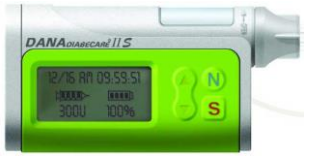
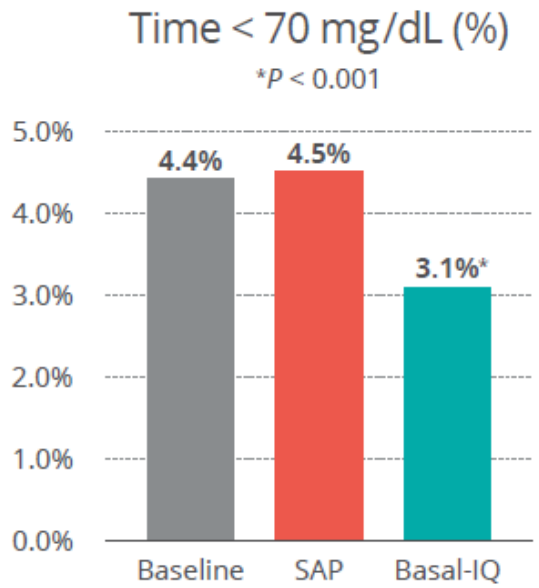
DTN 2019
Technology Update

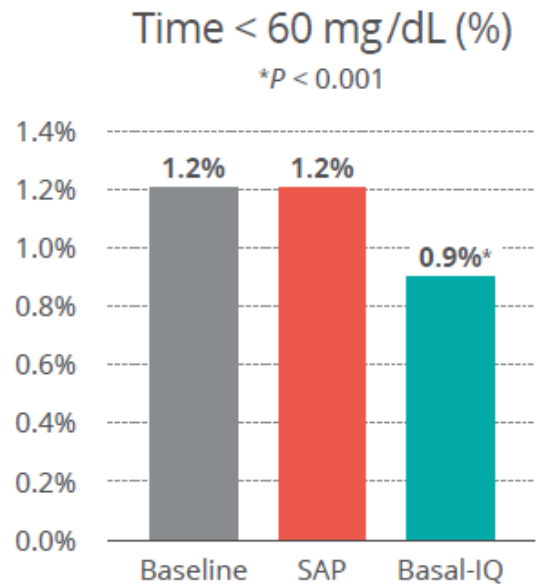
Peter Hammond
Consultant Physician
Harrogate District Hospital

	Medtronic 640G*	Omnipod patch pump	Tandem t:slim X2*	Roche Insight	Dana Diabecare R	Medtrum A6 Touchcare*
Pump features						
Weight	96 g	25 g	112 g	122 g	62 g	21.5 g
Basal increment	0.025 U (0.025-35)	0.05 U (0.05-30)	0.001 U (0.001-15)	0.01 U (0.02-25)	0.01 U (0.04-16)	0.05 U (0.05-10)
Basal rate/d	48	24 @ 30 min	16	24	24	48
Basal profiles	8	7	6	5	4	5
Basal pulse	10m (0.2-60)	0.05 u pulse	5 min	3 min	4 min	?
BG target	Range: target correct	Single target + threshold	Single target	Range: mid correct		Range: ?mid correct
Bolus increments	0.1 U (max 75)	0.05 U (max 30)	0.01 U (max 25)	0.05 U (max 50)	0.05 U (max 80)	0.05 U (max 25)
Occlusion alarm @1.0u/h	2-3.8 h	1.5-5.5 h	< 2 h** **2 u/h	2.2 h	?	< 3 h
Insulin volume	300 u	200 u	300 u	160 u	300 u	200 u

*Sensor augmentation option

Tandem t:slim X2™ Insulin Pump with Basal-IQ™ Technology





Forlenza et al. *Diabetes Care* 2018;41:2155-61

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Occlusion Detection

Pump system	Insulin pump
1 AI-F	Accu-Chek® Insight
2 AI-R	Accu-Chek® Insight
3 ASC-F	Accu-Chek® Spirit Combo
4 ASC-R	Accu-Chek® Spirit Combo
5 AV-I	Animas® Vibe®
6 M6-Q	MiniMed® 640G
7 MO	mylife™ OmniPod®
8 PV-M	Paradigm® VEO™
9 PV-Q	Paradigm® VEO™
10 PV-S	Paradigm® VEO™

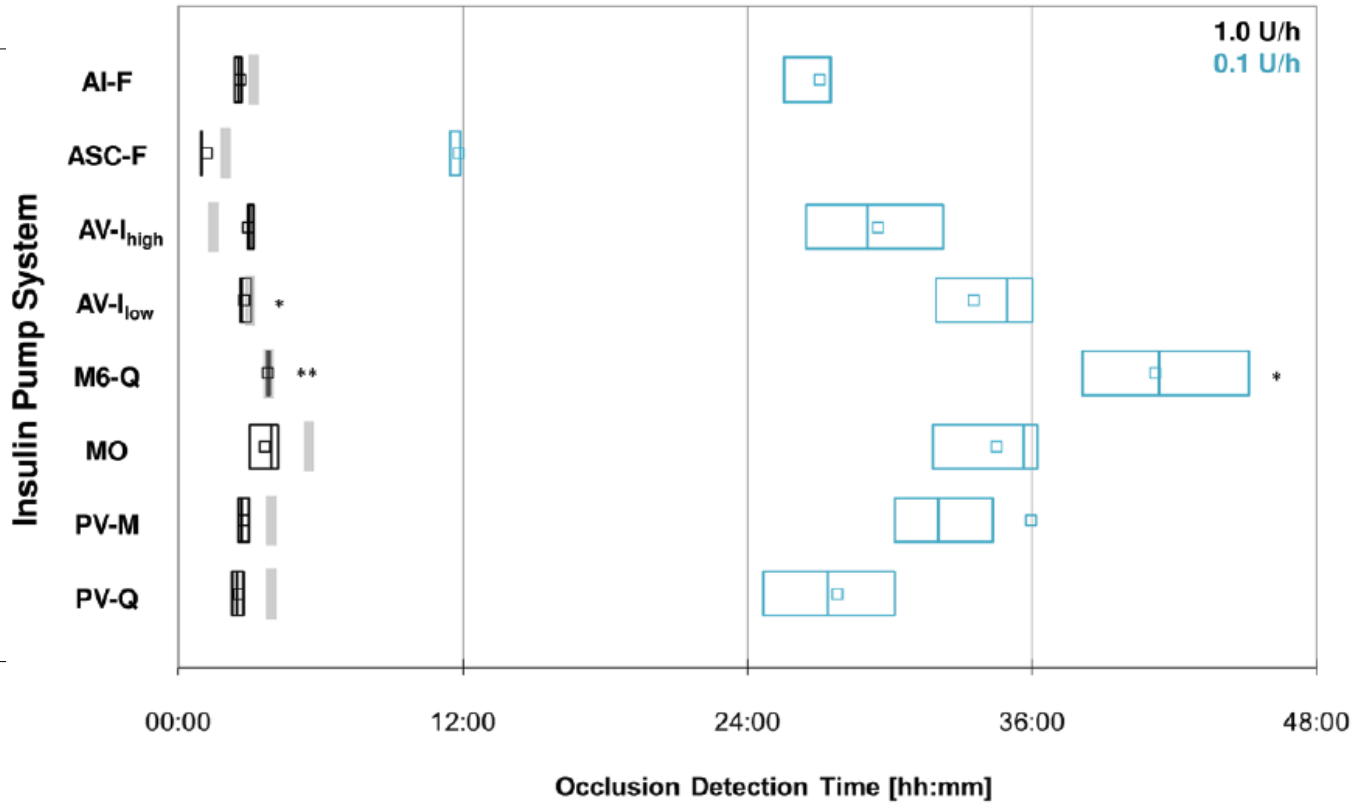

Figure 2. Occlusion detection time of insulin pump systems with soft cannula at basal rates of 1.0 U/h (black) and 0.1 U/h (blue), 9 measurements each. Squares show the mean value, boxes the interquantile range (25-75%) with median, and gray bars the maximal occlusion detection time for 1.0 U/h as indicated by the manufacturer. *8 measurements (no alarm in 1 measurement). **7 measurements (no alarm in 2 measurements).

