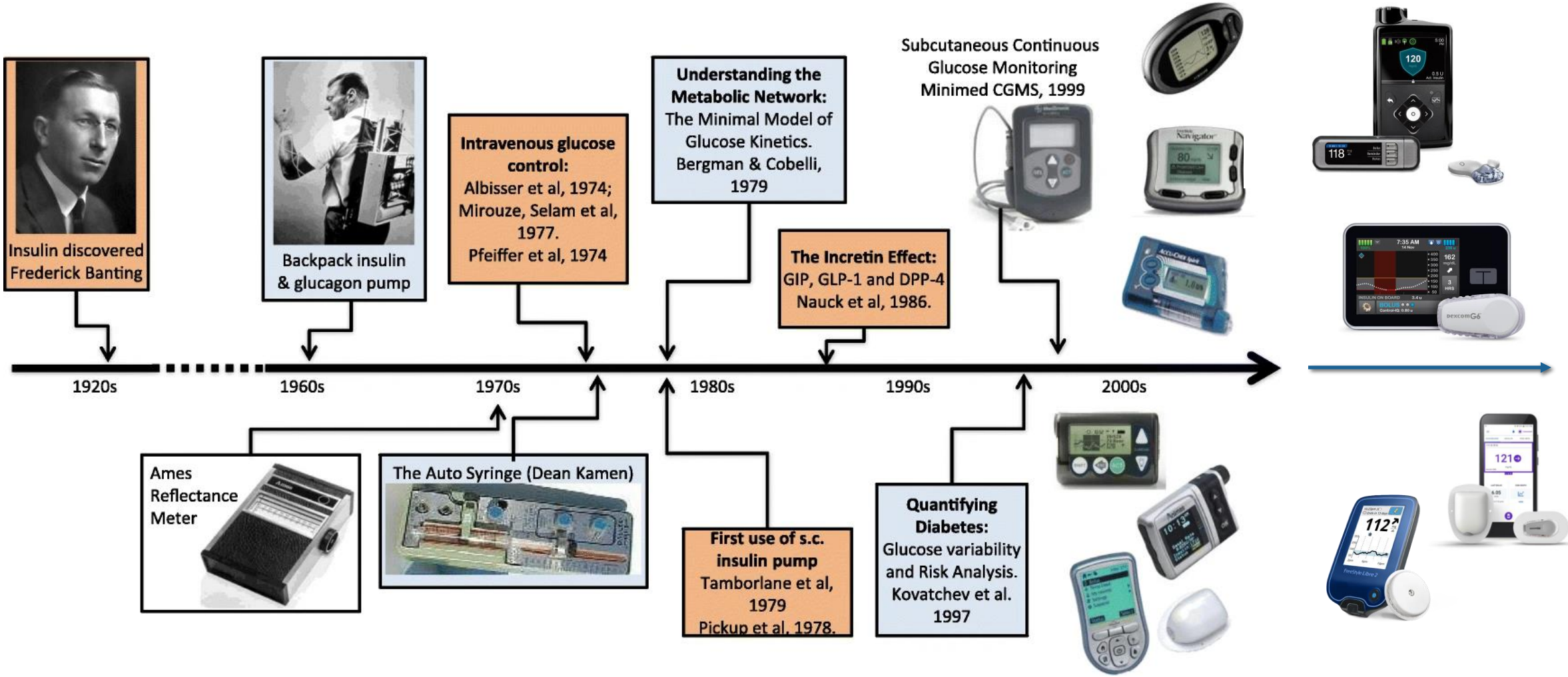
Hardware, devices, and software that people with diabetes use to help manage their condition, from lifestyle to blood glucose levels

Insulin administered by syringe, pen, or pump (continuous subcutaneous insulin infusion)

Blood glucose as assessed by blood glucose monitoring (BGM) or continuous glucose monitoring (CGM)

American Diabetes Association Professional Practice Committee; 7. Diabetes Technology: *Standards Of Medical Care In Diabetes—2022. Diabetes Care* 1 January 2022; 45 (Supplement_1): S97–S112

Overview of Diabetes technology over time



Kovatchev, B. Automated closed-loop control of diabetes: the artificial pancreas. Bioelectron med 4, 14 (2018). Https://doi.Org/10.1186/s42234-018-0015-6

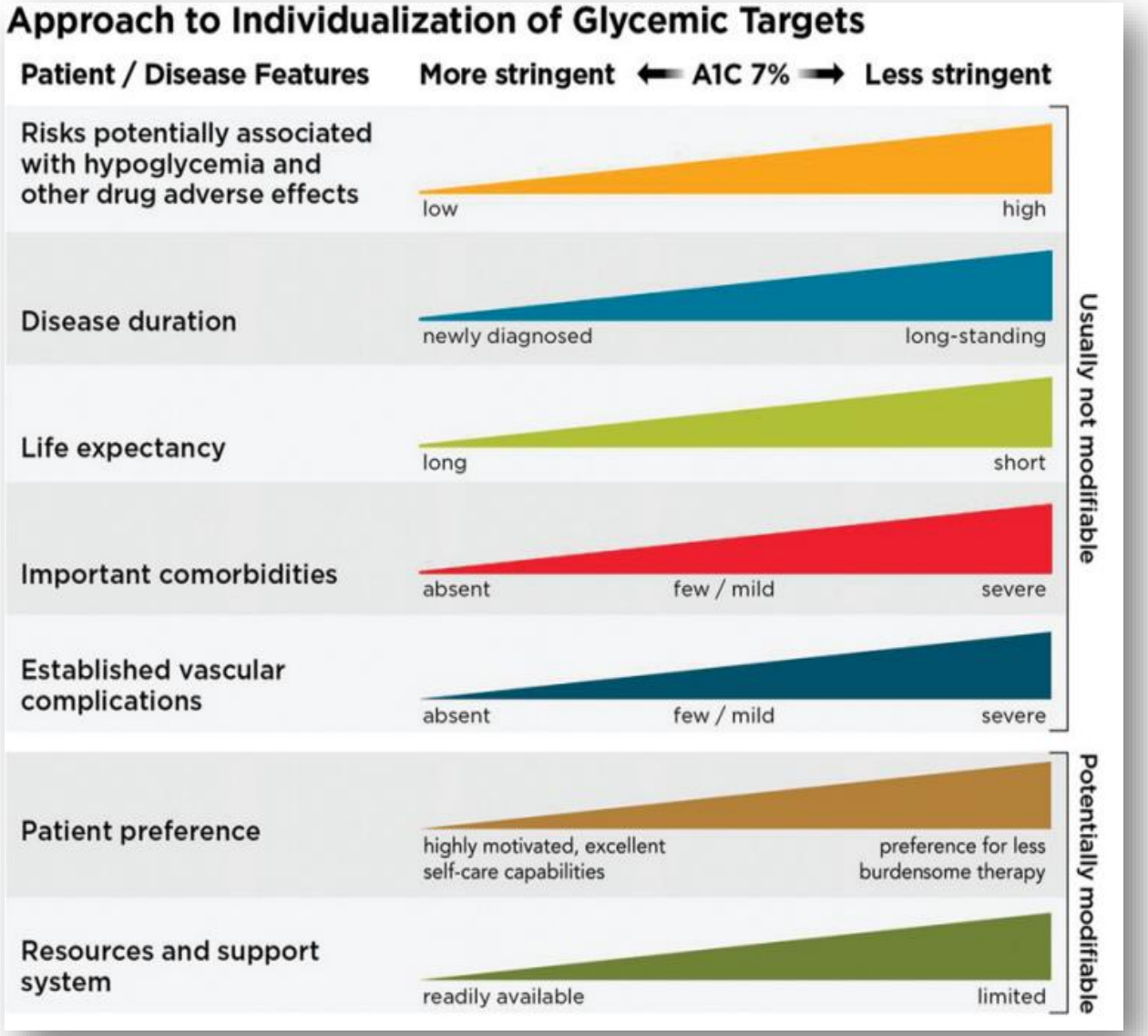
ADA Standards of Care: When to solely Using A1C to assess glycemic control

"Clinicians should exercise judgment when using A1C as the sole basis for assessing glycemic control"

Table 6.3—Summary of glycemic recommendations for many nonpregnant adults with diabetes

A1C	<7.0% (53 mmol/mol)*#
Preprandial capillary plasma glucose	80–130 mg/dL* (4.4–7.2 mmol/L)
Peak postprandial capillary plasma glucose†	<180 mg/dL* (10.0 mmol/L)

American Diabetes Association Professional Practice Committee; 6. Glycemic Targets: *Standards Of Medical Care In Diabetes—2022*. *Diabetes Care* 1 January 2022; 45 (Supplement_1): S83–S96. Https://Doi.Org/10.2337/Dc22-s006



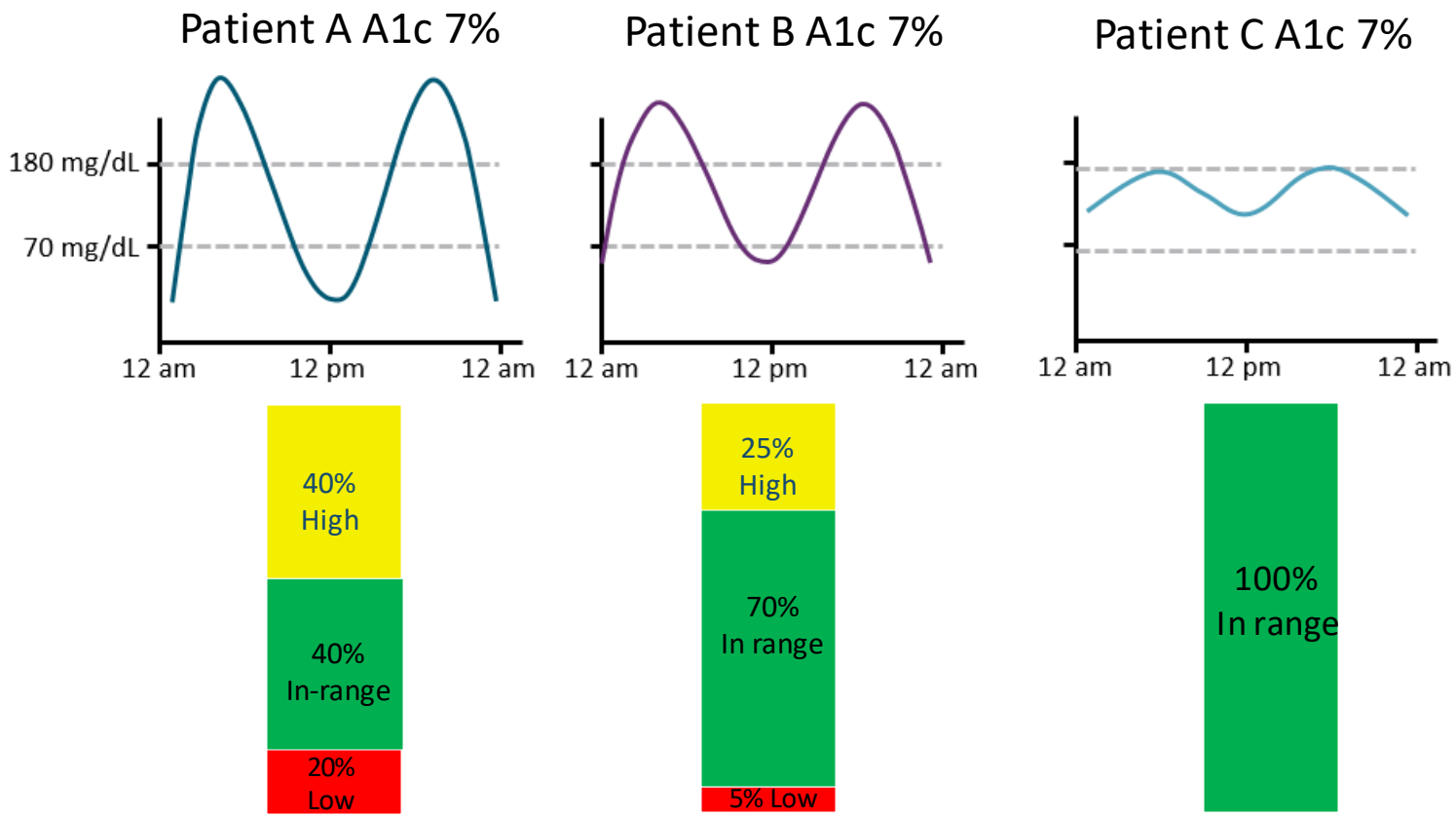
American Diabetes Association Professional Practice Committee; 6. Glycemic Targets:*Standards Of Medical Care In Diabetes—2022*. *Diabetes Care* 1 January 2022; 45 (Supplement_1): S83–S96. Https://Doi.Org/10.2337/Dc22-s006

ADA Standards of Care: When to solely Using A1C to assess glycemic control

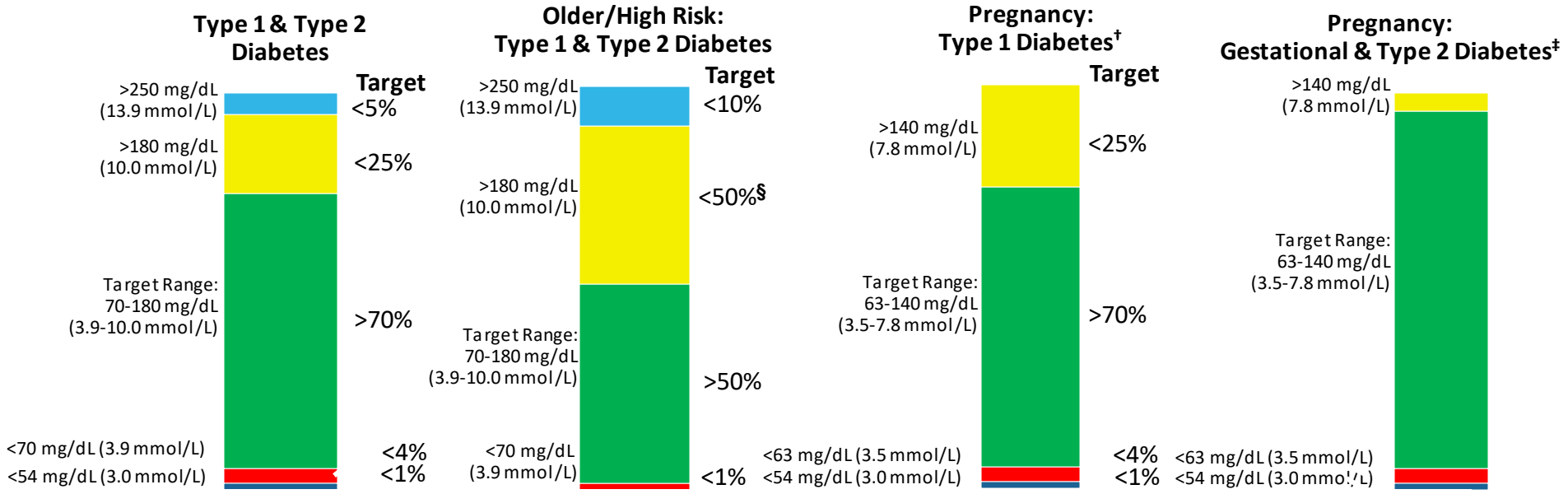
- A1C does not provide a measure of glycemic variability or hypoglycemia
- For patients prone to glycemic variability, glycemic control is best evaluated by the combination of results from BGM/CGM and A1C

American Diabetes Association Professional Practice Committee; 6. Glycemic Targets: *Standards Of Medical Care In Diabetes—2022*. *Diabetes Care* 1 January 2022; 45 (Supplement_1): S83–S96. Https://Doi.Org/10.2337/Dc22-s006

Glycemic Variability



Time in Range Goals: International Consensus

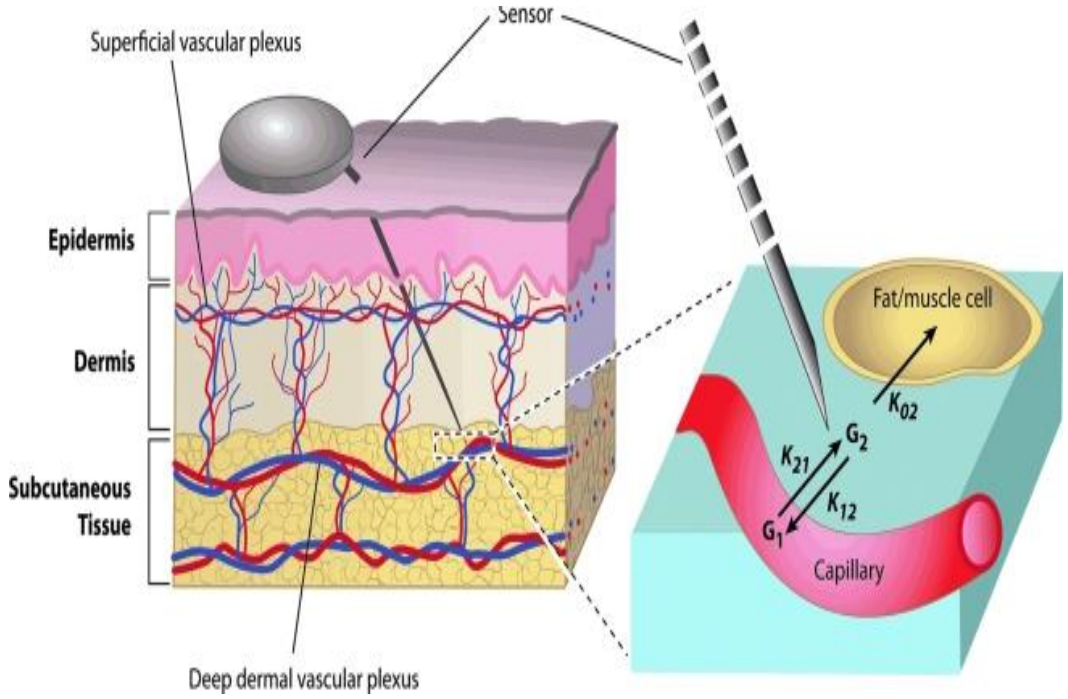


†Percentages of time in ranges are based on limited evidence. More research is needed.
‡Percentages of time in ranges have not been included because there is very limited evidence in this area. More research is needed.