Freckman G et al. *J Diabet Sci Tech* 2018;12:608-13

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Bolus accuracy

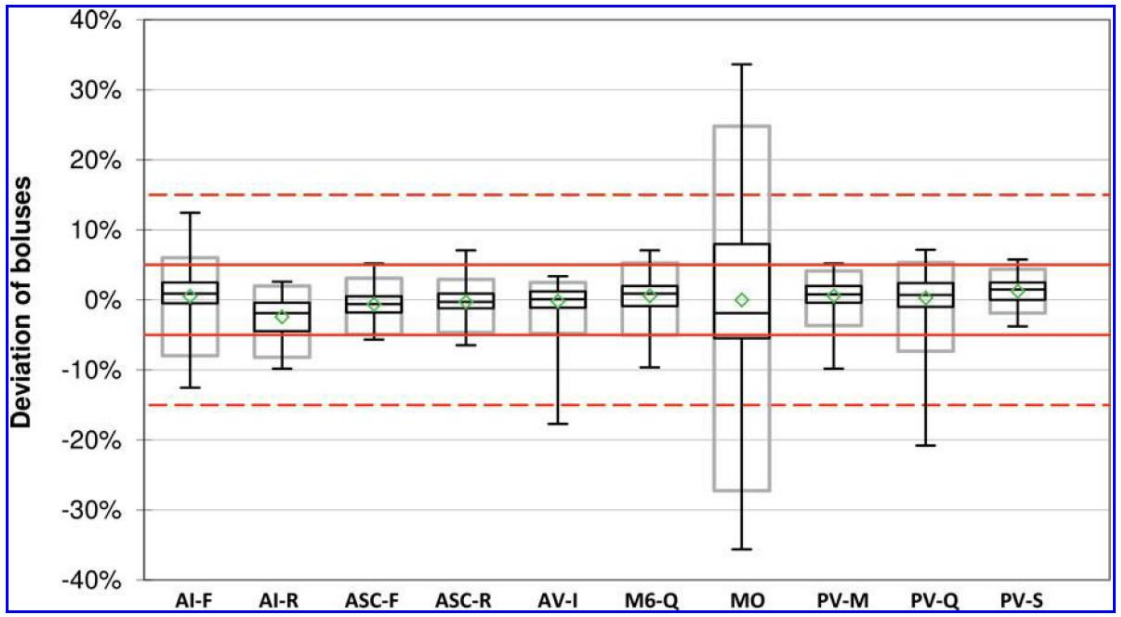

FIG. 1. Bolus accuracy for 1 U boluses. For each system, mean (green diamonds), median with first and third quartile (black boxes), minimum and maximum (antennae), and 95% range (gray boxes) are shown ($n = 225$ boluses). Red lines and red dashed lines indicate target ±5% and target ±15%, respectively.

Pump system	Insulin pump
1 AI-F	Accu-Chek® Insight
2 AI-R	Accu-Chek® Insight
3 ASC-F	Accu-Chek® Spirit Combo
4 ASC-R	Accu-Chek® Spirit Combo
5 AV-I	Animas® Vibe®
6 M6-Q	MiniMed® 640G
7 MO	mylife™ OmniPod®
8 PV-M	Paradigm® VEO™
9 PV-Q	Paradigm® VEO™
10 PV-S	Paradigm® VEO™

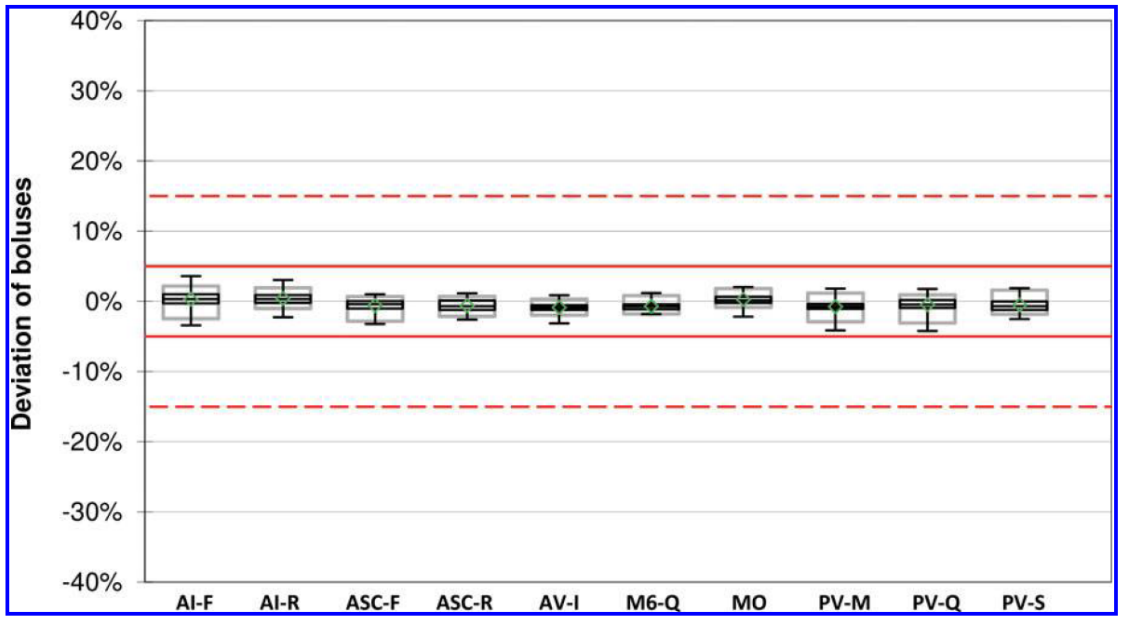

FIG. 2. Bolus accuracy for 10 U boluses. For each system, mean (green diamonds), median with first and third quartile (black boxes), minimum and maximum (antennae), and 95% range (gray boxes) are shown ($n = 108$ boluses). Red lines and red dashed lines indicate target ±5% and target ±15%, respectively.

Freckman G et al. *Diabetes Tech Ther* 2019;21:201-8

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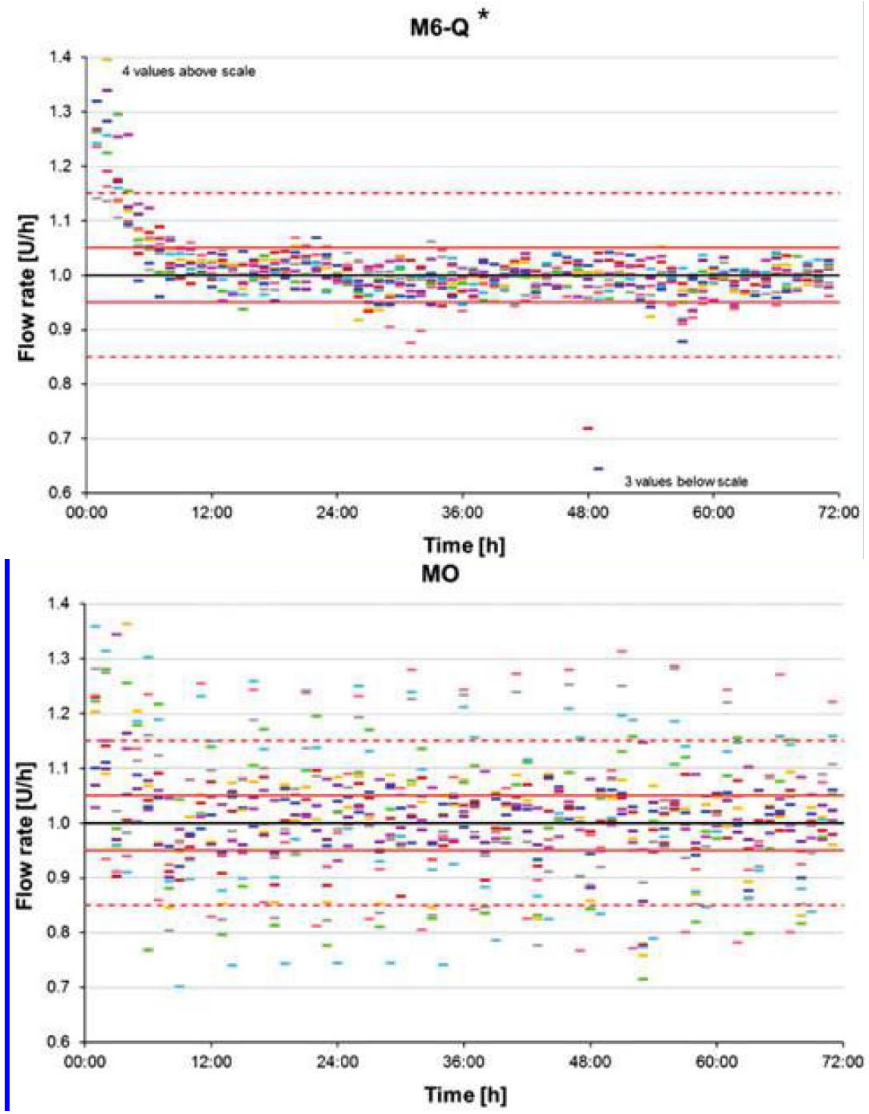
Basal rate accuracy



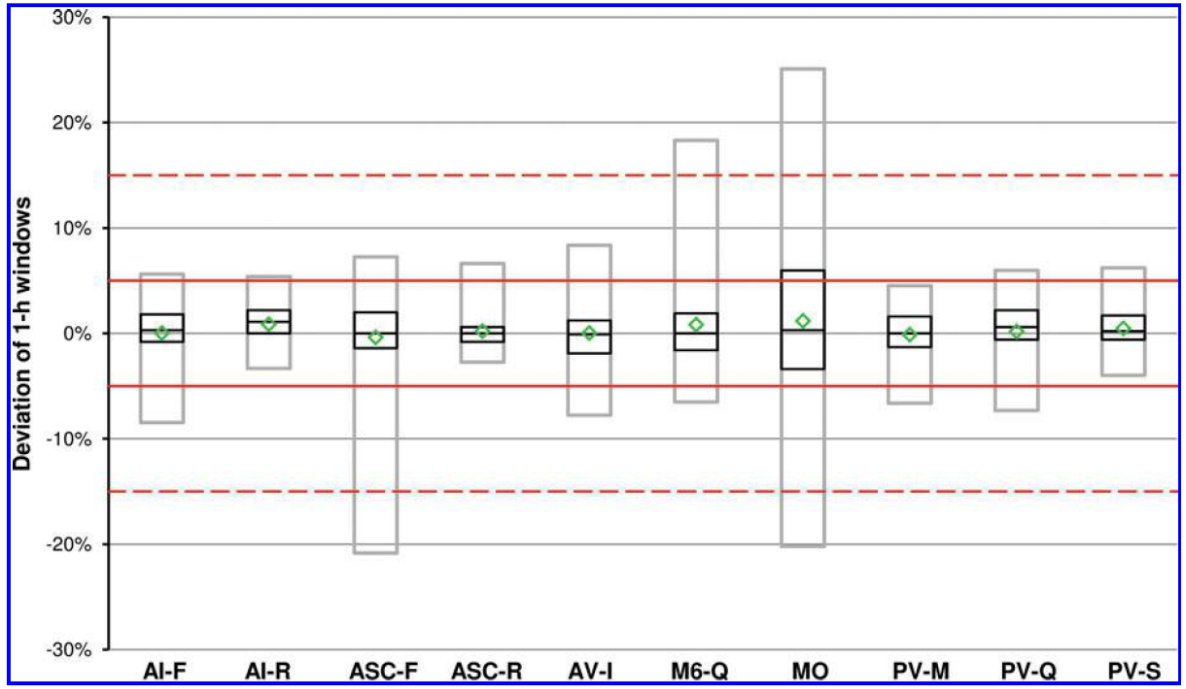


FIG. 4. Basal rate accuracy of 1-h windows of all insulin pump systems at 1.0 U/h. For each system, mean (green diamonds), median with first and third quartile (black boxes), and 95% range (gray boxes) are shown ($n = 648$ values). Red lines and red dashed lines indicate target ±5% and target ±15%, respectively.

Pump system	Insulin pump
1 AI-F	Accu-Chek® Insight
2 AI-R	Accu-Chek® Insight
3 ASC-F	Accu-Chek® Spirit Combo
4 ASC-R	Accu-Chek® Spirit Combo
5 AV-I	Animas® Vibe®
6 M6-Q	MiniMed® 640G
7 MO	mylife™ OmniPod®
8 PV-M	Paradigm® VEO™
9 PV-Q	Paradigm® VEO™
10 PV-S	Paradigm® VEO™

Freckman G et al. *Diabetes Tech Ther* 2019;21:201-8

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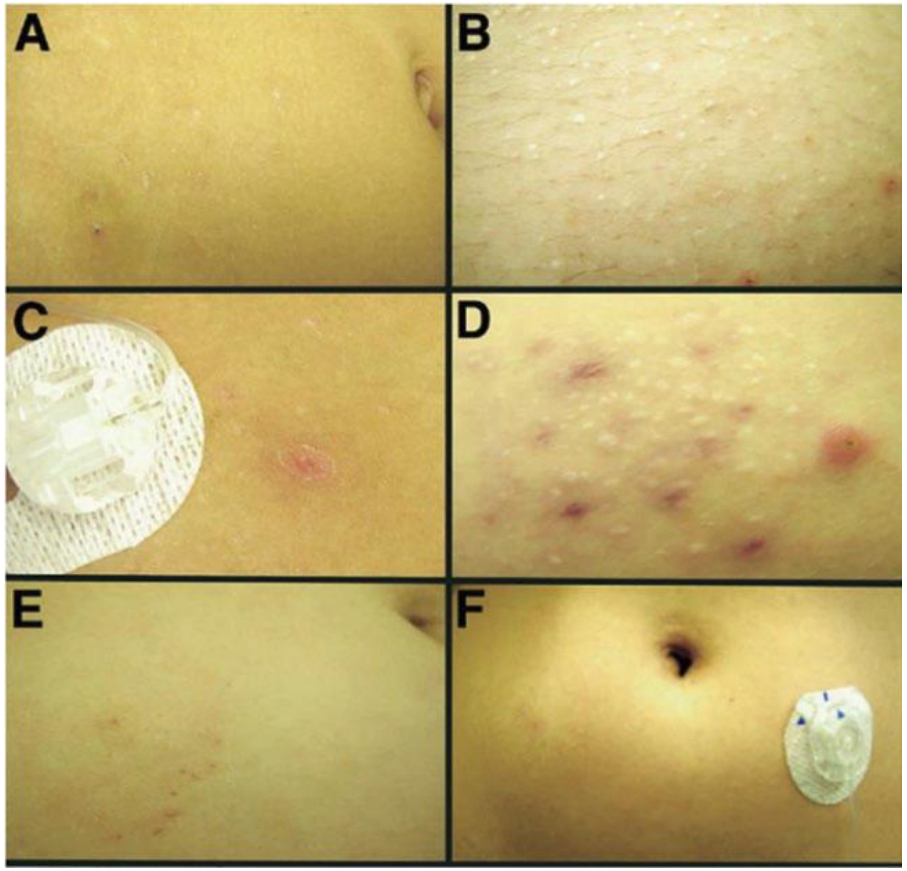
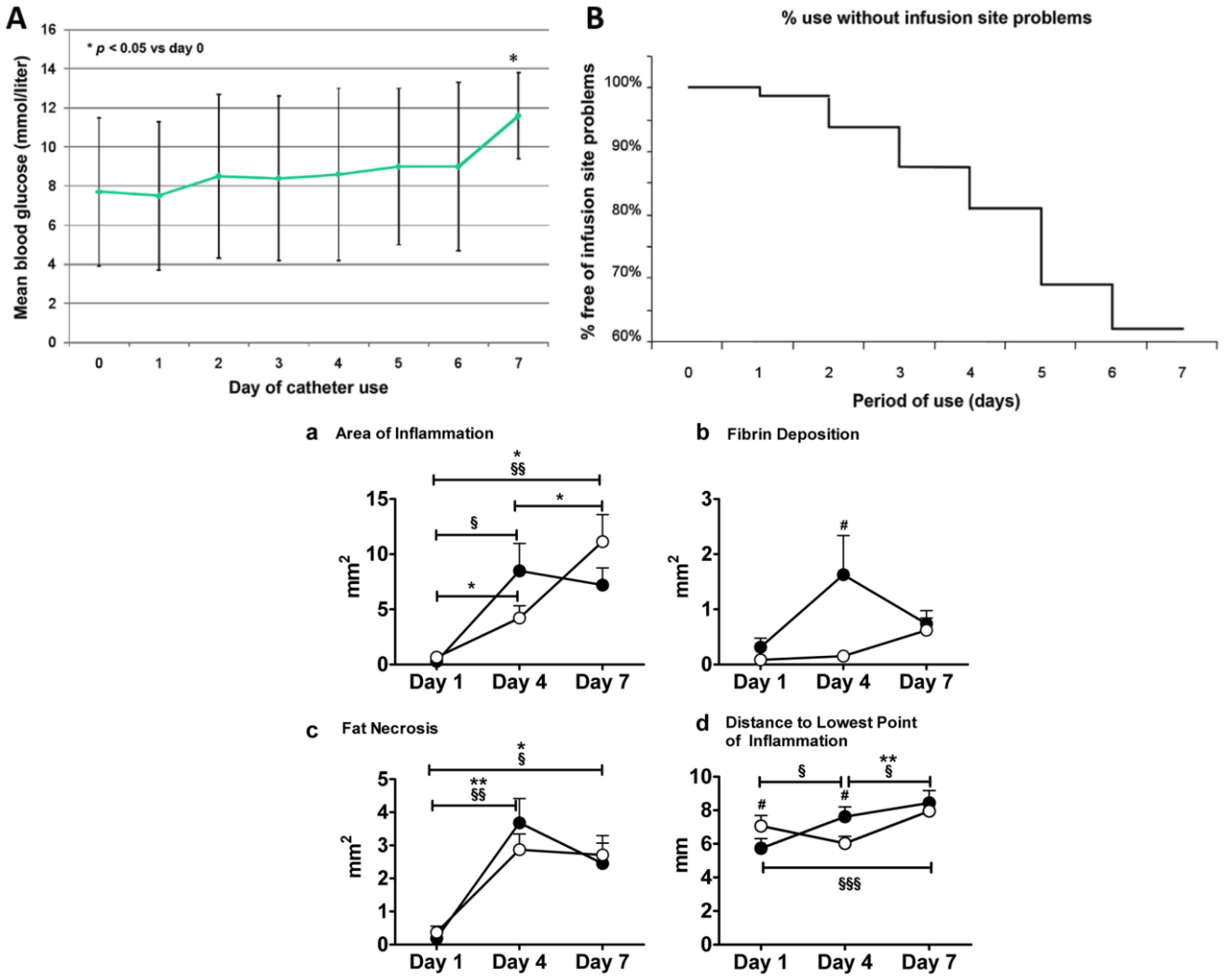
Infusion set reactions





Zhang E, Cao Z *J Diabetes Sci Technol* 2019 e pub before print#
Hauzenberger JR et al. *Science Reports* 2018;8:1132