Orientation to continuous glucose monitoring

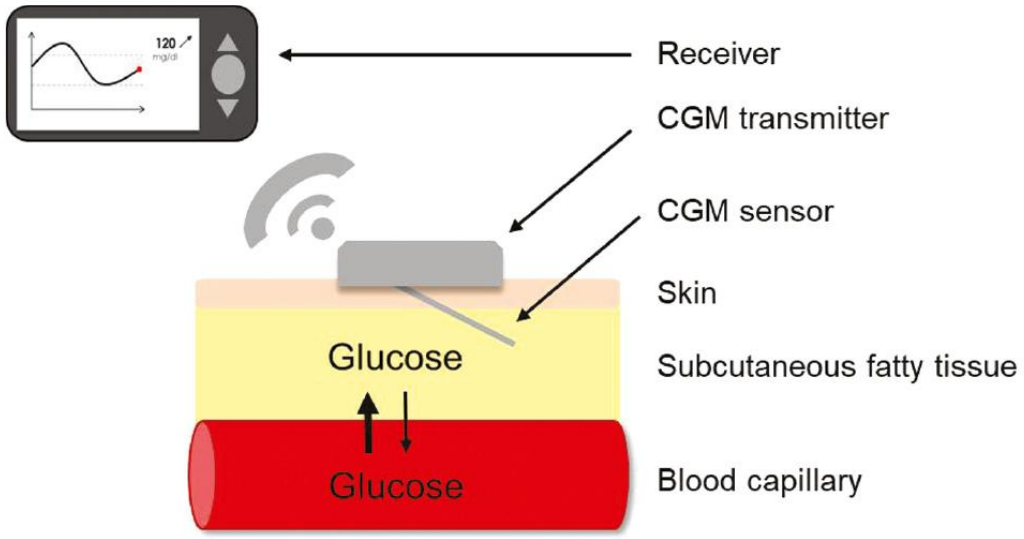
Basics of Continuous Glucose Monitoring (CGM)

- CGM sensor measures glucose in interstitial fluid every 1-15 minutes
- Glucose data is transmitted automatically in a continuous stream to the receiver, reader or smartphone
- The user can scan the receiver to obtain glucose data
- The data is presented as glucose value, trend arrows or trend graph



Cengiz E, Tamborlane WV. A Tale Of Two Compartments: Interstitial Versus Blood Glucose Monitoring. Diabetes Technol Ther. 2009;11 Suppl 1(suppl 1):S11-S16. Doi:10.1089/Dia.2009.0002

CGM measurement compartment



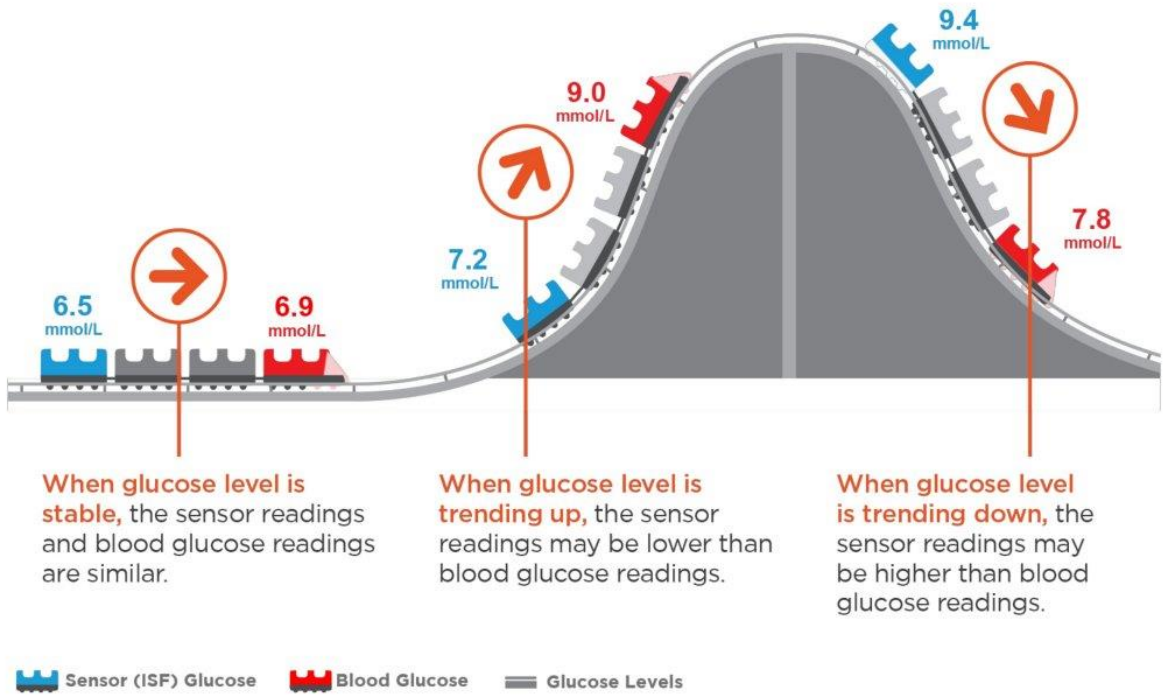
Physiologic delay

The diffusion of glucose from the intravascular to the subcutaneous interstitial fluid compartment leads to a physiologic delay

Processing of the gained data results in a technological delay

Time lag between the measurement and display of the result

Time Lag



Time Lag: During rapid states of change, SG and BG may differ more than 20%

Continuous Glucose Monitoring Systems

Professional CGM

- Newly diagnosed with diabetes mellitus
- Not using CGM
- May have problematic hypoglycemia, but no access to personal CGM
- Persons with T2D treated with non-insulin therapies as an educational tool
- Persons who would like to learn more about CGM before committing to daily use

FreeStyle Libre Pro

Dexcom G6 Pro

Grunberger G, Et Al. American Association Of Clinical Endocrinology Clinical Practice Guideline: The Use Of Advanced Technology In The Management Of Persons With Diabetes Mellitus. Endocr Pract. 2021 Jun;27(6):505-537

Continuous Glucose Monitoring Systems

Real-time CGM

- Measure and store glucose levels continuously and without prompting
- Recommended over intermittently scanned CGM for diabetics with problematic hypoglycemia; predicts alarms

Intermittently scanned CGM

- Measure glucose levels continuously but require scanning for storage of glucose values
- Newer versions have real time-optional alarms
- Recommended for patients newly diagnosed with T2D treated with non-hypoglycemic therapies

Current Options for Personal CGM Systems

Dexcom G6	Guardian Connect Guardian Sensor 3	FreeStyle Libre Flash	Eversense	Libre 2

Comparison of current CGM systems available

	Dexcom G6®	Eversense® Eversense® XL	Freestyle® Libre	Freestyle® Libre 2	Freestyle® Libre 3	Medtronic Guardian 3
CGM group	rtCGM	rtCGM	isCGM	isCGM	rtCGM	rtCGM
Sensor life	10 days	180 days	14 days	14 days	14 days	7 days
Sensor application	Abdomen	Upper arm (implanted)	Back of upper arm	Back of upper arm	Back of upper arm	Abdomen
Calibration	Factory-calibrated	Yes – 24 hours after insertion 4 calibrations 2-12 hours apart, then twice daily 10-14 hours apart	Factory-calibrated	Factory-calibrated	Factory-calibrated	Yes – minimum of twice daily
Integrations with Pump	Yes – Tandem t:slim X2 and OmniPod5	No	No, but is compatible with Bigfoot smart pen cap	No	No	Guardian 3: Medtronic 670G/770G Guardian Connect standalone CGM
Separate Receiver Available	Yes	No	Yes	Yes	Not available	No
Radiograph/MRI Compatible	No	Yes	No	No	No	No
MARD (%) Mean absolute relative difference	9	8	9.4	9.3	7.9	Abdomen 9.6-10.6 Arm 8.7-9.1

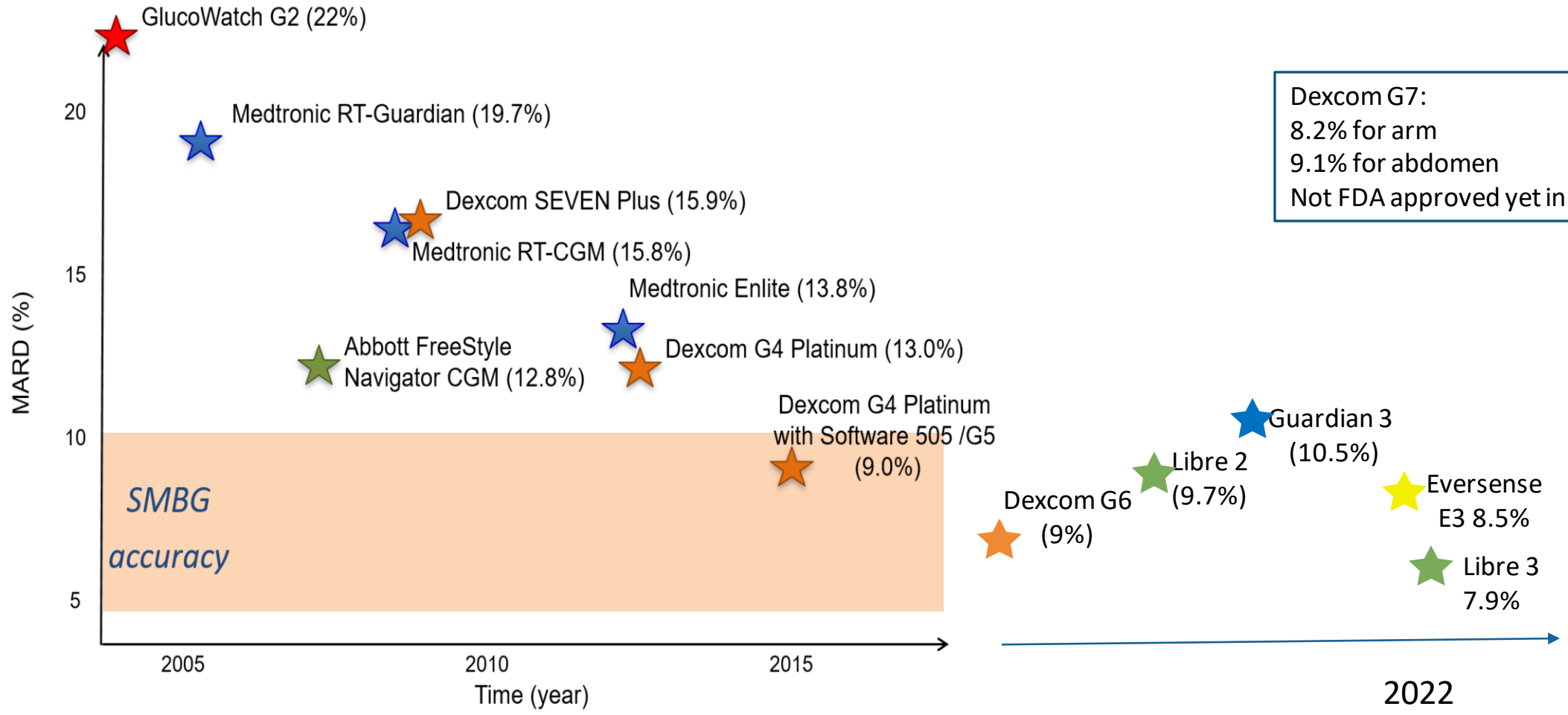
Kravarusic J, Aleppo G. Diabetes Technology Use in Adults with Type 1 and Type 2 Diabetes. Endocrinol Metab Clin North Am. 2020 Mar;49(1):37-55. doi: 10.1016/j.ecl.2019.10.006. Epub 2019 Dec 10. PMID: 31980120.

Comparison of current CGM systems available

	Dexcom G6®	Eversense® Eversense® XL	Freestyle® Libre	Freestyle® Libre 2	Freestyle® Libre 3	Medtronic Guardian 3
Warm-up time (hours)	2	24	1	1	1	2
Audible Alarms/Alerts	Yes Hypoglycemia predictive alerts	Yes Predictive alerts (vibrates)	No	Yes	Yes	Yes Predictive alerts
Trend Arrows	Yes	Yes	Yes	Yes	Yes	Yes
Share features	Up to 10 people with Dexcom Follow app (Apple, Google)	Up to 5 people with Eversense Now app	Up to 20 people with LibreLinkup app (Apple, Google)	Up to 20 people with LibreLinkup app (Apple, Google)	Up to 20 people with LibreLinkup app (Apple, Google)	Up to 4 people with CareLinkTM Connect web app (Apple, Google
Software Compatibility	Dexcom CLARITY Glooko Tidepool	Glooko	LibreView Tidepool (reader only)	LibreView Tidepool (reader only)		Medtronic CareLink
Interferences	Hydroxyurea – may falsely elevate sensor readings)	Tetracyclines – may falsely lower sensor readings	Vitamin C – may falsely elevate sensor readings Aspirin – may falsely lower sensor readings	Vitamin C >500mg/day – may falsely elevate sensor readings	Vitamin C >500mg/day – may falsely elevate sensor readings	Tylenol – may falsely elevate sensor readings)

Kravarusic J, Aleppo G. Diabetes Technology Use in Adults with Type 1 and Type 2 Diabetes. Endocrinol Metab Clin North Am. 2020 Mar;49(1):37-55. doi: 10.1016/j.ecl.2019.10.006. Epub 2019 Dec 10. PMID: 31980120.

CGM Accuracy over time



Facchinetti A. Continuous Glucose Monitoring Sensors: Past, Present and Future Algorithmic Challenges. *Sensors*. 2016; 16(12):2093. https://doi.org/10.3390/s16122093

CGM as standard of care: Indications for CGM therapy

American Diabetes Association 2022 (a)

- T1D/T2D on intensive insulin therapy or continuous subcutaneous insulin infusion
- Diabetes management in adults with diabetes on basal insulin

American Association of Clinical Endocrinologist 2021 (b)

- All persons with diabetes treated with intensive insulin therapy
- All individuals with problematic hypoglycemia
- Children/adolescents with T1D
- Pregnant women with T1D and T2D treated with intensive insulin therapy

Endocrine society 2016 (c)

- T1D patients who have A1C levels above target or are well controlled and willing to use these devices
- Intermittent RT-CGM use in adult patients with T2D (not on prandial insulin) who have A1C levels >7%

(a) American Diabetes Association Professional Practice Committee; 7. Diabetes Technology: *Standards Of Medical Care In Diabetes—2022. Diabetes Care* 1 January 2022; 45 (Supplement_1): S97–S112
(b) Grunberger G, Et Al. American Association Of Clinical Endocrinology Clinical Practice Guideline: The Use Of Advanced Technology In The Management Of Persons With Diabetes Mellitus. Endocr Pract. 2021 Jun;27(6):505-537
(c) Anne L. Peters Et Al, Diabetes Technology—continuous Subcutaneous Insulin Infusion Therapy And Continuous Glucose Monitoring In Adults: An Endocrine Society Clinical Practice Guideline, *The Journal Of Clinical Endocrinology & Metabolism*, Volume 101, Issue 11, 1 November 2016, Pages 3922–3937

Evidence of rtCGM Efficacy
Large Randomized Trials Comparing CGM use with SMBG in patients with T1D or T2D on MDI

STUDY	Reduced HbA1C	Reduced hypoglycemia	Reduced Glycemic variability	Improved quality of Life	Improved treatment satisfaction	Reduced Distress due to hypoglycemia
GOLD/GOLD-3 Studies[1,2] Poorly controlled Type 1 DM	☑	☑	☑	☑	☑	☑
IMPACT[3] Well controlled T1D	--	☑	☑	--	☑	†
REPLACE[4] Poorly controlled T2D	--	☑	☑	--	☑	†
DIAMOND Studies[5,7] Poorly controlled T1D/T2D	☑	☑(T1D)	☑	†	☑	☑
HypoDE[8] Poorly controlled T1D with problematic hypoglycemia	--	☑	☑	†	☑	☑
WISDM Study[9] Older adults with T1D	☑	☑	☑	†	†	†
Mobile Study[10] Adults with poorly controlled T2D managed in Primary care	☑	†	†	†	†	†

† Not reported/Not an outcome.

1. Lind M, et al. *JAMA*. 2017;317(4):379–387.. 2 Ólafsdóttir AF, et al. Diabetes Technol Ther. 2018 Apr;20(4):274-284. 3. Oskarsson P, et al. *Diabetologia*. 2018;61(3):539-550.
4. Haak T, et al. *Diabetes Ther*. 2017;8(1):55-73. 5. Beck R, et al.. *JAMA*. 2017;317(4):371-378. 69. *Lancet Diabetes Endocrinol*. 2017;5(9):700-708. 7. Ruedy KJ, *J Diabetes Sci Technol*. 2017;11(6):1138-1146. 8. Heinemann L, *Lancet*. 2018;391(10128):1367-1377. 9. Pratley RE, at al . *JAMA*. 2020;323(23):2397-2406. 10Martens T, et al. *JAMA*. 2021;325(22):2262-2272.

JAMA | Original Investigation

Effect of Continuous Glucose Monitoring on Glycemic Control in Patients With Type 2 Diabetes Treated With Basal Insulin
A Randomized Clinical Trial

Thomas Martens, MD; Roy W. Beck, MD, PhD; Ryan Bailey, MS; Katrina J. Ruedy, MSPH; Peter Calhoun, PhD; Anne L. Peters, MD; Rodica Pop-Busui, MD, PhD; Athena Philis-Tsimikas, MD; Shichun Bao, MD, PhD; Guillermo Umpierrez, MD; Georgia Davis, MD; Davida Kruger, MSN, APN-BC; Anuj Bhargava, MD; Laura Young, MD, PhD; Janet B. McGill, MD; Grazia Aleppo, MD; Quang T. Nguyen, DO; Ian Orozco, MD; William Biggs, MD; K. Jean Lucas, MD; William H. Polonsky, PhD; John B. Buse, MD, PhD; David Price, MD; Richard M. Bergenstal, MD; for the MOBILE Study Group

JAMA Network™

QUESTION For adults with poorly controlled type 2 diabetes treated with basal insulin without prandial insulin in primary care practices, does continuous glucose monitoring (CGM) improve hemoglobin A_{1c} (HbA_{1c}) levels compared with blood glucose meter (BGM) monitoring?

CONCLUSION This randomized clinical trial found there was a significantly greater decrease in HbA_{1c} level over 8 months with CGM than with BGM monitoring.

POPULATION

88 Women
87 Men

Adults with type 2 diabetes treated with basal insulin without prandial insulin

Mean age: **57 years**

LOCATIONS

15
Primary care practices in the US

INTERVENTION

175 Patients randomized

116
Continuous glucose monitoring
CGM with BGM testing performed as needed

59
Blood glucose meter monitoring
BGM testing performed when fasting and postprandial 1 to 3 times daily

PRIMARY OUTCOME

HbA_{1c} level at 8 months adjusted for the baseline value

FINDINGS

Mean HbA_{1c} level at 8 months

Continuous glucose monitoring		Blood glucose meter monitoring	
HbA_{1c}		HbA_{1c}	
Baseline	8 Months	Baseline	8 Months
9.1%	▶ 8.0%	9.0%	▶ 8.4%

Risk-adjusted difference was significant,
−0.4% (95% CI, −0.8% to −0.1%)

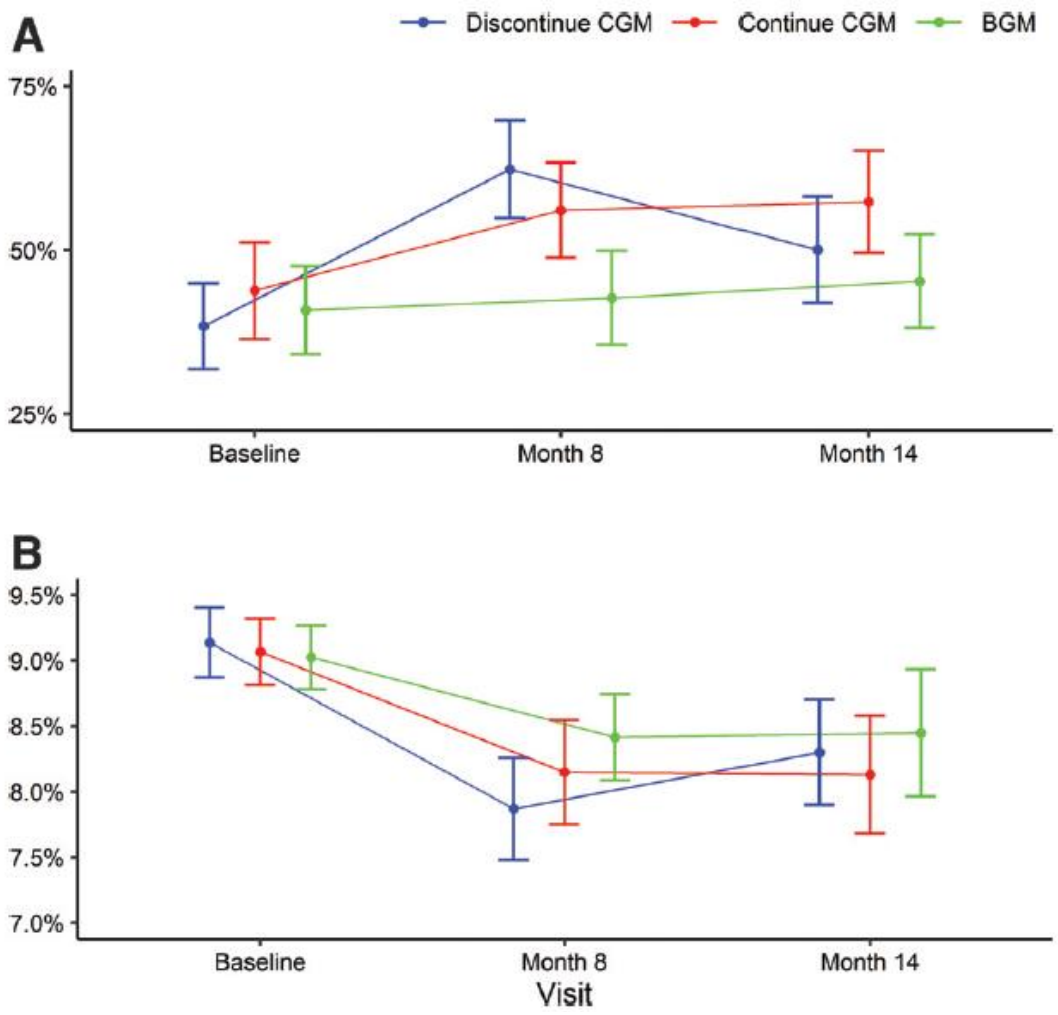
Martens T, Beck RW, Bailey R, et al; MOBILE Study Group. Effect of continuous glucose monitoring on glycemic control in patients with type 2 diabetes treated with basal insulin: a randomized clinical trial. *JAMA*. Published online June 2, 2021. doi:10.1001/jama.2021.7444

The Effect of Discontinuing Continuous Glucose Monitoring in Adults With Type 2 Diabetes Treated With Basal Insulin

Diabetes Care 2021;44:2729–2737 | https://doi.org/10.2337/dc21-1304

Mean TIR

Mean HbA1C

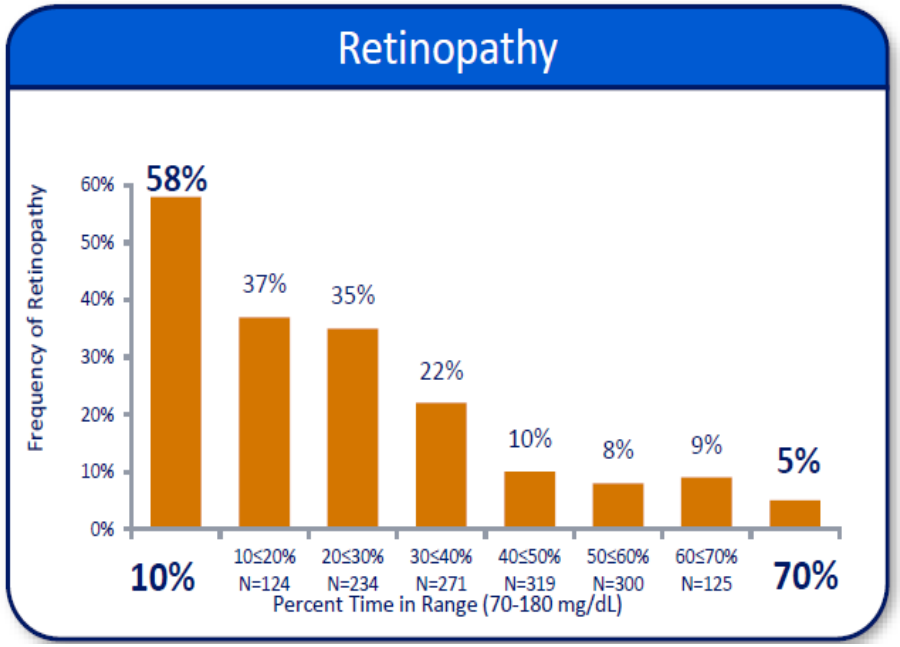


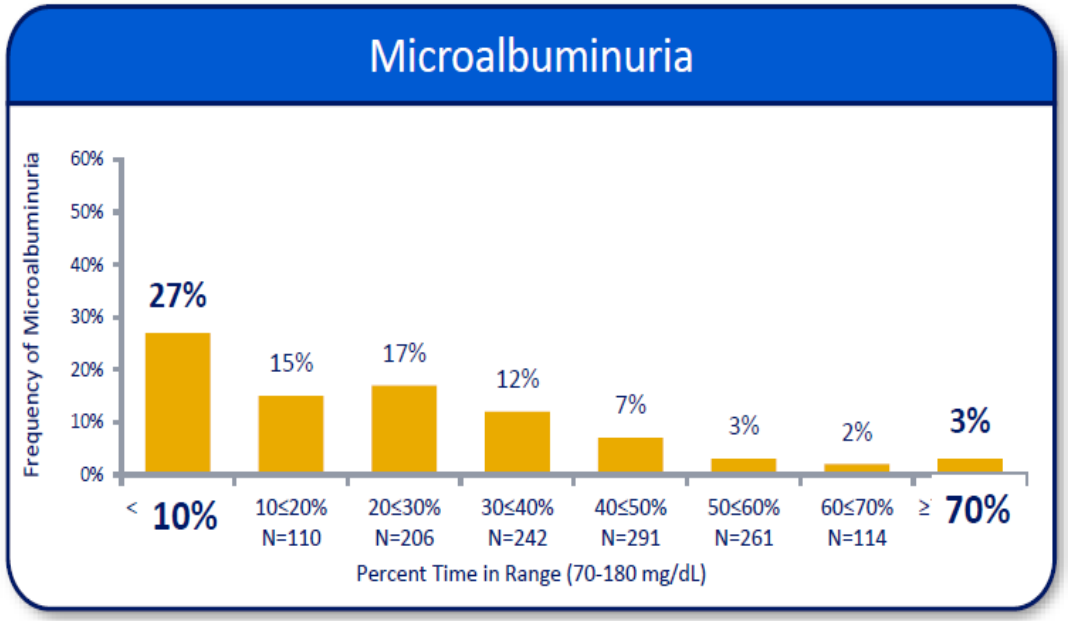
Aleppo G, et al. MOBILE Study Group; The Effect of Discontinuing Continuous Glucose Monitoring in Adults With Type 2 DiabetesTreated With Basal Insulin. Diabetes Care 1 December 2021; 44 (12): 2729–2737. https://doi.org/10.2337/dc21-1304

Validation of Time in Range as an Outcome Measure for Diabetes Clinical Trials

Roy W. Beck,[1] Richard M. Bergenstal,[2] Tonya D. Riddlesworth,[1] Craig Kollman,[1] Zhaomian Li,[1] Adam S. Brown,[3] and Kelly L. Close[4]

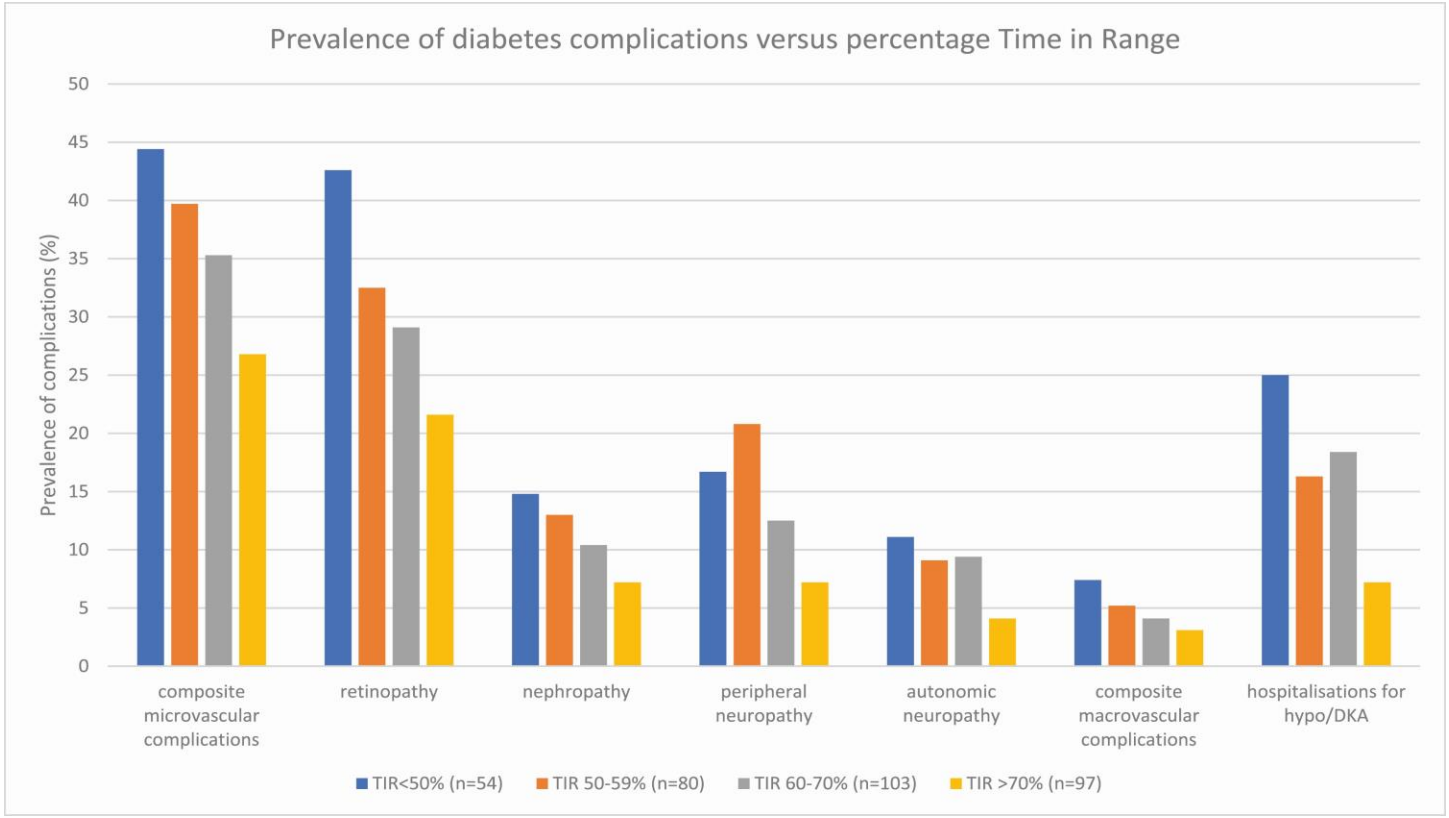
Diabetes Care 2019;42:400–405 | https://doi.org/10.2337/dc18-1444



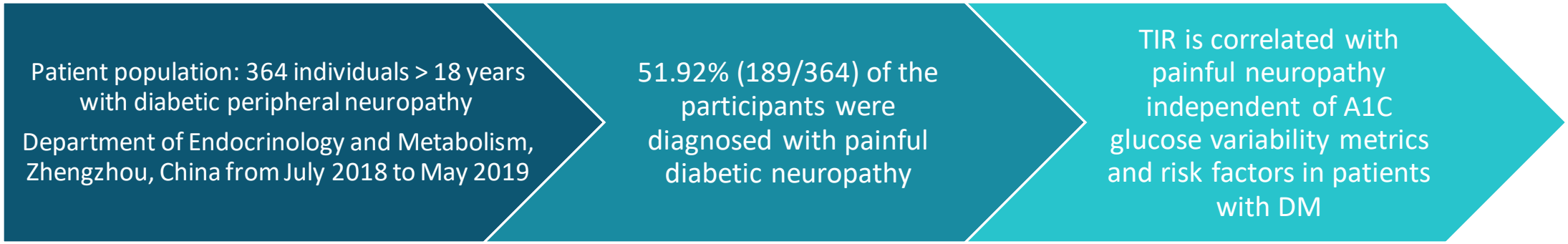


For each 10% less TIR retinopathy progression increased by 64% % (95% CI 51–78) and the microalbuminuria outcome d by 40% (95% CI 25–56)

Figure 2. Prevalence of complications versus percentage of time spent in optimal range



J CLIN ENDOCRINOL METAB, VOLUME 107, ISSUE 2, FEBRUARY 2022, PAGES E570–E581, HTTPS://DOI.ORG/10.1210/CLINEM/DGAB688



Yang J, Yang X, Zhao D, Wang X, Wei W, Yuan H. Association of time in range, as assessed by continuous glucose monitoring, with painful diabetic polyneuropathy. J Diabetes Investig. 2021;12(5):828-836. doi:10.1111/jdi.13394

Time in Range in Relation to All-Cause and Cardiovascular Mortality in Patients With Type 2 Diabetes: A Prospective Cohort Study

Jingyi Lu,[1] Chunfang Wang,[2] Yun Shen,[1] Lei Chen,[2] Lei Zhang,[1] Jinghao Cai,[1] Wei Lu,[1] Wei Zhu,[1] Gang Hu,[3] Tian Xia,[2] and Jian Zhou[1]

Diabetes Care 2021;44:549–555 | https://doi.org/10.2337/dc20-1862

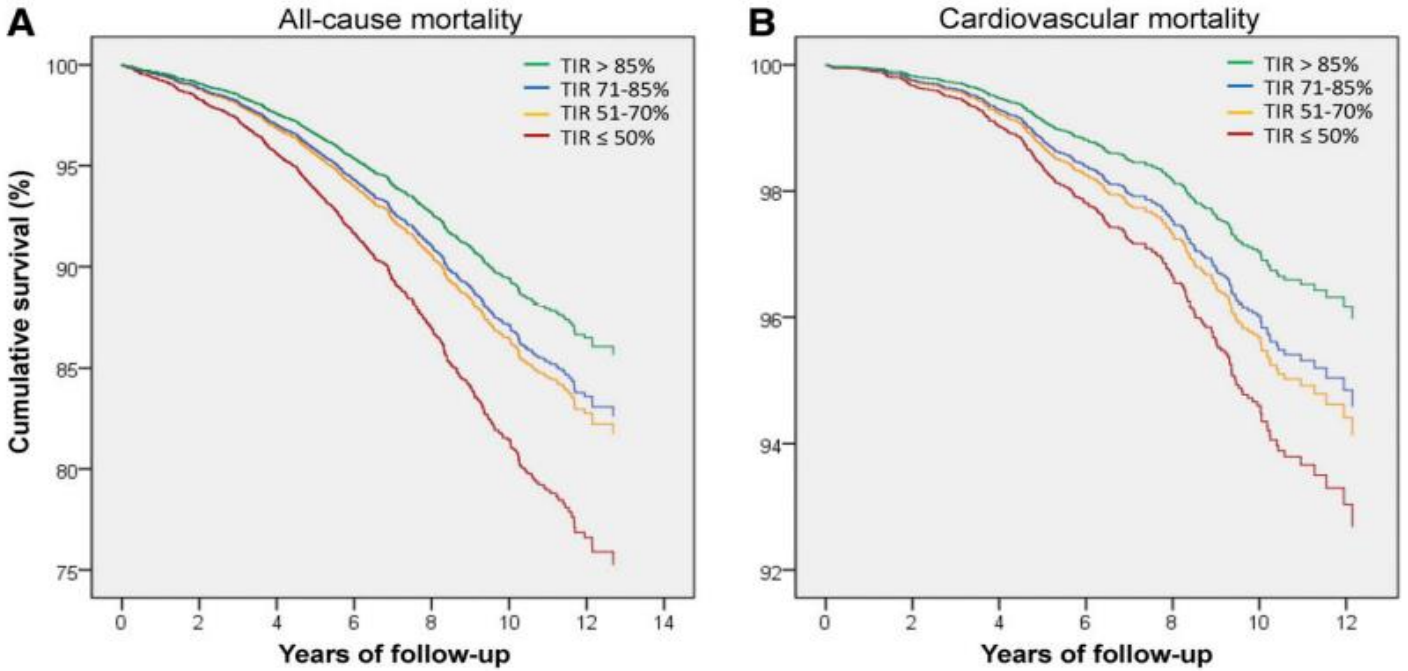


Figure 1—Multivariate-adjusted cumulative survival curves of all-cause (*A*) and cardiovascular (*B*) mortality by different levels of TIR. Adjusted for age, sex, BMI, diabetes duration, systolic blood pressure, triglyceride, HDL cholesterol, LDL cholesterol, smoking status, history of cancer and CVD, and use of antihypertensive drugs, aspirin, and statins.