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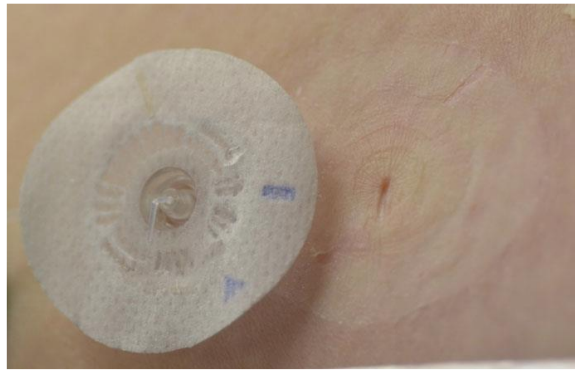
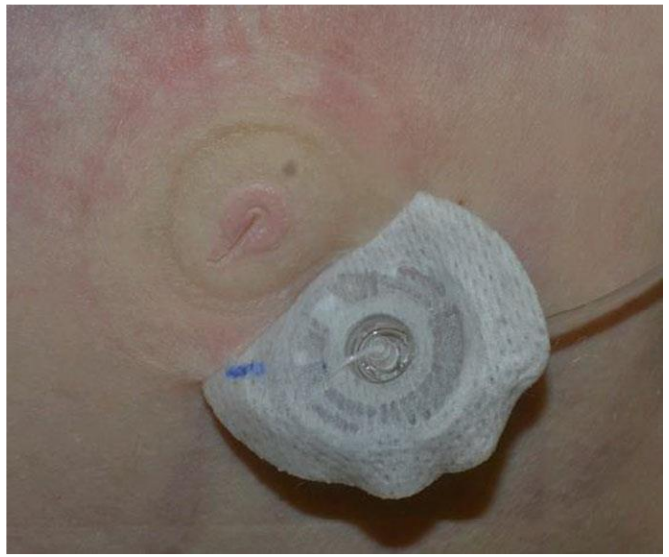
Pump fatalities





Ziegler A et al. *J Forensic Sci* 2019;64:275-80

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ONSET 5: FiAsp as pump insulin

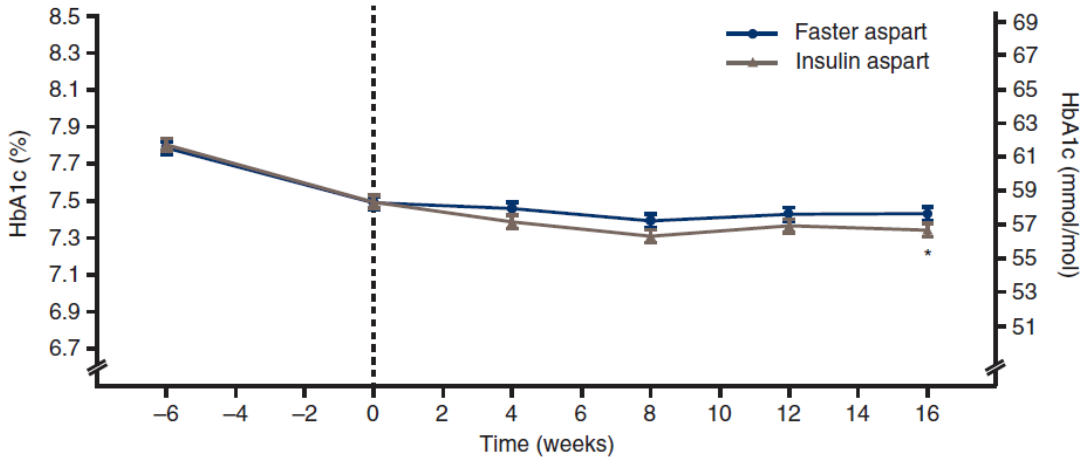

FIGURE 1 Mean glycated haemoglobin (HbA1c) over time. Error bars: ± SE (mean). *Estimated treatment difference was in favour of insulin aspart: 1.00 mmol/mol (95% confidence interval [CI] 0.14; 1.87) or 0.09% (95% CI 0.01; 0.17); $P = 0.022$. Non-inferiority confirmed at 0.4% level (one-sided test for non-inferiority evaluated at the 2.5% level: $P < 0.001$). All available information regardless of treatment discontinuation was used. Faster aspart = fast-acting insulin aspart

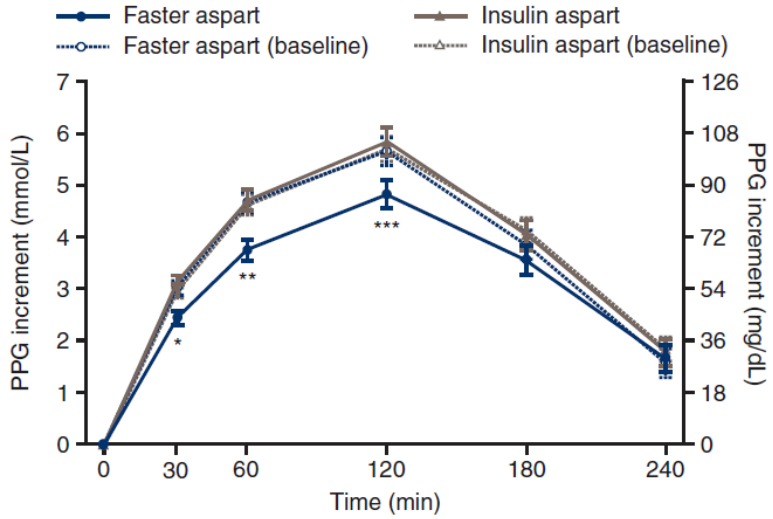

FIGURE 2 Postprandial glucose (PPG) increment after a standardized meal test at baseline and week 16. Error bars: ± SE (mean). *Estimated treatment difference (ETD) at week 16: –0.66 mmol/L (95% confidence interval [CI] –1.00; –0.31] or –11.8 mg/dL (95% CI –18.1; –5.6; $P < 0.001$). **ETD at week 16: –0.91 mmol/L (95% CI –1.43; –0.39) or –16.4 mg/dL (95% CI –25.7; –7.1; $P = 0.001$). ***ETD at week 16: –0.90 mmol/L (95% CI –1.58; –0.22) or –16.2 mg/dL (95% CI –28.5; –4.0; $P = 0.01$). All available information regardless of treatment discontinuation was used. Faster aspart = fast-acting insulin aspart

Klonoff DC et al. *Diabetes Obes Metab* 2019;21:961-7

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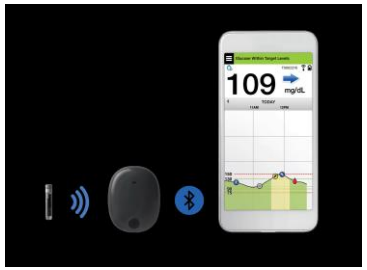
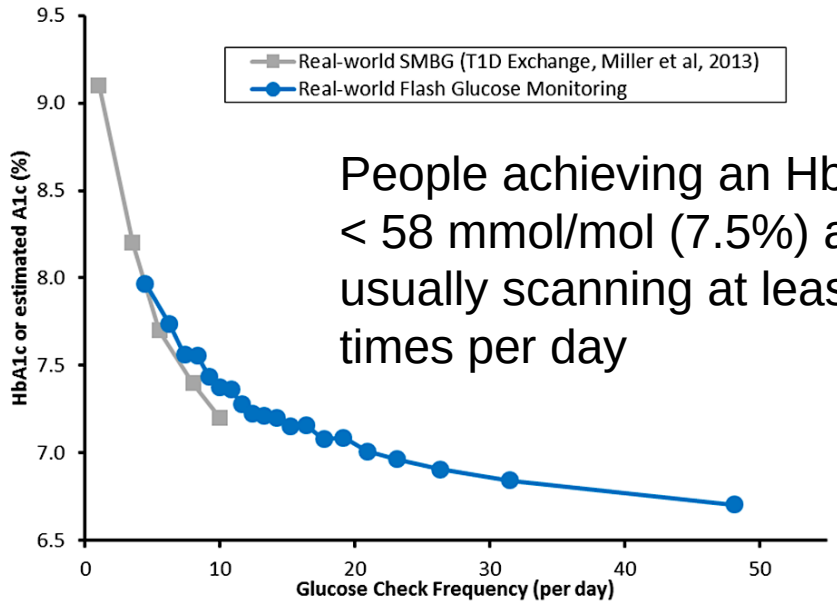
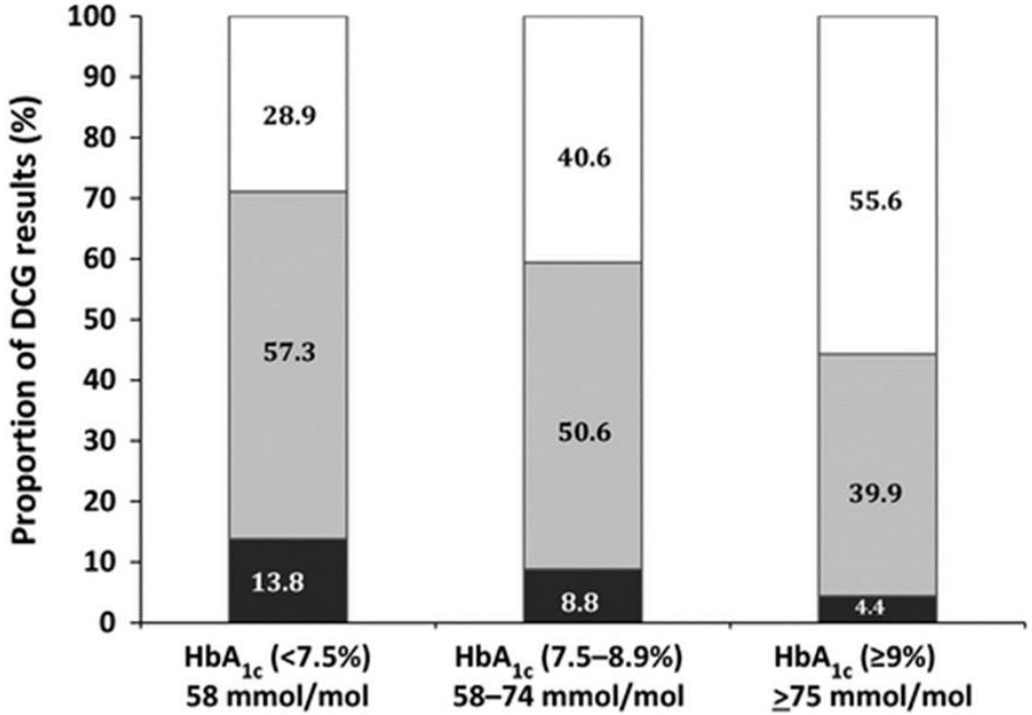
	Guardian Connect	640G Smart Guard	DexCom G6 Mobile	Freestyle Libre	Eversense	Medtrum
						