Diabetes. 2020;69(Supplement_1). doi:10.2337/db20-21-LB

Figure. Association between derived TIR and MACE

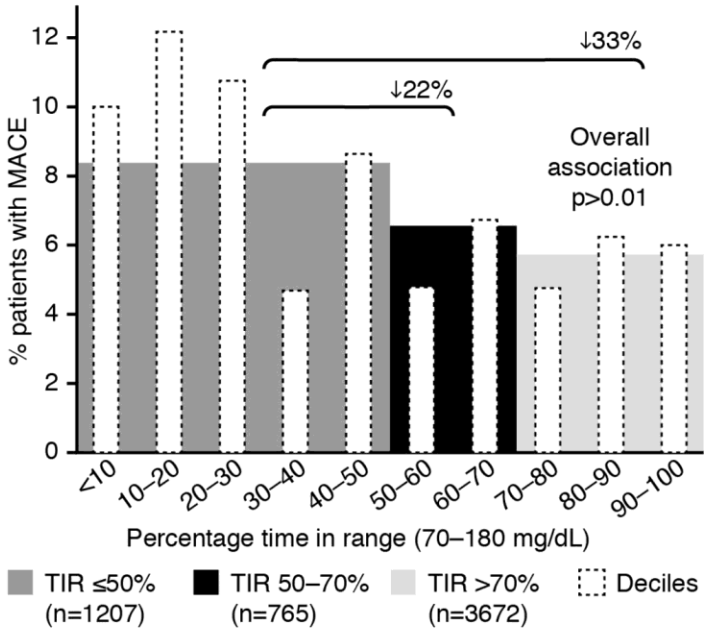


Figure Legend:

Narrow white bars (dashed lines) indicate deciles. Wide, dark grey bar indicates TIR≤50%; black bar indicates TIR 50–70%; light grey bar indicates TIR>70%. The overall association between TIR category and rate of first MACE was significant ($p<0.01$) with estimated reductions of 22% (hazard ratio: 0.78[0.55; 1.09]$_{95\%\ CI}$) and 33% (hazard ratio: 0.67[0.53;0.85]$_{95\%\ CI}$), respectively.
MACE, major adverse cardiovascular events (CV-death, non-fatal myocardial infarction or non-fatal stroke); TIR, time-in-range (percentage of time with plasma glucose between 70–180 mg/dL [3.9–10.0 mmol/L]).

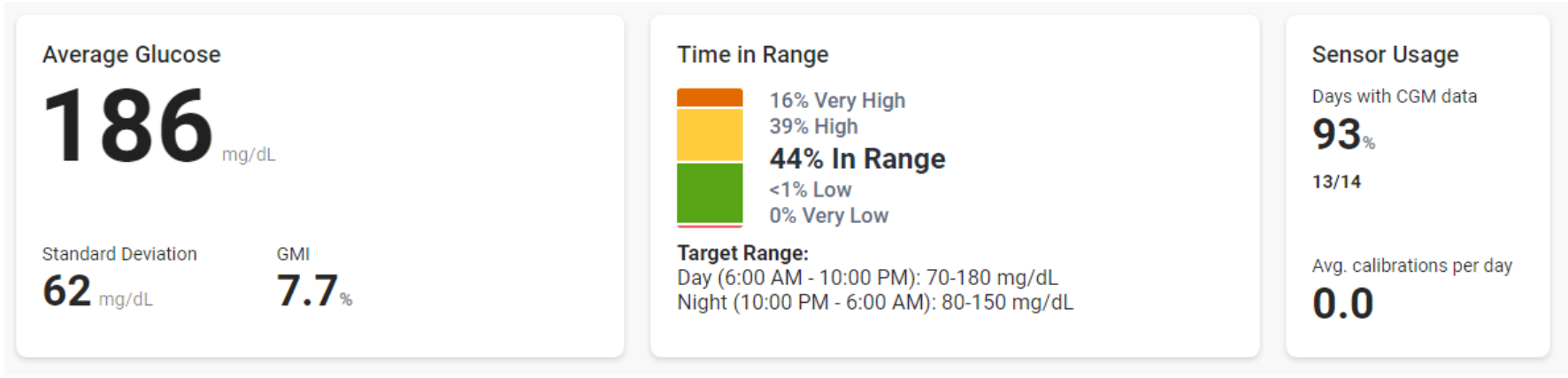
Patients who spend more TIR are more likely to experience a lower rate of first major adverse cardiac events (MACE)

Monthly blood glucose logbook

Day	Breakfast		Lunch		Dinner		Bedtime	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	100							
2	110							
3	95							
4	80							
5	100						200	
6	150							
7	105							
8	99							
9	106							
10	120						150	
11	130							
12	95							
13	80							
14	115							
15	180							
16	120							
17	110							
18	120						160	
19								

Age: 65
Sex: female

A1c 8.2%
Regimen:
liraglutide 1.8 mg daily
metformin 1000 mg twice a day
glargine 25 units daily



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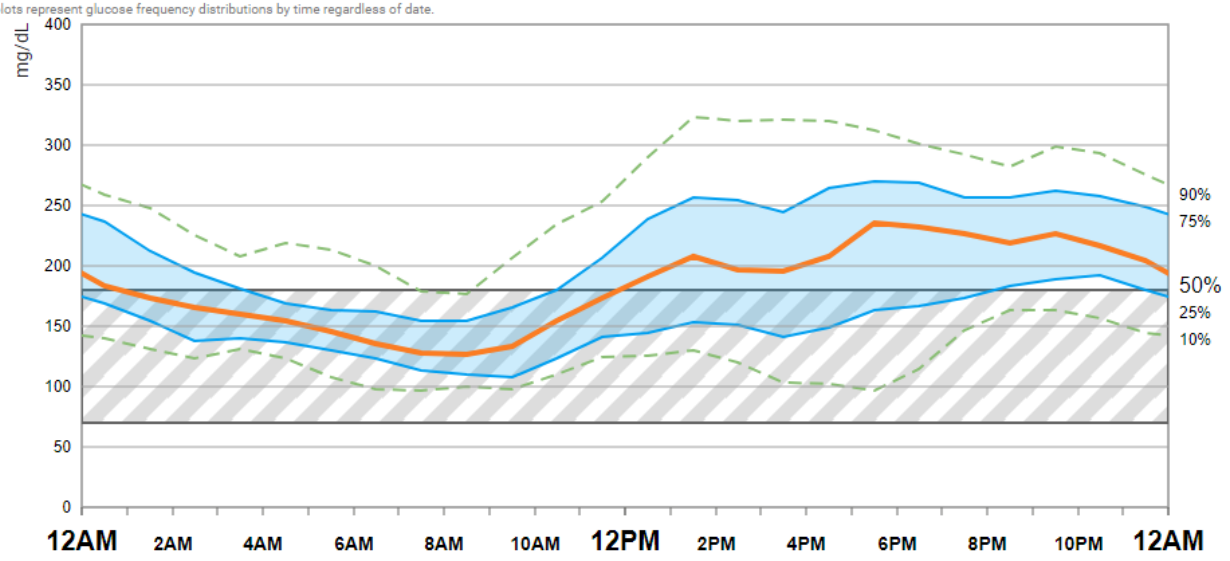
Glucose Statistics

Avg Glucose mg/dL	Very Low	Low	In Target Range	High	Very High	Coefficient of Variation	SD mg/dL	% Time CGM Active
	< 54 mg/dL	< 70 mg/dL	70 - 180 mg/dL	> 180 mg/dL	> 250 mg/dL			
186	0.0%	0.1%	54.7%	45.2%	16.4%	33.5%	62	96.8%
Glucose Exposure	Glucose Ranges					Glucose Variability		Data Sufficiency

CGM | 50% - Median | 25/75% - IQR | 10/90% | Target Range

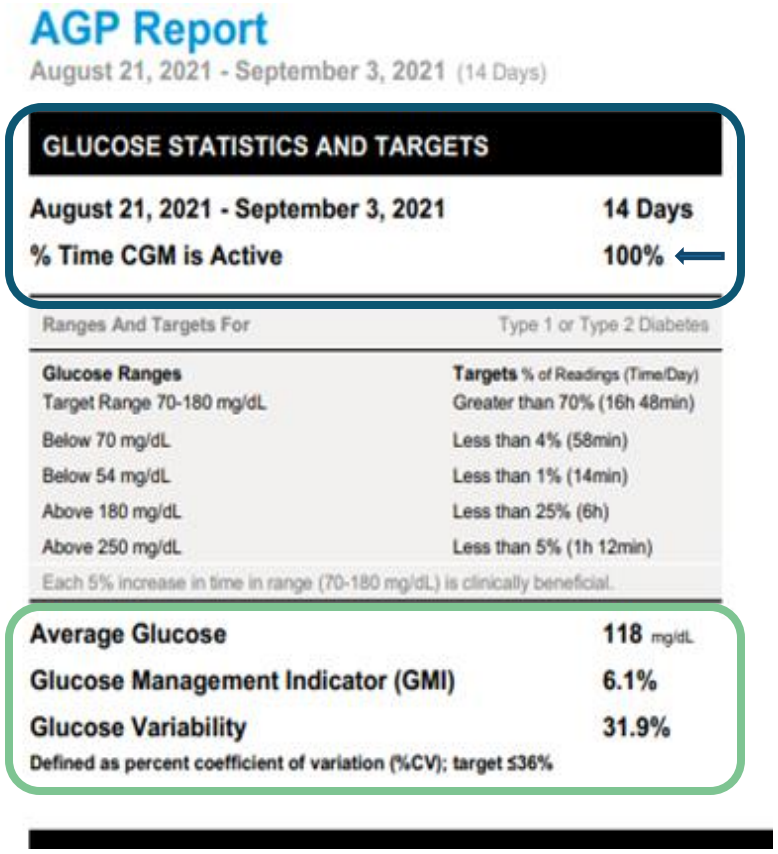
Curves/plots represent glucose frequency distributions by time regardless of date.

Ambulatory Glucose Profile



Interpretation of CGM Reports

Standardized CGM Metrics for Clinical care
Data sufficiency



AGP Report

August 21, 2021 - September 3, 2021 (14 Days)

GLUCOSE STATISTICS AND TARGETS

August 21, 2021 - September 3, 2021	**14 Days**
% Time CGM is Active	**100%** ←

Ranges And Targets For	Type 1 or Type 2 Diabetes
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 180 mg/dL	Less than 25% (6h)
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	**118** mg/dL
Glucose Management Indicator (GMI)	**6.1%**
Glucose Variability	**31.9%**

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

- Ideally 14 days of data
- >70% of data from 14 days
- Glucose management indicator CGM-derived estimate of current A1C level
- Measure of glycemic variability (SD/mean) ≤36% considered acceptable

Grunberger G, Sherr J, Allende M, et al. American Association of Clinical Endocrinology Clinical Practice Guideline: The Use of Advanced Technology in the Management of Persons With Diabetes Mellitus. Endocr Pract. 2021 Jun;27(6):505-537.

How does GMI Compare With The A1C?

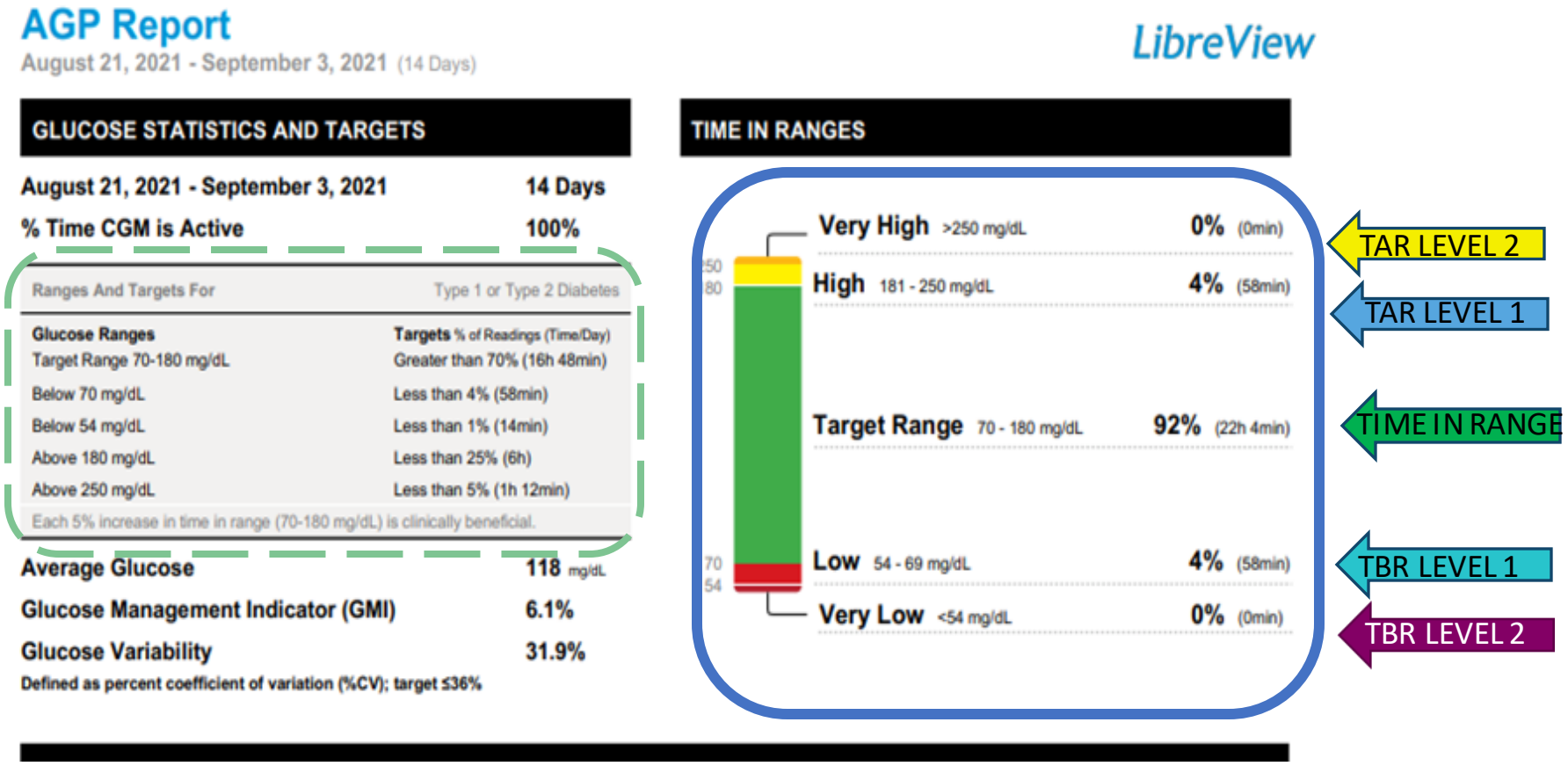
- Glucose Management Indicator (GMI) approximates a patient's A1c using at least 14 days of data
  - Mathematical algorithm based on between 2800 and 20,160 interstitial glucose values obtained during sensor wear of 10-14 days
- A1c is based on glycation to red blood cells assuming the RBC lifespan is 3 months
- 50 % of the total A1C is based upon glycation which occurs within 4 weeks prior to testing.

Limitations to HgbA1c:

- Checked quarterly
- Inaccurate/inconclusive in certain patient populations (ESRD, anemia, hemoglobinopathy, pregnancy, liver disease).
- Over glycation can occur with anemia. Underglycation can occur with rapid RBC turnover such as in patients undergoing dialysis

TIME IN RANGES METRICS

Two metrics should be used as starting point for assessing glycemic control:
%TIR and %TBR



AGP Report

August 21, 2021 - September 3, 2021 (14 Days)

LibreView

GLUCOSE STATISTICS AND TARGETS

August 21, 2021 - September 3, 2021	14 Days
% Time CGM is Active	100%

Ranges And Targets For	Type 1 or Type 2 Diabetes
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 180 mg/dL	Less than 25% (6h)
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	118 mg/dL
Glucose Management Indicator (GMI)	6.1%
Glucose Variability	31.9%

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

TIME IN RANGES

	Very High	>250 mg/dL	0% (0min)
250 / 180	High	181 - 250 mg/dL	4% (58min)
	Target Range	70 - 180 mg/dL	92% (22h 4min)
70 / 54	Low	54 - 69 mg/dL	4% (58min)
	Very Low	<54 mg/dL	0% (0min)

TAR LEVEL 2

TAR LEVEL 1

TIME IN RANGE

TBR LEVEL 1

TBR LEVEL 2

AGP Report

March 18, 2022 - March 31, 2022 (14 Days)

LibreView

GLUCOSE STATISTICS AND TARGETS

March 18, 2022 - March 31, 2022	**14 Days**
% Time CGM is Active	**60%**

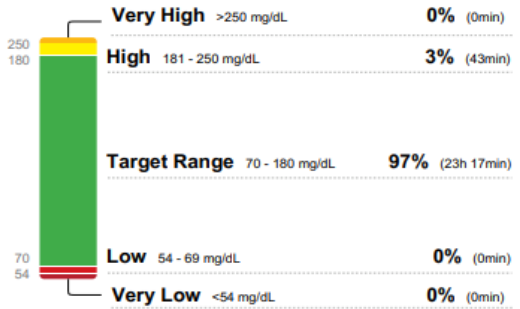
Ranges And Targets For	Type 1 or Type 2 Diabetes
Glucose Ranges	**Targets** % of Readings (Time/Day)
Target Range 70-180 mg/dL	Greater than 70% (16h 48min)
Below 70 mg/dL	Less than 4% (58min)
Below 54 mg/dL	Less than 1% (14min)
Above 180 mg/dL	Less than 25% (6h)
Above 250 mg/dL	Less than 5% (1h 12min)

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

Average Glucose	**122** mg/dL
Glucose Management Indicator (GMI)	**6.2%**
Glucose Variability	**22.3%**

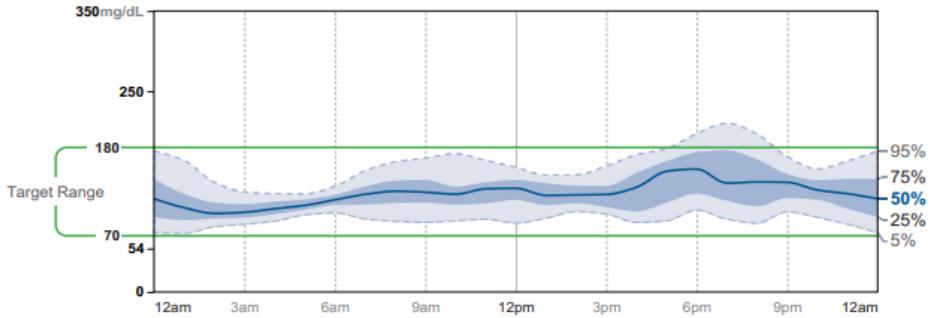
Defined as percent coefficient of variation (%CV); target ≤36%

TIME IN RANGES



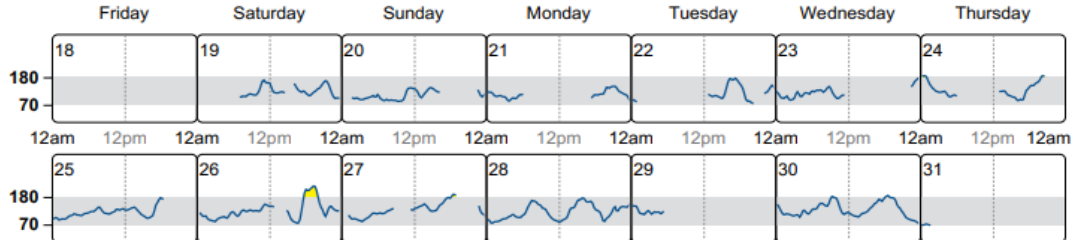
AMBULATORY GLUCOSE PROFILE (AGP)

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 with the date displayed in the upper left corner.



AGP Report

February 27, 2022 - March 12, 2022 (14 Days)

LibreView

GLUCOSE STATISTICS AND TARGETS

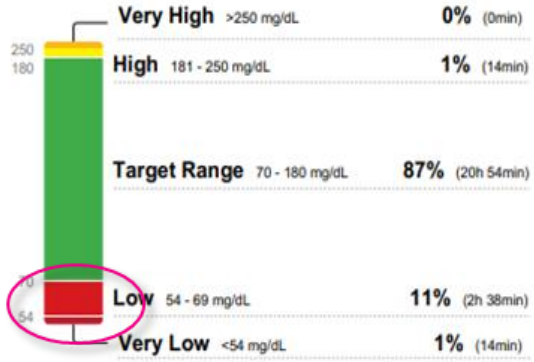
February 27, 2022 - March 12, 2022	**14 Days**
% Time CGM is Active	**100%**

Ranges And Targets For	Type 1 or Type 2 Diabetes
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 180 mg/dL	Less than 25% (6h)
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	**101** mg/dL
Glucose Management Indicator (GMI)	**5.7%**
Glucose Variability	**27.9%**

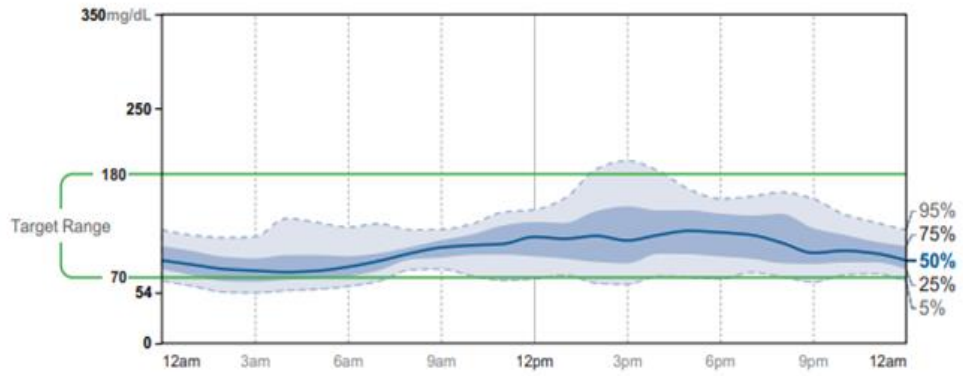
Defined as percent coefficient of variation (%CV); target ≤36%

TIME IN RANGES



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.



Addressing Patterns

Hypoglycemia

- Missing meals
- Stop or decrease Medications
- Consider use of meds which do not increase likelihood of hypoglycemia
- Reduce basal or pre-meal insulin dose
- Modify exercise timing related to insulin dosing
- Reduce or stop alcohol consumption
- Mismatch of prandial insulin dose and carbohydrate meal/intake

Time in Range < 70 %

- Discuss med adherence
- Add agents
- Discuss carb counting (identification) or meal size as related to prescribed insulin dosing

CGM Qualifying Criteria

CGM: type 1 diabetes or type 2 diabetes on intensive insulin therapy

Diagnosis codes are important

Commercial Plans	Medicare[1]	Medicaid[2]
▪ Plan specific, more flexibility ▪ Coverage often through pharmacy vs DME companies	▪ 3+ injections per day or established on insulin pump for ≥6 mo ▪ Requires frequent adjustments of insulin based on BG/CGM data ▪ 6-mo provider visits for continued coverage	▪ Similar to Medicare with a few plan-specific exceptions ▪ Some plans require either documented hypoglycemia unawareness or evidence of multiple severe low BGs (<50 mg/dL) ▪ 30-day log showing >4 finger sticks per day required for most plans

cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNProducts/Downloads/ProviderComplianceTipsforGlucoseMonitors-ICN909465.pdf. 2. diatribe.org/medicaid-cgm.

CPT Codes for Professional Reimbursement

CPT code	Descriptor
95249	Patient-owned (non-professional) CGM sensor placement, hook-up, calibration, patient training, removal of sensor, and printout of recording - Requires minimum of 72 hours of data collection - Can only be billed once for the duration the patient owns the device
95250	**Professional** CGM sensor placement, hook-up, calibration, patient training, removal of sensor, and printout of recording - Requires minimum of 72 hours of data collection - Can be billed once per month
95251	CGM download and interpretation - Patient does not have to be physically in the office - Can be billed once a month - Requires minimum of 72 hours of data for review
99091	Download and interpretation of insulin pump data - Can be billed once a month - CPT codes 95249, 95250, and 95251 cannot be billed in addition to this code

https://www.cms.gov/medicare/physician-fee-schedule/search

Diabetes Technology in the Inpatient Setting

Diabetes Technology in the Inpatient Setting

- Remote inpatient diabetes management is rapidly evolving
- Recent studies have showed accuracy and improved clinical outcomes
- Use of CGM devices have demonstrated increased detection of hyper- and hypoglycemia, and reduced hypoglycemia
- Currently, CGM devices are not approved by the FDA for use in the hospital

Gothong C, Singh LG, Satyarengga M, Spanakis EK. Continuous glucose monitoring in the : an update in the era of COVID-19. Curr Opin Endocrinol Diabetes Obes. 2022 Feb 1;29(1):1-9.
Perez-Guzman MC, Shang T, Zhang JY, Jornsay D, Klonoff DC. Continuous Glucose Monitoring in the Hospital. Endocrinol Metab (Seoul). 2021 Apr;36(2):240-255

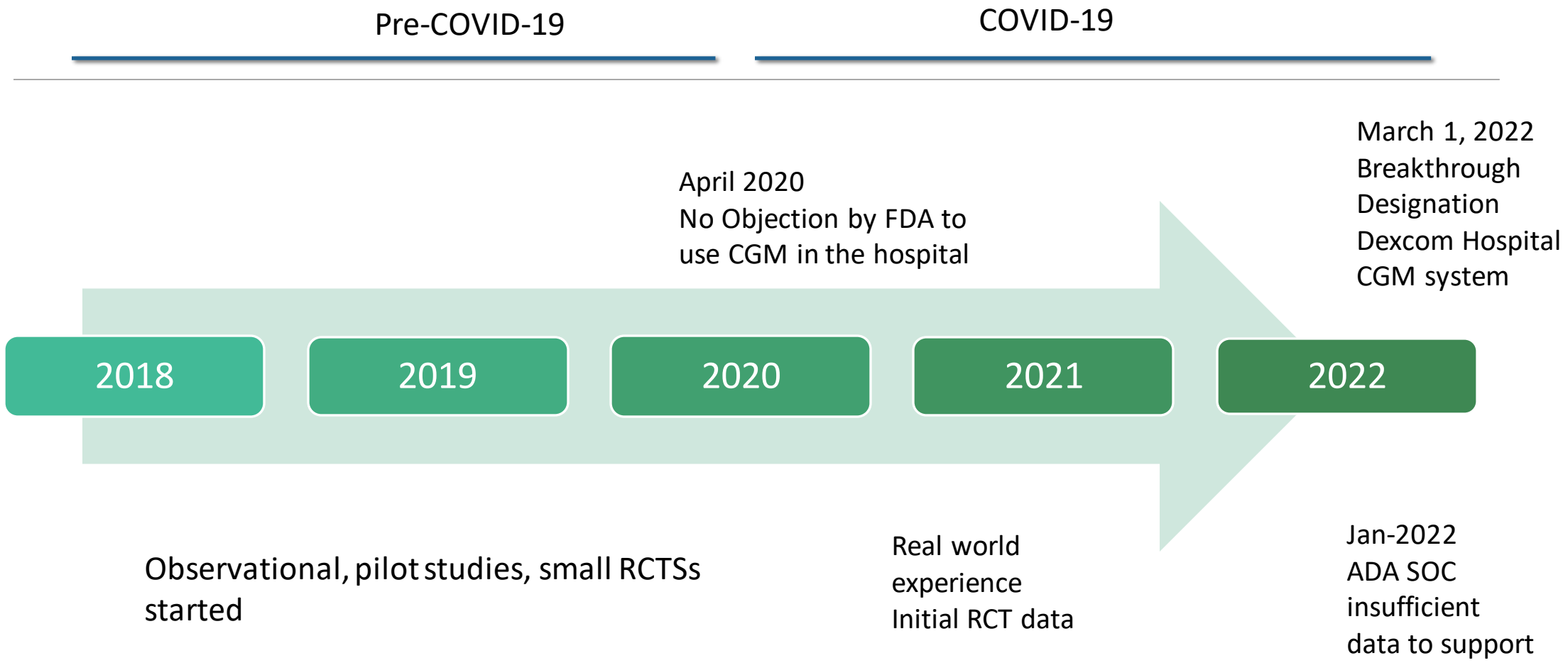
Diabetes Technology in the Inpatient Setting

- The continuation of CGM and/or CSII should be considered in hospitalized persons with diabetes (AACE guideline/Grade A; Intermediate Strength of Evidence; BEL 1)
- Noncritically ill hospitalized patients who are at high risk of hypoglycemia, the use of real-time CGM with confirmatory bedside POC blood glucose is suggested (Endocrine Society Clinical Practice Guideline 2022/(2⊕⊕OO))
- Noncritically ill hospitalized patients using insulin pump can continue it rather than changing to SQ basal bolus insulin therapy in hospitals with access to personnel with expertise in insulin pump therapy (Endocrine Society Clinical Practice Guideline 2022/(2⊕⊕OO))

Grunberger G, Et Al. American Association Of Clinical Endocrinology Clinical Practice Guideline: The Use Of Advanced Technology In The Management Of Persons With Diabetes Mellitus. Endocr Pract. 2021 Jun;27(6):505-537

Korytkowski, et al/ , Management of Hyperglycemia in Hospitalized Adult Patients in Non-Critical Care Settings: An Endocrine Society Clinical Practice Guideline, *The Journal of Clinical Endocrinology & Metabolism*, Volume 107, Issue 8, August 2022, Pages 2101–2128, https://doi.org/10.1210/clinem/dgac278

Timeline of CGM in the Inpatient setting



Reference	Population	Study design	CGM used	Study aim	Results
Singh et al.	T2DM (n = 72) Non-ICU Medicine	RCT Single center	Dexcom G6	RT-CGM/GTS for the prevention of hypoglycemia	RT-CGM/GTS had fewer hypoglycemic events (<70 mg/dL) per patient vs. POC group (0.67 vs. 1.69, P = 0.024).
Fortmann et al.	T2DM (n = 110) Non-ICU Medicine/Surgery	RCT Single center	Dexcom G6	RT-CGM for management of acute hyper-/hypoglycemia	RT-CGM reduced percentage of time spent in hyperglycemia > 250 mg/dL vs. UC (27% vs. 33%, P = 0.04)
Davis et al.	T2DM (n = 209) DM (n = 9) Non-ICU Medicine/Surgery	Pooled analysis of clinical studies Multicenter	Dexcom G6	Accuracy study between CGM and POC	CGM had an overall MARD of 12.8% and median ARD of 10.1%.
Galindo et al.	T2DM (n = 97) Non-ICU Medicine/Surgery	Prospective study Multicenter	Abbott FreeStyle Libre Pro	Feasibility and accuracy study between CGM and POC	CGM had an overall MARD of 14.8%.
Nair et al.	DM (n = 10) Non-ICU Surgery	Prospective study Single center	Dexcom G6	Peri-operative accuracy study between CGM and POC	CGM had an overall MARD of 9.4%.
Tripyla et al.	T2DM (n = 8) T1DM (n = 2) Pancreatic diabetes (n = 5) Prediabetes (n = 5) Non-ICU Surgery	Prospective study Single center	Dexcom G6	Peri-operative accuracy study between CGM and POC	CGM had an overall MARD of 12.7% and median ARD of 9.9%.
Perez-Guzman et al.	No DM (n = 15) OR and CICU Surgery	Prospective study Single center	Dexcom G6	Peri-operative accuracy study between CGM and POC	CGM had an overall MARD of 12.9% and median ARD of 10.5%. - Intermittent signal loss during surgery (electrocautery interference).
Migdal et al.	T1DM/T2DM (n = 49) Non-ICU Medicine/Surgery	Pooled analysis of clinical studies Multicenter	Dexcom G6	Accuracy of CGM during radiologic procedures	For diagnostic studies using radiation (X-rays, CT scan, Angiography), CGM had an overall MARD of 13.3% preimaging and 12.7% postimaging.
Dillmann et al	T1DM (n = 28) T2DM (n = 25) Non-ICU Medicine	Prospective study Single center	Medtronic Guardian Connect (Enlite)	Feasibility study of glucose telemetry using Guardian Connect	In those with T2DM and those hospitalized for acute complications, TIR significantly increased between the start of the hospitalization and end of hospitalization, from 75.7% (95%CI 48.5–84.6) to 82.2% (95%CI 63.2–91.8) [P = 0.043], and from 58.3% (95%CI 46.3–69.7) to 66.4% (95%CI 55.6–75.5) [P = 0.031], respectively. - 95% of nurses found GC to be useful while 64% reported that it saved time
Bichard et al.	T1DM (n = 8) T2DM (n = 2) Non-ICU Medicine	Prospective study Single center	Abbot FreeStyle Libre Pro	Feasibility study between CGM and POC in the setting of DKA	Mean POC of the 167 paired measurements was higher than the mean CGM however, both were highly correlated (r = 0.84, P < 0.001)
Furushima et al.	DM/UnDM (n = 40) ICU Medicine	Prospective study Single center	Abbot FreeStyle Libre	To determine the MAGE using CGM data in septic patients and to assess associations of MAGE with clinical outcomes and oxidative stress	Nonsurvivors had a higher median value of MAGE [68.8 (IQR: 39.7–97.2) mg/dL] compared to survivors [39.3 (IQR: 19.9–53.5) mg/dL], (P = 0.02).
Abdelhamid et al.	T2DM (n = 31) Non-ICU Medicine/Surgery	Prospective study Multicenter	Dexcom G4	Detection of hypoglycemia in ICU survivors after ICU discharge	12 patients (39%; 95% CI, 22–56%) experienced at least one hypoglycemic episode. Hypoglycemia in the ICU survivors were predominantly nocturnal (40/51 hr, 78%), asymptomatic (25/29 episodes, 86%), with 5.24% ± 5.50% of total monitoring time spent in hypoglycemia.