Sensor life	6 days		10 days	14 days	180 days	7-14 days
Alarms	Multiple		1 high, low and trend	None	Multiple	Multiple
Predictive	Yes		Yes	N/A	Yes	Yes
Trends	Yes		Yes	N/A	Yes	Yes
Rate change	Yes		Yes	N/A	Yes	Yes
Calibration	12 hourly		None	None	x4 at 2-12 h then12 hourly	12 hourly
MARD	9.64%		9.0%	9.7%	8.8%	9.1%

Optimising Libre use



People achieving an HbA1c < 58 mmol/mol (7.5%) are usually scanning at least 10 times per day



Miller K et al. *Diabetes Care* 2013;36:2009–14

Dunn T et al. *Diabetes Research and Clinical Practice* 2018;137:37-46

Sivasubramaniyam S et al. *Diabetes Medicine* 2017;34:1456–60

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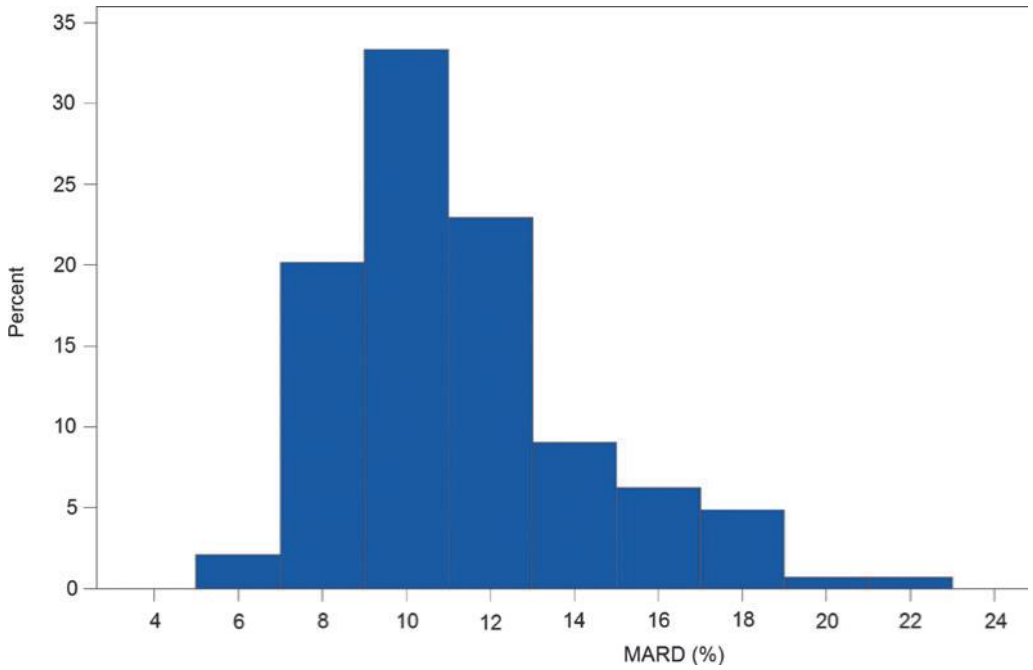
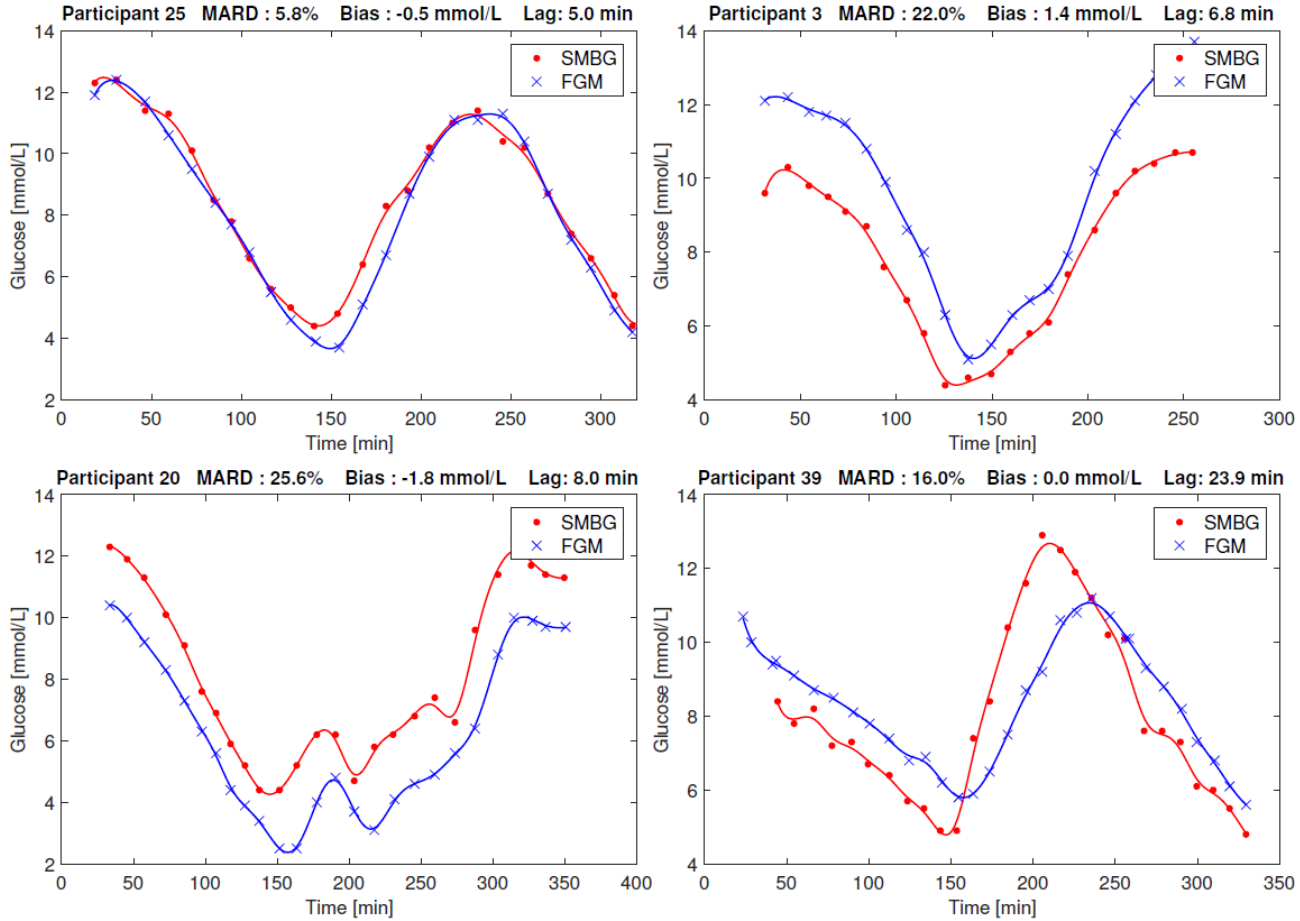
Libre Accuracy