Inpatient CGM Studies in non-COVID-19 patients

- Non critical care setting
- Glycemic outcomes with use of real-time-CGM -- 2 single-center RCTs
- Accuracy of Dexcom G6 MARD ranged between 9.4–12.9%
- Use of GTS: Real time-CGM/GTS group had fewer hypoglycemic events
- Accuracy of Freestyle Libre Pro: MARD of 14.8%.
- Despite reduced accuracy compared with the outpatient setting, CGMs have had acceptable safety profiles in the inpatient setting

Gothong C, Singh LG, Satyarengga M, Spanakis EK. Continuous glucose monitoring in the : an update in the era of COVID-19. Curr Opin Endocrinol Diabetes Obes. 2022 Feb 1;29(1):1-9.

Inpatient CGM Studies in COVID-19 patients

Reference	Population	Study Design	CGM Used	Study Aim	Results
Faulds et al.	T1DM (n = 2) T2DM (n = 16) No DM (n = 1) ICU Medicine	Retrospective analysis Single center	Dexcom G6	Feasibility of RT-CGM for insulin infusion titration	CGM had an overall MARD of 13.9 ± 7.8% (median 11.9, IQR 3.3–29.4) on day 1 and 13.5 ± 8.1% (median 10.6, IQR 9.0–15.0) on days 2 through 7. - Use of CGM resulted in 71% reduction in POC use - Negative association found between BMI and MARD (coefficient = -0.291, P = 0.007).
Chow et al.	DM (n = 30) ICU Medicine	Retrospective study Single center	Dexcom G6	Feasibility and accuracy study of RT-CGM and POC	14% reduction in mean glucose during RT-CGM management vs. pre RT-CGM management (235.7 ± 42.1 to 202.7 ± 37.6 mg/dl, P = 0.003). - Use of CGM resulted in 50% reduction in POC use - 63% of nurses reported RT-CGM helped improved clinical care while 49% reported concomitant reduction in PPE use.
Agarwal et al.	T1DM (n = 3) T2DM (n = 6) No DM (n = 2) ICU Medicine	Prospective study Single center	Dexcom G6	Feasibility and accuracy study between CGM and POC	- CGM had an overall MARD of 12.58% and median ARD of 6.3% - Use of CGM resulted in an estimated 60% reduction in POC use
Reutrakul et al.	DM (n = 9) Non-ICU Medicine	Prospective study Single center	Dexcom G6	Feasibility and accuracy study between CGM and POC	CGM had an overall MARD of 9.77%
Sadhu et al.	T1DM (n = 1) T2DM (n = 8) Prediabetes (n = 1) Posttransplant DM (n = 1) ICU Medicine	Retrospective study Single center	Medtronic Guardian Connect Dexcom G6	Feasibility and accuracy study between CGM and POC	Overall MARD was 13.1% for Medtronic and 11.1% for Dexcom (P = 0.13) - Sensor insertion for both systems were easily done however the Medtronic sensor required more steps as calibration was required when compared to Dexcom. Both systems were noted have a tedious initial setup (i.e., creation of individual accounts on manufacturer's cloud-based platforms)
Ushigome et al.	T2DM (n = 1) Non-ICU Medicine	Case report Single center	Dexcom G4	Feasibility study of RT-CGM for insulin infusion titration	Safe and effective management of hyperglycemia using RT-CGM for insulin infusion without increasing hypoglycemia risk.
Davis GM et al.	T2DM (n = 9) ICU Medicine	Prospective study Single center	Dexcom G6	Proof of concept study utilizing hybrid CGM/POC protocol and Glucommander	During protocol use, 75.7% of sensor glucose values > 100mg/dL were within 20% of the reference POC, with a mean number of POC tests per day of 8.24 ± 3.06 (63% reduction in POC use) - Sensor readings were lower during hypoperfusion states (PEA, shock) and with signal loss during cardiac arrest and defibrillator use. - Sensor accuracy was also impacted during therapeutic hypothermia and position changes including pronation or inadvertent sensor compression.

Shehav-Zaltman et al.	T1DM (n = 1) T2DM (n = 3)	Case series Single center	Medtronic Guardian Connect (Enlite)	Feasibility study of glucose telemetry using Guardian Connect	- Mean daily glucose measurements decreased from 3.75 ± 0.86 to 1.94 ± 0.31 with CGM use (P = 0.005). - Main challenges include training alternating teams with the calibration procedures and cost from weekly replacement of sensors.
Chow et al.	No DM (n = 1)	Case report	Dexcom G6	Feasibility study of RT-CGM for PN-induced hyperglycemia	RT-CGM found to facilitate timely adjustments to insulin infusion in order to achieve target glucose levels.
Garelli et al.	T2DM (n = 3) COVID-19 induced DM (Pediatric) (n = 1) Posttransplant DM (Pediatric) (n = 1) ICU Medicine	Case series Single center	Dexcom G6	Feasibility study of a multipatient, multisite, multi-CGM sensor monitoring platform	- Developed a multipatient platform (Insumate) for simultaneous remote glucose monitoring. - All patients showed improvement in TIR from 12.8% up to 51.65%
Gomez et al.	T2DM (n = 44) No DM (n = 16) Non-ICU & ICU Medicine	Prospective study Single center	Abbot FreeStyle Libre	Examination of glycemic control metrics using CGM	- No differences between the values of TIR, TAR, TBR, CV, or GMI in patients with the composite outcome (ICU admission, ARDS, AKI) - In a subgroup analysis for patients with hyperglycemia without diabetes, higher TAR > 180 mg/dL was seen in patients with AKI (18 vs. 1%, P = 0.01), and in those with the composite outcome (22.5% vs. 16%, P = 0.04)
Longo et al.	T2DM (n = 27) LADA (n = 1) Non-ICU and ICU Medicine	Prospective study Single center	Dexcom G6	Feasibility and accuracy study between CGM, POC, and Lab reference.	- CGM had an overall MARD of 13.2% (12.1% for ICU and 14% for non-ICU). - CGM glucose values showed higher accuracy when compared to glucose Lab reference (MARD 10.9%) than to POC (MARD 13.9%).
Shen et al.	DM (n = 35) Non-ICU Medicine	Prospective study Single center	Abbot Freestyle Libre	Determine the threshold of glycemia and its association with the outcomes of COVID-19	- Patients with composite adverse outcomes (admission to ICU, need for mechanical ventilation, or morbidity with critical illness) had significantly higher TBR (P = < 0.01) than those without composite adverse outcomes. - Mean glucose level was significantly higher in patients with composite adverse outcomes than those without (174 ± 49.0 vs. 144 ± 21.2 mg/dL, P < 0.01).

Most studies were observational studies or case reports with a small number of subjects.
To date, there are no published RCTs examining CGM devices in COVID-19 patients

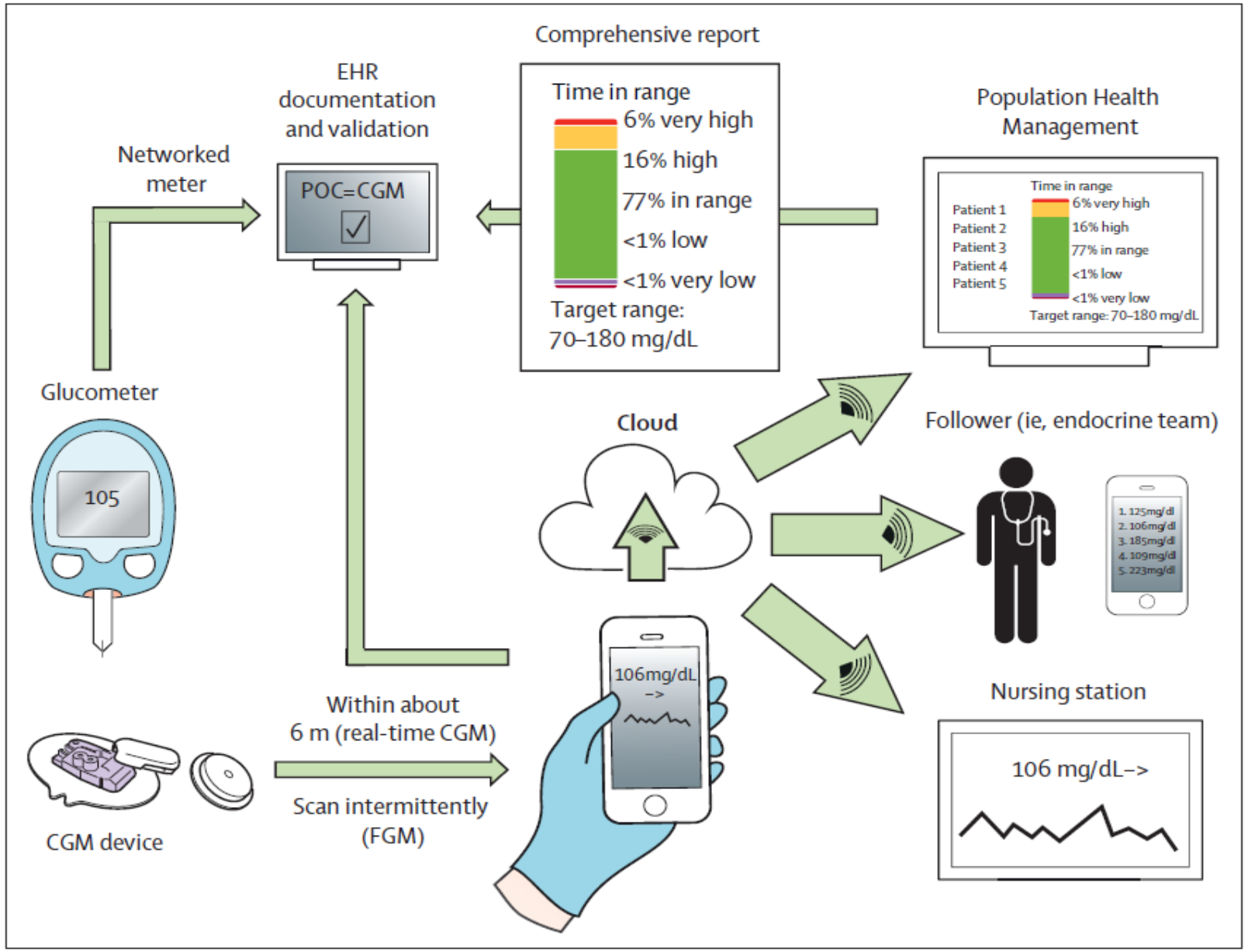


Figure 2: **Remote glucose management during the COVID-19 pandemic**

Pasquel FJ, Lansang MC, Dhatariya K, Umpierrez GE. Management of diabetes and hyperglycaemia in the hospital. Lancet Diabetes Endocrinol. 2021 Mar;9(3):174-188. doi: 10.1016/S2213-8587(20)30381-8. Epub 2021 Jan 27. PMID: 33515493

Challenges of CGM use in the hospital

- Substance interference (Acetaminophen, ascorbic acid, dopamine, mannitol, heparin and ASA) with some CGM devices
- Limited evidence on the accuracy during periods of arterial hypotension, hypothermia or hypoxia
- Measurement Lag
- Information overload with risk of overtreatment
- Real time data transmission to nursing staff and EMR. Documentation of the sensor placement location and inspection of the site
- Need of imaging studies
- Most medical centers still require finger stick values for dosing insulin as a safety precaution
- Cost

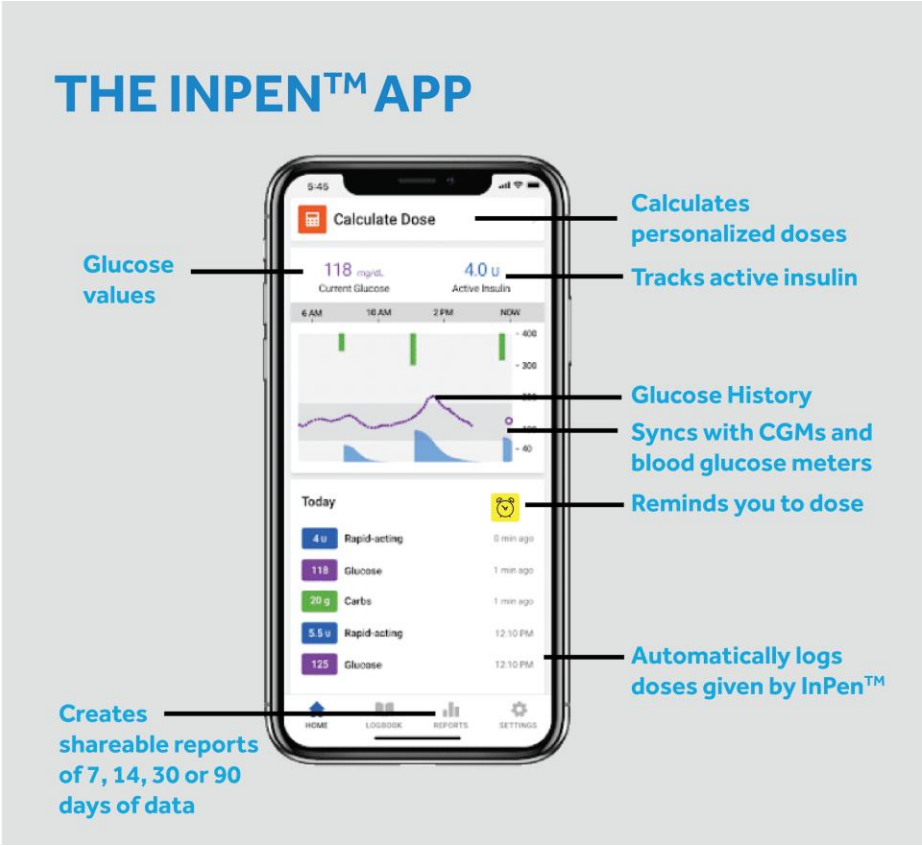
Insulin delivery devices

Subcutaneous basal and bolus injection

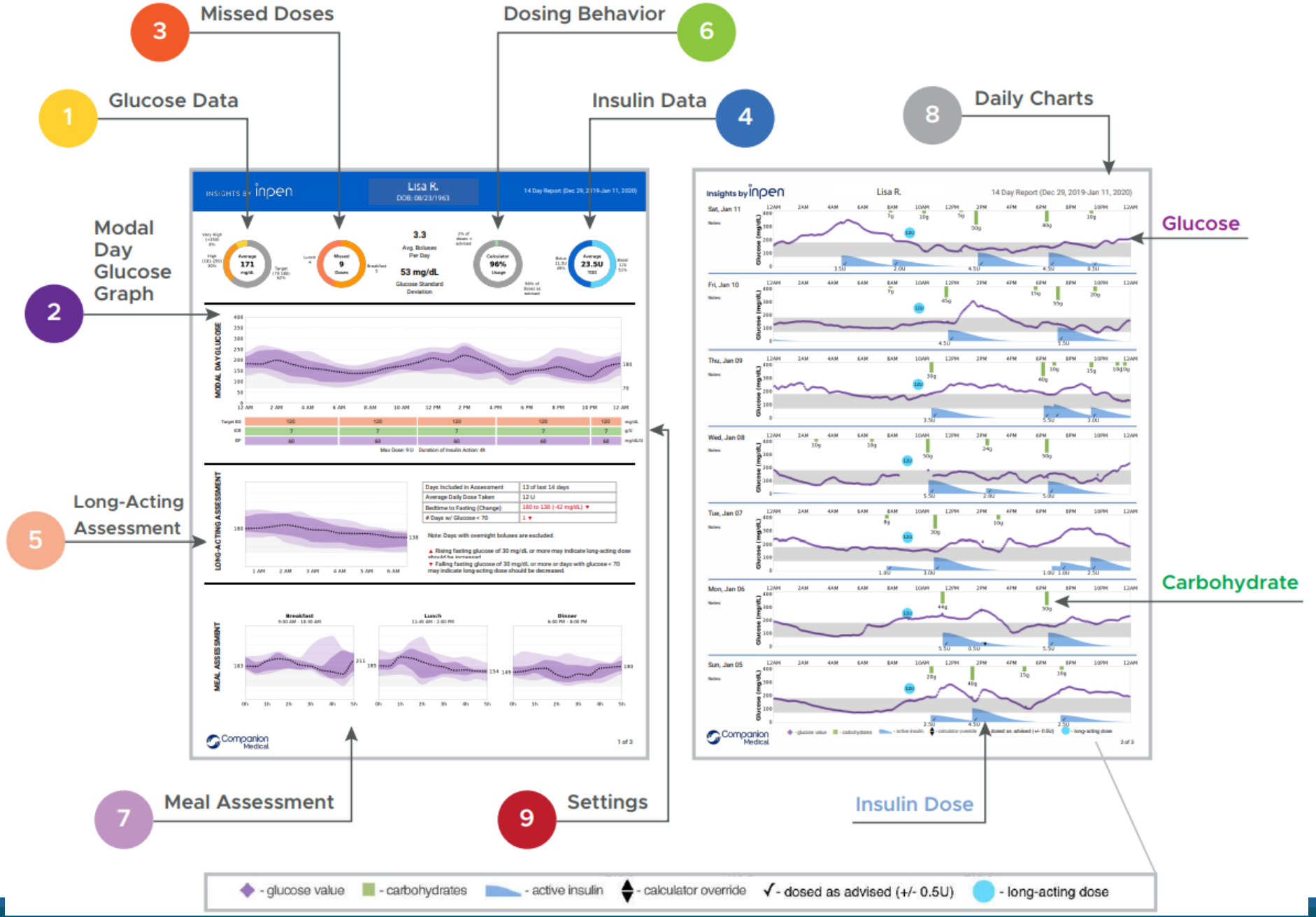
Smart Pens

- Ability to program factors to allow for determination of insulin doses
  - Correction doses are possible using a correction factor/insulin sensitivity factor and a target
  - Meal announcements: insulin-to-carbs ratio with discrete carb counting or a more simplified approach using the size of the meals (small, medium, large)
- Prevent stacking of insulin that could increase the risk of hypoglycemia
- Integration with BGM or sensor glucose data
- Dose reminders, temperature tracking, and units remaining are also features that some smart pens afford