Bailey T et al. *Diabetes Tech Ther 2*015;*17:787-94*



Staal OM et al. *Biosensors 2*018;8*:93*

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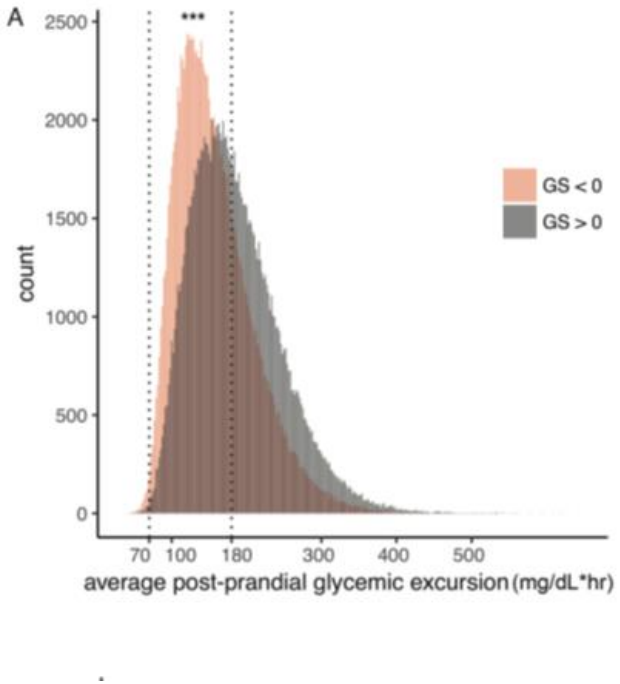
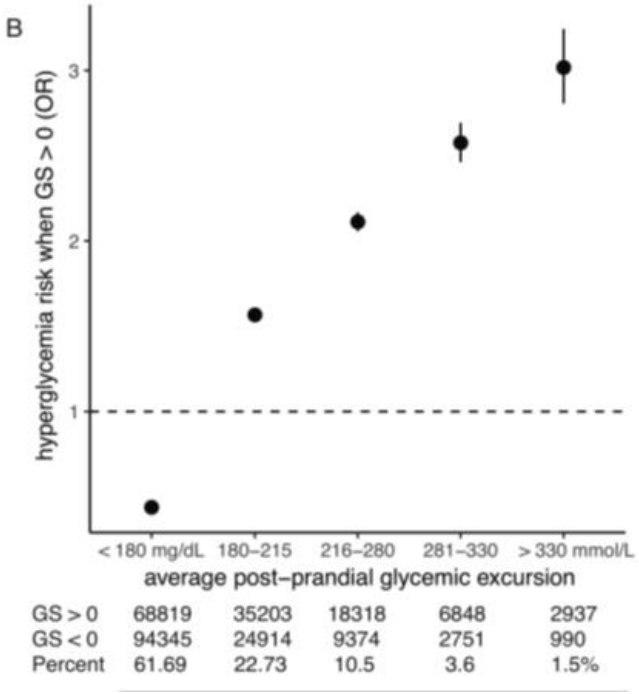
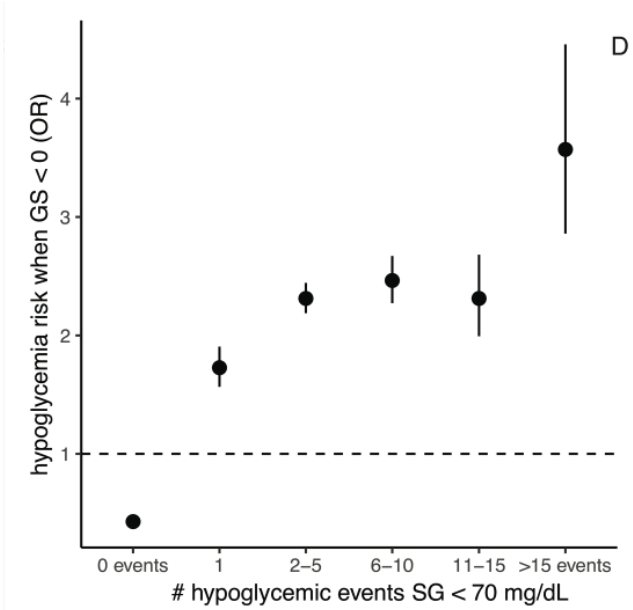
Pre-meal BG trajectory and post-meal BG

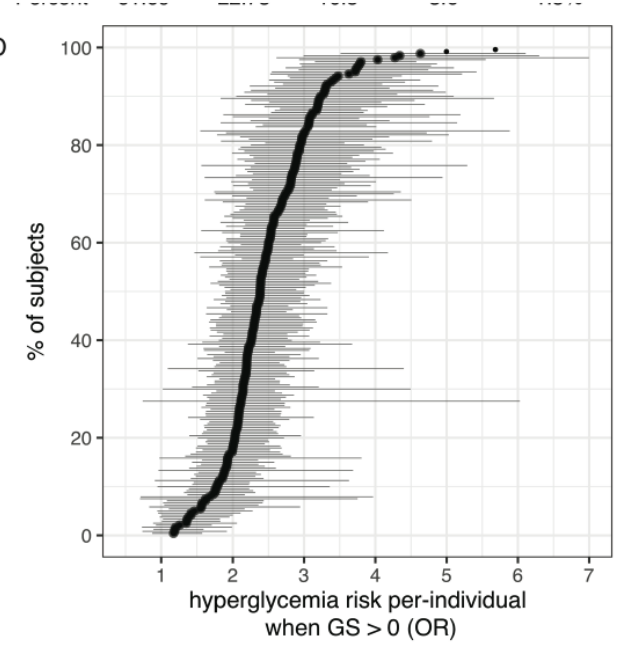




GS > 0	68819	35203	18318	6848	2937
GS < 0	94345	24914	9374	2751	990
Percent	61.69	22.73	10.5	3.6	1.5%



GS > 0	128451	636	1848	839	251	100
GS < 0	124085	1097	4204	2052	580	357
Percent	95.48	0.65	2.3	1.1	0.31	0.17%



Majithia AR et al. *J Diabetes Sci Technol* 2018;12:76-82.

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JDRF CGM – HbA1c and hypoglycaemia

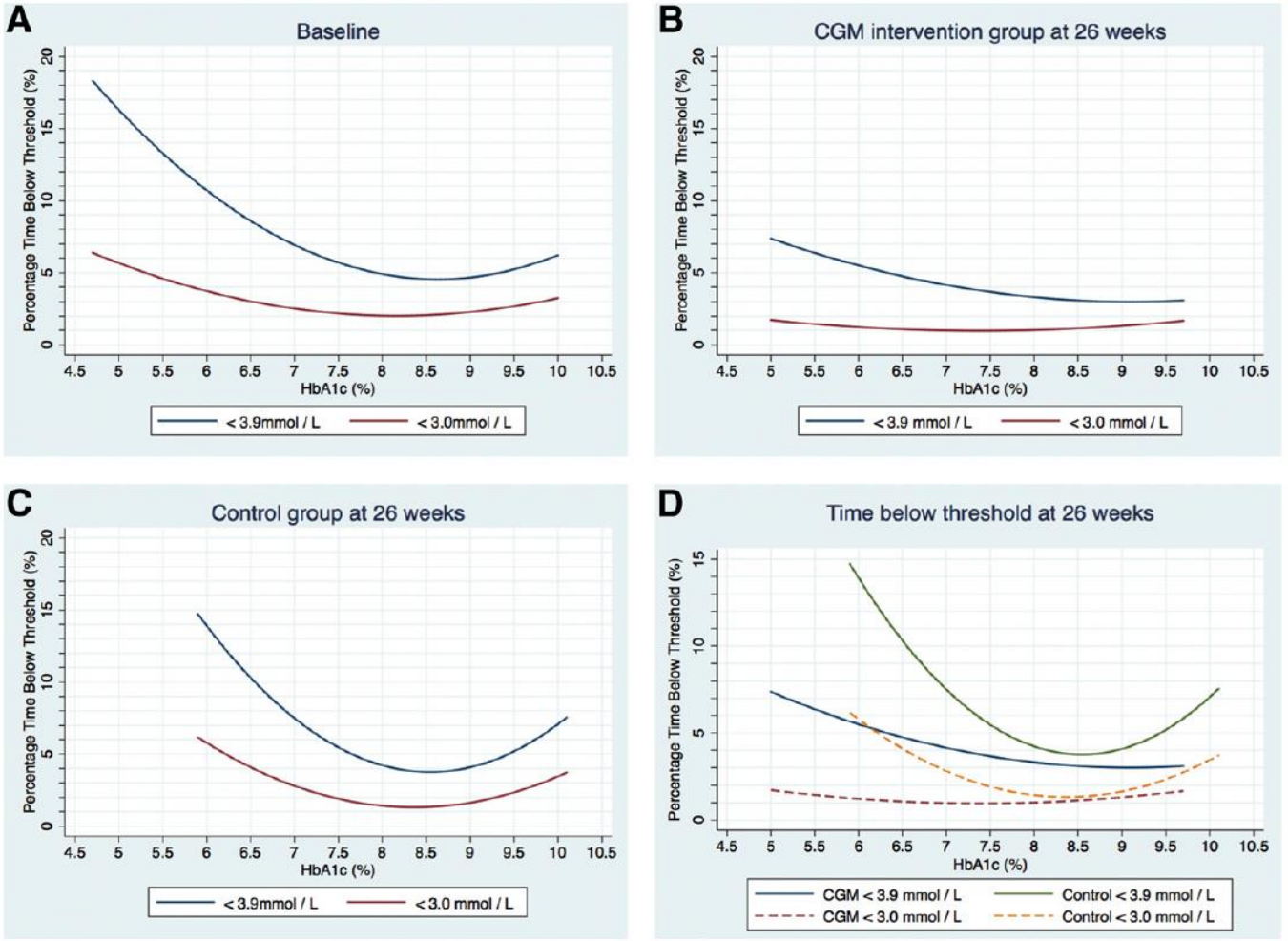

Figure 1—Quadratic regression plots of percentage time in hypoglycemia for each biochemical threshold. *A*: Baseline group (n = 448). *B*: CGM group at 26 weeks (n = 155). *C*: Control group at 26 weeks (n = 185). *D*: Overlap control and intervention groups at 26 weeks.

Gimenez M et al. *Diabetes Care* 2018;41:326-32.

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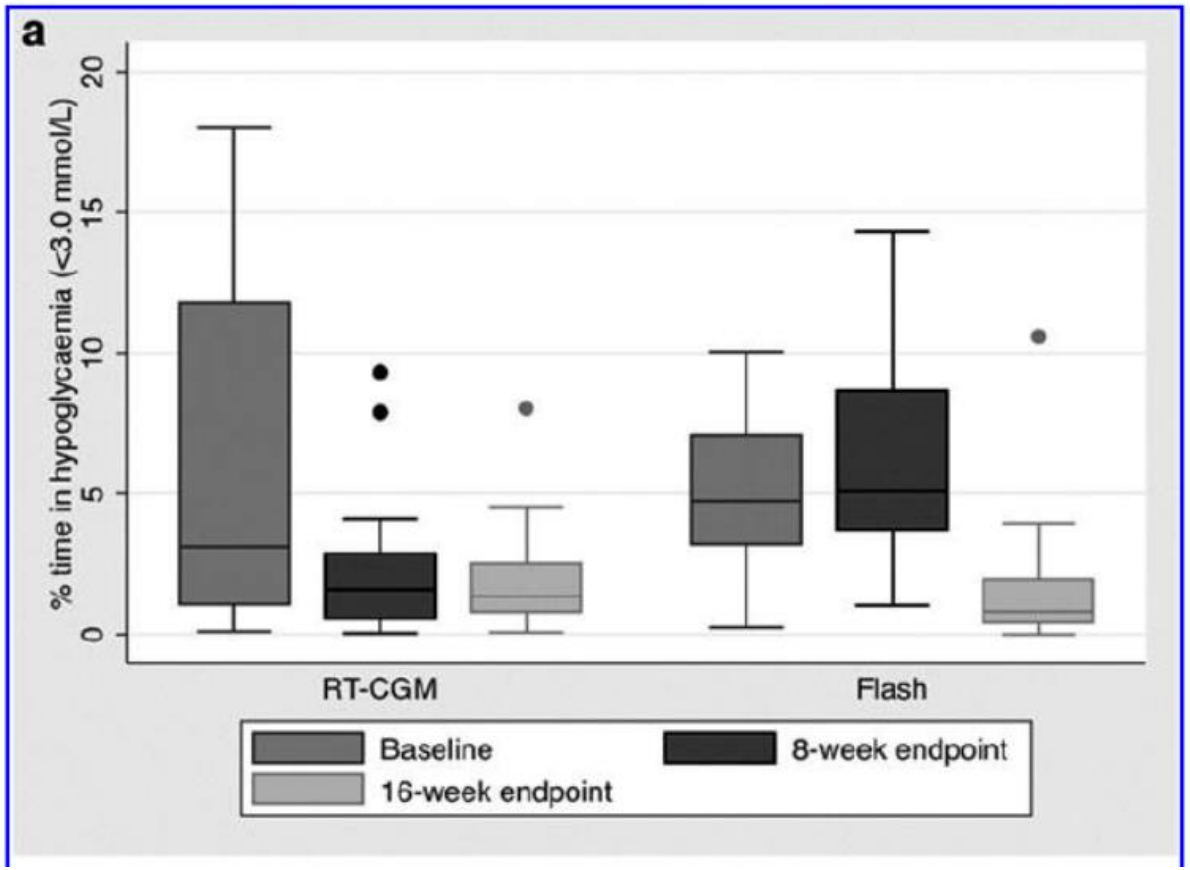
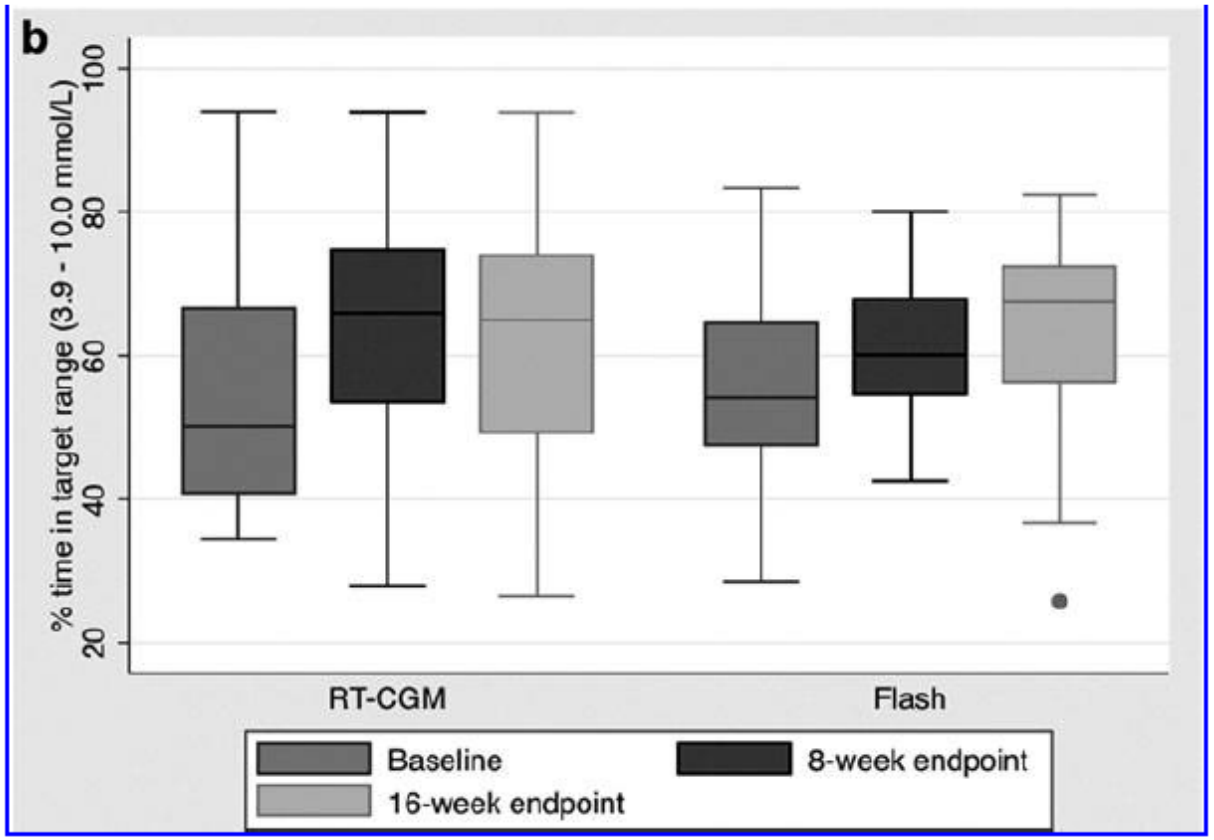
iHART extension: FGM vs CGM





Reddy M et al. *Diabetes Ther Technol* 2018;20:751-7

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SMILE: Smart Guard in Hypoglycaemia prone