Medtronic InPen:
Insulin dose calculator + Integrated system + App



https://www.medtronicdiabetes.com/products/inpen-smart-insulin-pen-system


3 Missed Doses
6 Dosing Behavior
1 Glucose Data
Insulin Data 4
8 Daily Charts
Modal Day Glucose Graph
2
Glucose
Carbohydrate
Long-Acting Assessment
5
7 Meal Assessment
9 Settings
Insulin Dose
Lisa R.
DOB: 08/23/1963
14 Day Report (Dec 29, 2019-Jan 11, 2020)
3.3
Avg. Boluses Per Day
53 mg/dL
Glucose Standard Deviation
MODAL DAY GLUCOSE
LONG-ACTING ASSESSMENT
MEAL ASSESSMENT
Companion Medical
- glucose value
- carbohydrates
- active insulin
- calculator override
✓ - dosed as advised (+/- 0.5U)
- long-acting dose

Bigfoot unity diabetes

Packaged with Freestyle Libre and meter. All connected, works as a pen cap, all insulins even concentrated

AACE Guideline: Recommendations for Insulin Delivery Technologies

Topic	Recommendation	Grade/Strength of Evidence/Best Evidence Level
Who would benefit from the use of connected pens?	All persons with diabetes treated with intensive insulin management, with ≥3 injections/day and who are not on insulin pump therapy, in whom an assessment of insulin dosing may help the person with diabetes and the clinician optimize the insulin regimen and avoid stacking rapid-acting insulin doses that could lead to hypoglycemia.	C/Intermediate/2
Who would benefit from the use of an insulin pump without CGM?	Persons with diabetes who are achieving glycemic targets with minimal TBR, who report infrequent episodes of symptomatic hypoglycemia, and who are using SMBG on a regular basis (≥4 times/day for T1D).	B/Intermediate-High/1
Who would benefit from the use of an insulin pump with CGM?	All persons with diabetes treated with intensive insulin management who prefer not to use automated insulin suspension/dosing systems or have no access to them.	A/High/1
Who would benefit from the use of more advanced insulin pump technologies: low-glucose suspend (LGS), predictive LGS, and HCL?	LGS strongly recommended for all persons with T1D to reduce severity and duration of hypoglycemia; predictive LGS strongly recommended for all persons with T1D to mitigate hypoglycemia.	A/High/1
	Automated insulin dosing systems strongly recommended for all persons with T1D, since their use has been shown to increase TIR, especially in the overnight period, without causing an increased risk of hypoglycemia. Preferred above other modalities.	A/High/1

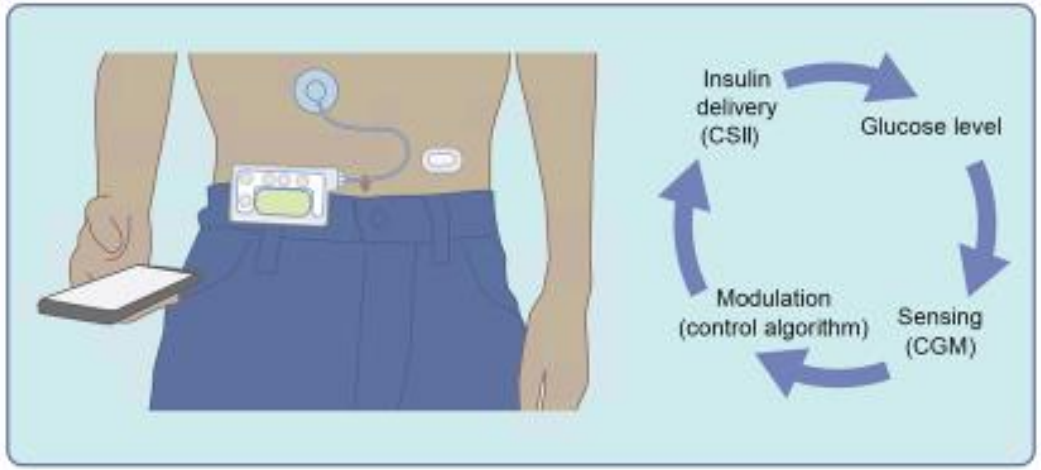
Grunberger. Endocr Pract. 2021;27:505.

Benefits of Pump Therapy

- Changing the infusion set every 3 days
- Finer tuned adjustments of basal insulin delivery
- Smaller increments for basal and bolus insulin dosing
- Preprogrammed bolus calculators
- Insulin on board calculators help prevent stacking of insulin that could increase the risk of hypoglycemia
- Uploading and review of data to help with dose optimization
- Use temporary basal rates physical activity or times of increased insulin needs (illness)
- Provides the foundation for automated insulin delivery

What is the artificial pancreas?

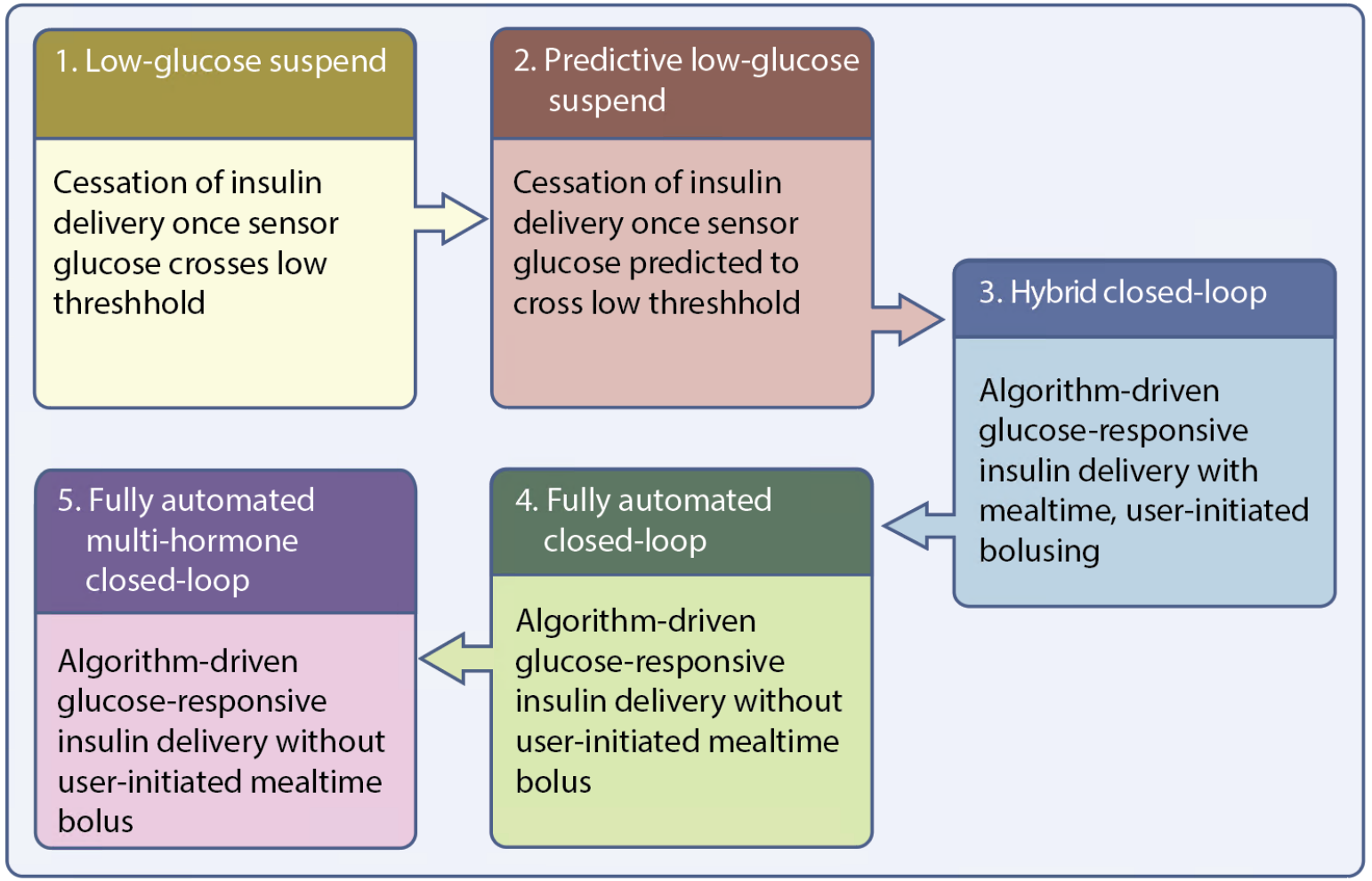
Schematic of the configuration of closed-loop insulin delivery



Boughton and Hovorka (2021) Diabetologia DOI 10.1007/s00125-021-05391-w

Diabetologia

Key developmental milestones towards a truly artificial pancreas

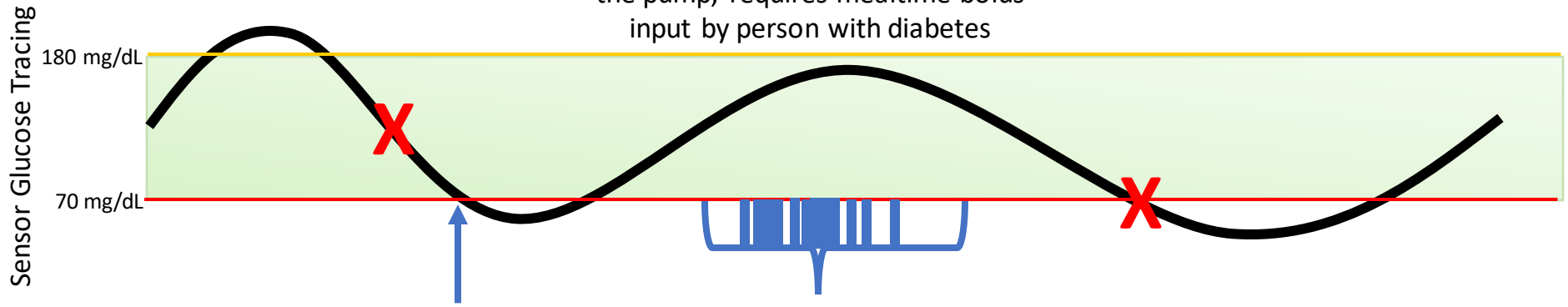


Boughton and Hovorka (2021) Diabetologia DOI 10.1007/s00125-021-05391-w

Diabetologia

Degrees of Automation

Hybrid closed-loop
Sensor glucose data fed to an algorithm, adjusts insulin delivery via the pump, requires mealtime bolus input by person with diabetes



Predictive Low Glucose Suspend
Basal insulin is interrupted once glucose is predicted to crosses low threshold

Additional insulin delivered

Low Glucose Suspend
Basal insulin is interrupted once glucose crosses low threshold

Slide credit: clinicaloptions.com

What pump to choose?

Pod shown without the necessary adhesive.

MiniMed 670 G system with SmartGuard™ technology
Hybrid closed-loop

Initiation: Insulin must be delivered in manual mode for at least 48 hours (preferably 5-7 days)

Auto basal (targets 120 mg/dL)

- Algorithm determines insulin delivery every 5 minutes accounting for current SG value, rate of change, IOB/insulin feedback, other parameters
- Temporary target (150 mg/dL)

Food bolus

- Programmed carbohydrate ratio and number of grams
- Determine meal bolus amount

Correction bolus (target is 150 mg/dL)

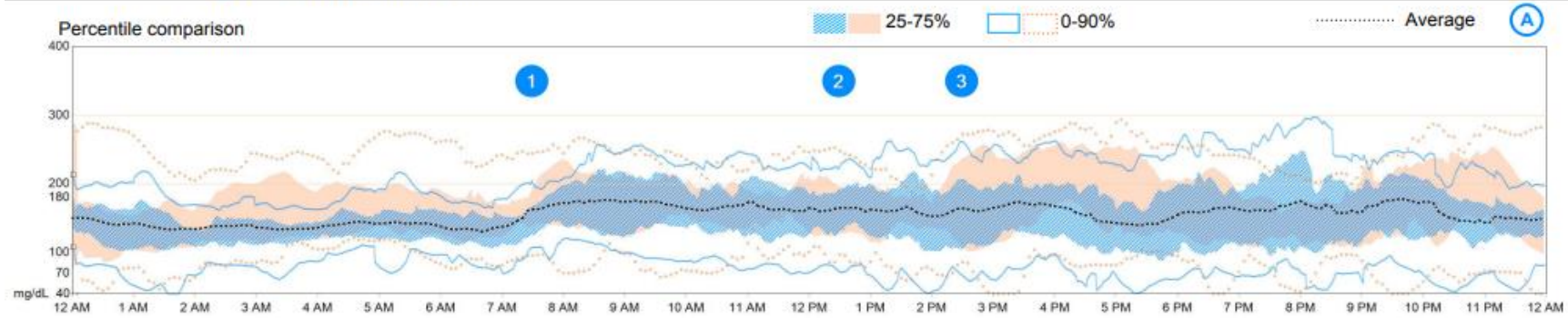
- Sensitivity factor is determined by the algorithm

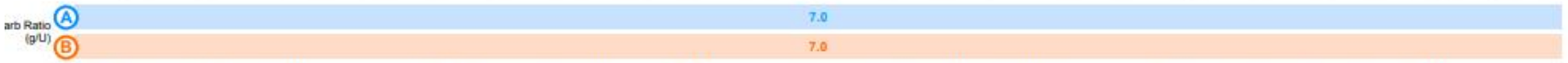
Limitations to 670 G

- Too many alerts
- Requires a minimum of 3-4 BG checks per day to calibrate the CGM
- Requires carb announcements for all meals
- Many guardrails for safety (min basal, max basal, etc.)
- Target at 120 mg/dL with temporary target of 150

MiniMed 770G System

- Bluetooth-enabled version of MiniMed 670G





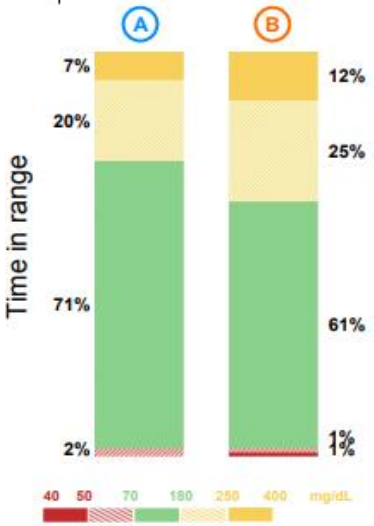
A

Hypoglycemic patterns (0) # Episodes (per day): 0.4

None

Hyperglycemic patterns (13)** # Episodes (per day): 3.2

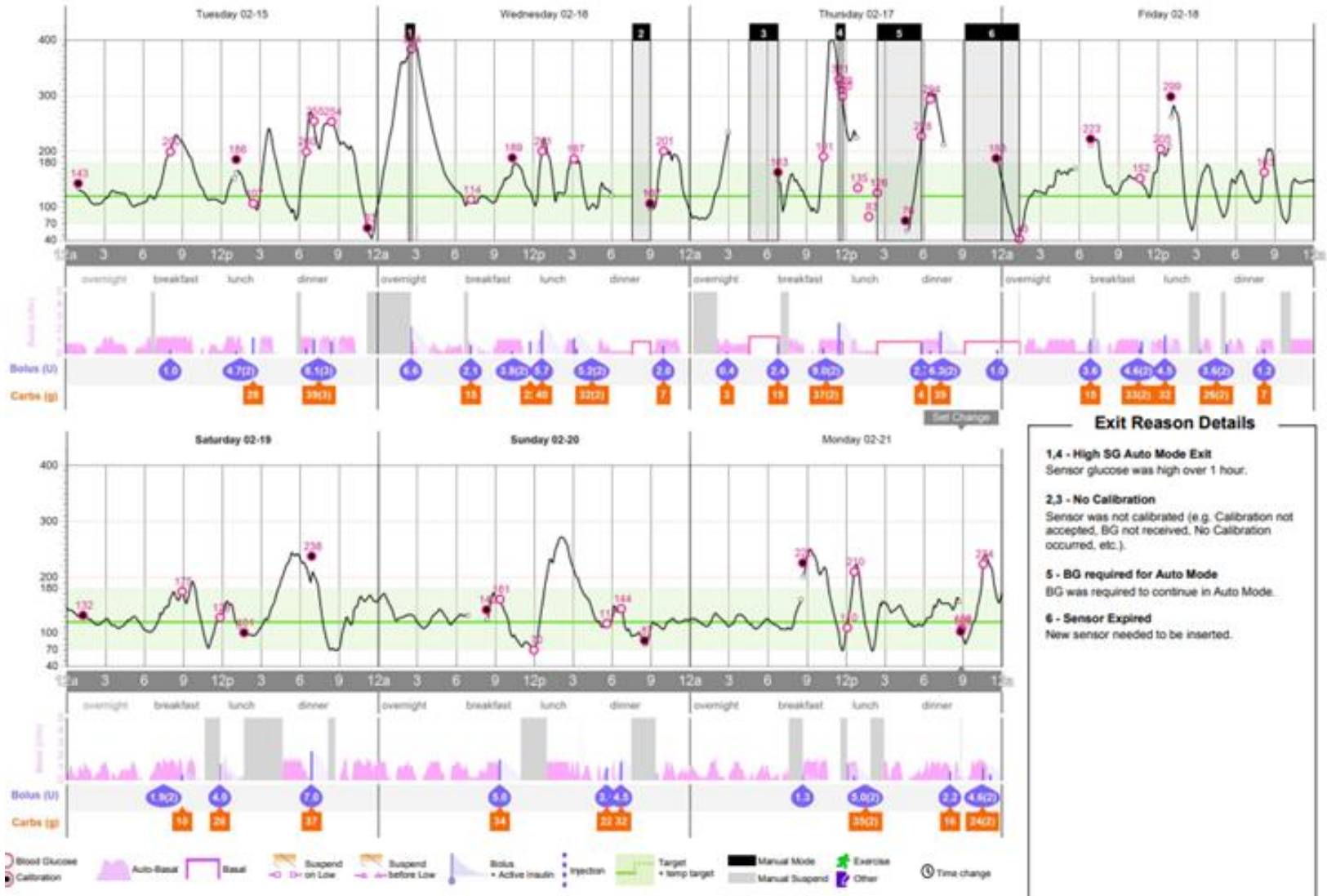
1 7:00 AM - 7:59 AM (9 occurrences)
2 12:00 PM - 12:59 PM (9 occurrences)
3 2:00 PM - 2:59 PM (6 occurrences)



* Only highest priority shown.
** Glucose Management Indicator

Auto Mode Exits	A	B
No Calibration	+ • • • • • 6	6 • • • • • +
High SG Auto Mode Exit	• • • • 4	3 • • •
Auto Mode max delivery	0	0
Auto Mode min delivery	• 1	0
BG required for Auto Mode	• 1	2 • •
Sensor Algorithm Underread	0	1 •
Sensor Updating	• 1	3 • • •
No SG values	• • 2	2 • •
Sensor Expired	• 1	0
Auto Mode disabled by user	0	0
Alarms	0	0
Pump Suspend by user	0	1 •
Auto Mode Warm Up	0	0
Unidentified	0	0

Statistics	A	B
Auto Mode (per week)	95% (6d 16h)	62% (4d 08h)
Manual Mode (per week)	5% (08h)	12% (19h)
Sensor Wear (per week)	91% (6d 08h)	57% (4d 00h)
Average SG ± SD	155 ± 57 mg/dL	168 ± 60 mg/dL
GMI***	7.0%	7.3%
Coefficient of Variation (%)	36.8%	35.7%
Low / High SG Alerts (per day)	3.8 / 4.0	2.8 / 4.5
Average BG	189 ± 76 mg/dL	192 ± 65 mg/dL
BG / Calibration (per day)	7.6 / 2.4	7.5 / 2.1
Total daily dose (per day)	35.1 units	34.0 units
Bolus amount (per day)	19.1U (54%)	16.0U (47%)
Auto Basal / Basal amount (per day)	16.0U (46%)	18.0U (53%)
Set Change	Every 6.3 days	Every 8.0 days
Reservoir Change	Every 4.8 days	Every 7.5 days
Meal (per day)	5.4	4.3
Carbs entered (per day)	100 ± 31 g	69 ± 34 g
Active Insulin time	2:15 hrs	2:15 hrs



Exit Reason Details

1,4 - High SG Auto Mode Exit
Sensor glucose was high over 1 hour.

2,3 - No Calibration
Sensor was not calibrated (e.g. Calibration not accepted, BG not received, No Calibration occurred, etc.).

5 - BG required for Auto Mode
BG was required to continue in Auto Mode.

6 - Sensor Expired
New sensor needed to be inserted.

LAUNCHING

MiniMed™ 670G Hybrid Closed-Loop System

- Over 135K U.S. patients currently trained on the 670G
- Ongoing international rollout

Guardian™ Connect CGM

- Only CGM with IQcast, predicting potential lows, up to 4 hours in advance
- Strong interest outside traditional sales channels in U.S.

FY20

Advanced Hybrid Closed-Loop System with Bluetooth
(MiniMed™ 780G)

- Bluetooth connectivity allowing sharing and software upgrades
- Auto correction bolusing for simplified meal management and hyperglycemia protection
- Data from 3 feasibility studies indicating time-in-range (TIR) of approximately 80%

Non-Adjunctive iCGM Designation

- Non-adjunctive sensor to allow dosing and CMS reimbursement

Sugar.IQ™ Gen 2

- Meal handling + carb counting with Nutrino
- Extend predictive insights beyond 60 mins

BEYOND

Personalized Closed-Loop System
(MiniMed™ 890G)

- Real-time personalized therapy
- Advanced adaptation
- >85% TIR goal

Synergy Sensor

- 50% smaller than GS3
- Day 1 calibrations
- Easy 3 step application

Unity Sensor

- No calibrations
- 10-14 days of wear

Sugar.IQ™ Gen 3

- Behavioral feedback
- Overnight glucose prediction

Sugar.IQ™ Gen 4

- Meal prediction w/ dosing
- Advanced glucose prediction

- Auto Basal and Auto boluses correction features
- Adjustable target glucose of as low as 100 mg/dL
- Fewer fingersticks with day 1 calibrations only
- Extended wear infusion set

- Adapts to physiology
- Automated meal handling
- 100% automode capable with TIR goal >85%
- Smartphone control

What is the Control-IQ technology?

- Control-IQ technology is an advanced hybrid closed loop system
- Automatically adjusts insulin delivery every 5 minutes based on 30-minute predicted CGM values, including delivery of automatic correction boluses as needed

Components

- T:slim X2 insulin pump
- Control-IQ embedded algorithm
- Dexcom G6 CGM / No calibration required

Unique Control-IQ algorithm Features

- Automatic basal rate adjustments designed to help keep users in target range
- Automatic corrections boluses
- Automatic pre-population of Dexcom G6 CGM value in bolus calculator
- No calibrations with CGM/Unexpected prompts
- Sleep activity that sets a narrower range of treatment values, designed to help achieve glucose levels of approximately 110-120 mg/dL by the morning
- Exercise activity sets a narrower and higher range of treatment values
- No complicated criteria to staying in closed loop. **CGM data = Control-IQ technology On**
- FDA approved t:connect mobile app to bolus insulin

Highest Blood Glucose
400

Average Blood Glucose
217

Lowest Blood Glucose
60

Blood Glucose Summary

Above Target	> 180 mg/dL	**50**%	**2** times
Target Range	70 - 180 mg/dL	**25**%	**1** times
Below Target	< 70 mg/dL	**25**%	**1** times

Highest CGM Reading
400

Average CGM Reading
127

Lowest CGM Reading
40

Time in Range

Above Target	13%	> 180 mg/dL
Target Range	82%	70 - 180 mg/dL
Below Target	5%	< 70 mg/dL

Number of Days CGM in Use
29.7 days

Control-IQ™ Technology

Average Reading		124 mg/dL
Time in Use	**95**%	**28** d **13** hrs.
Control-IQ Set to Off	**0**%	**0** min.
CGM Inactive[1]	**1**%	**9** hrs. **9** min.
Pump Inactive[2]	**4**%	**1** d **1** hr.
Avg. Sleep & Exercise		
Daily Sleep		**7** hrs. **51** min.
Weekly Exercise Events		**0** times

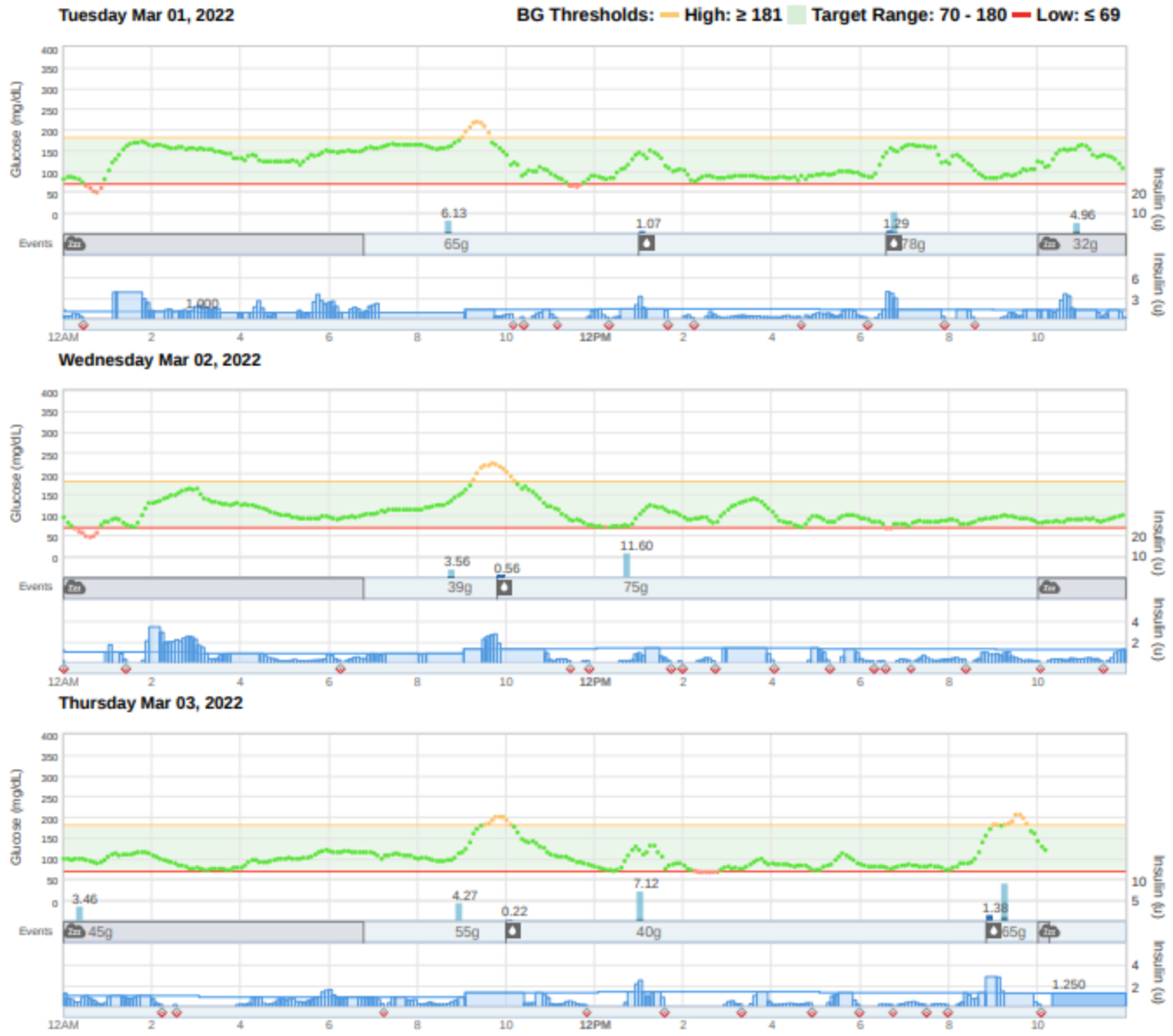
Average Daily Insulin Summary

Basal	**45**%	**20.36** u/day
Food Bolus	**48**%	**21.96** u/day
Correction Bolus	**3**%	**1.19** u/day
Control-IQ Auto Bolus	**4**%	**1.83** u/day

Average Total Daily Dose	**45.34** units / day
Average BG Tests	**0.13** times / day
Average CGM Readings	**284.77** times / day

	Cartridge	Tubing	Site/Cannula
Avg. Change Frequency	Every 3.60 days	Every 3.60 days	Every 12.50 days
Avg. Fill Amount	**150.00** units	**10.55** units	**0.50** units

Therapy Timeline | Friday Feb 25, 2022 - Thursday Mar 03, 2022 CGM Data by Dexcom

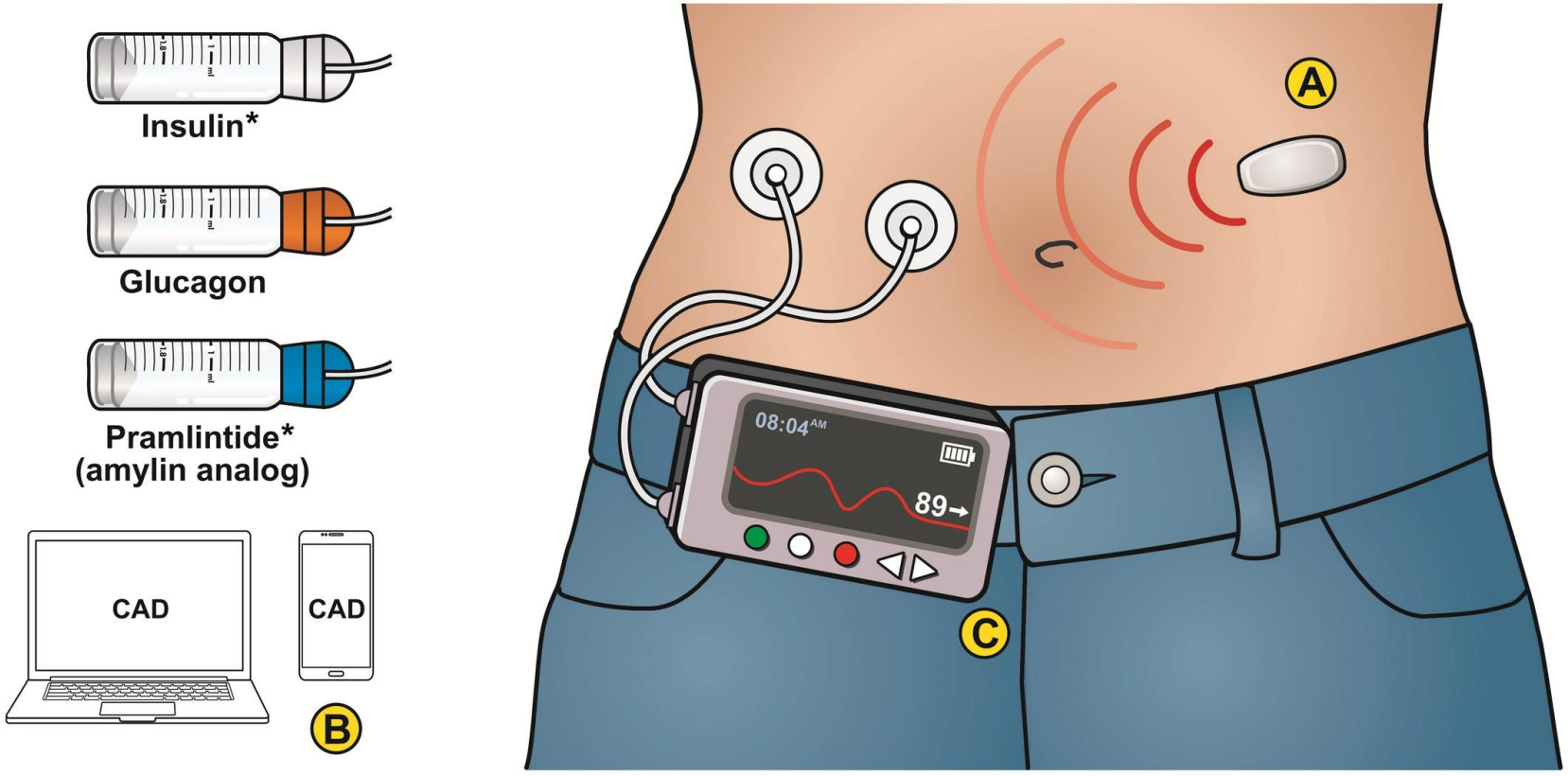


Omnipod® 5

omnipod®
HORIZON®
AUTOMATED GLUCOSE CONTROL

- Customizable Glucose control
- Glucose targets from 100-150 mg/dL, adjustable by time of day
- Hypoprotect Feature for times of elevated hypoglycemia
- Algorithm adapts based on user's insulin delivery history

Dual-hormone closed-loop systems



iLet® Bionic Pancreas

- Data lock completed for the RCT period of the Insulin-Only Bionic Pancreas Pivotal Trial
- Enrollment started for screening protocol of the Bihormonal Bionic Pancreas Pivotal Trial

Summary

- In the past decade there has been a high-speed evolution in diabetes technologies to improve the quality of life and life expectancy of diabetics
- Continues glucose monitoring is a standard of care
- CGM is a cost-effective technology which can successfully improve patient's time in range, reduce hypoglycemia risk and reduce glycemic variability
- CGM should be encouraged within the primary care setting where 90 % of all diabetes management occurs
- Daily SBGM costs are 4.5 x higher/day than using CGM ($11.60 vs $2.59)[1]
- Technologies provide insight in targeting a rational, safe and comprehensive approach to glycemic management
- Patients using advanced technology have been able to improve their time in range, reduce risk of and time spent within hypoglycemia, improve quality of life

1Unger, J. Continuous Glucose Monitoring Overview: Features And Evidence. American Journal Of Managed Care. Vol 28, N. 4; S59-s67. 2022

Summary

- rtCGM appears to be accurate and safe in the hospital settings including patients with reduced eGFR
- Need for more studies for FDA approval to use CGM in the hospital setting
- Smart pens with CGM to be standard of care
- Hybrid Closed Loop systems are improving
- Most systems achieve TIR (>70%)
- Reduce burden for patients
- Progression from Hybrid Closed Loop to fully close loop is undergoing investigation

Thank you