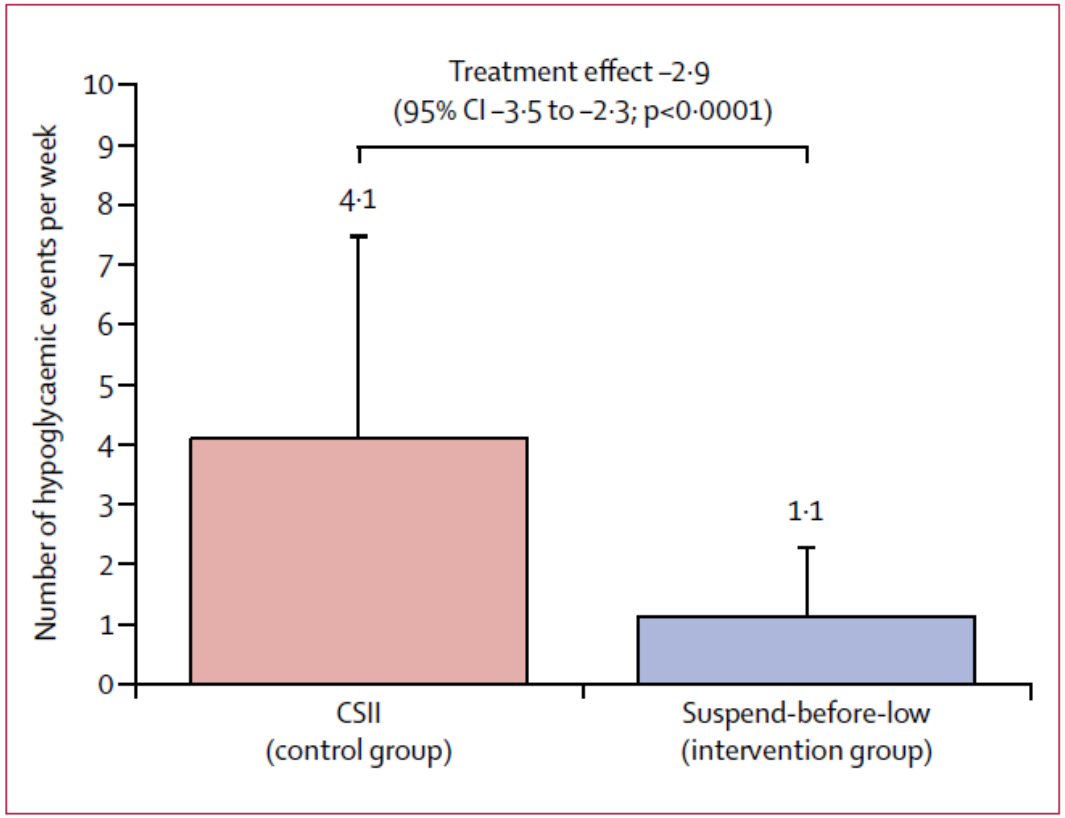

Figure 2: **Hypoglycaemic events per week**
The bar graph shows the mean (SD) number of hypoglycaemic events at sensor glucose values of 55 mg/dL (3·1 mmol/L) or lower per week in the continuous subcutaneous insulin infusion (CSII) control group (n=77) and the suspend-before-low intervention group (n=76) during the study phase.

Bosi E et al. *Lancet Diabetes Endocrinol* 2019: epub before print

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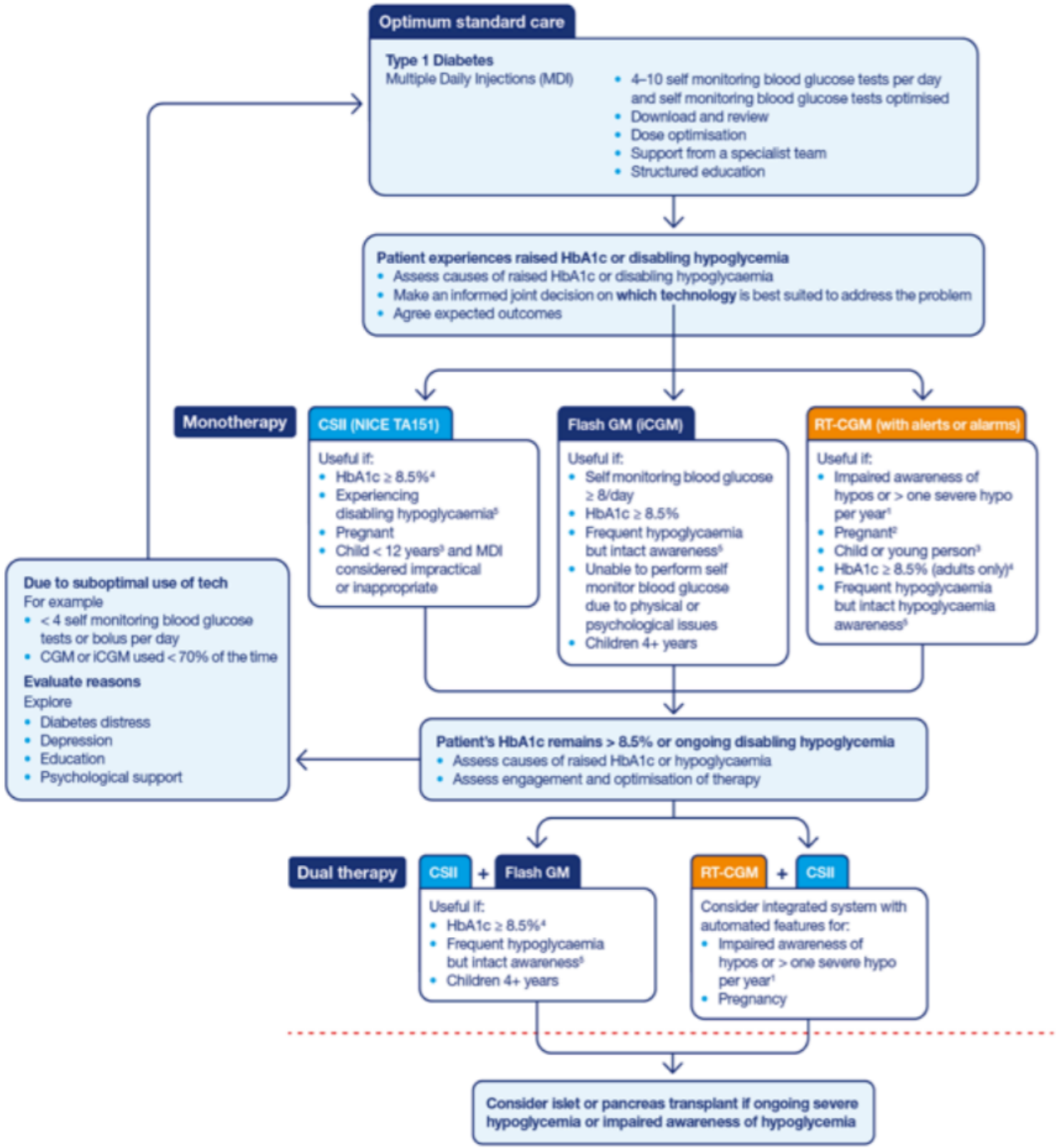

Diabetes Technology Pathway

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Closing the Loop

670G

- Manual mode
- Auto mode
  - Basal rate adjustment at 5 minute intervals
  - Maintain BG at target: 6.67 mmol/l default; 8.83 mmol/l for exercise ….
  - Safe basal mode

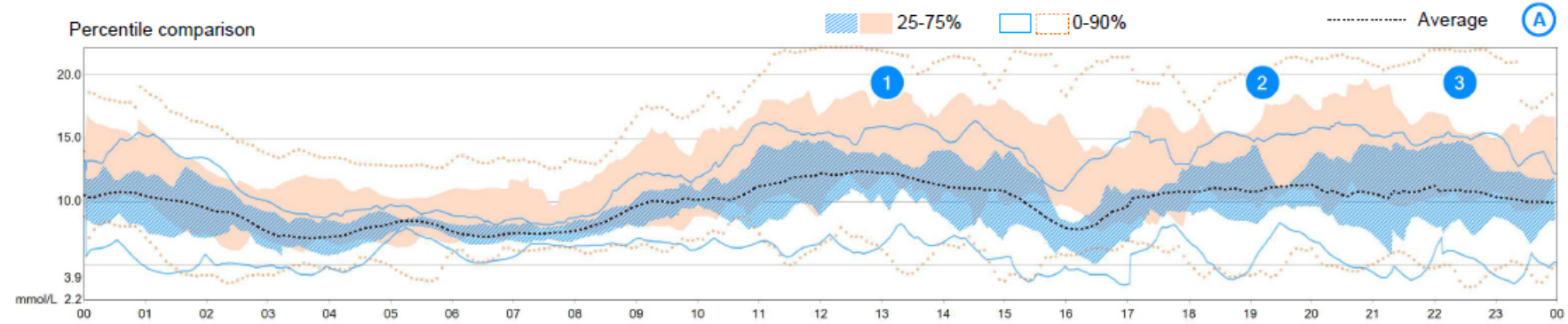
Medtronic

A 25/01/19 - 07/02/19 (14 Days)

B 11/01/19 - 24/01/19 (14 Days)

Data Sources: MiniMed 670G, MMT-1782 (NG1697843H)

Percentile comparison



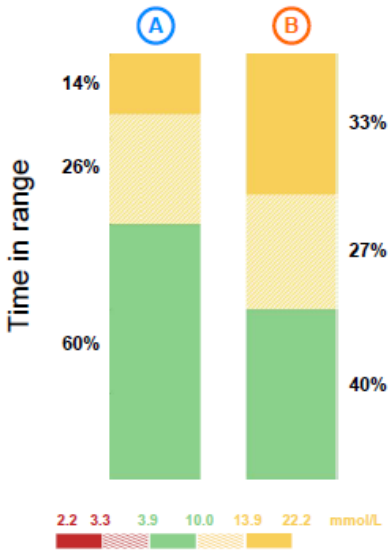
Carb Ratio (g/U)

A 8.0

B 8.0

A

Hypoglycemic patterns (0)	Hyperglycemic patterns (4)**
None	1 10:50- 15:20
	2 17:05- 21:20
	3 21:20- 23:30



** Only highest priority shown.

Auto Mode Exits	A	B
No Calibration	0	0
High SG Auto Mode Exit	+ • • • • • 7	4 • • • •
Auto Mode max delivery	0	1 •
Auto Mode min delivery	0	0
BG required for Auto Mode	• 1	1 •
Sensor Algorithm Underread	0	0
Sensor Updating	0	0
No SG values	0	0
Sensor Expired	• • 2	1 •
Auto Mode disabled by user	0	0
Alarms	0	0
Pump Suspend by user	0	0
Auto Mode Warm Up	0	0
Unidentified	0	2 • •

Statistics	A	B
Auto Mode (per week)	93% (6d 12h)	56% (3d 22h)
Manual Mode (per week)	7% (12h)	44% (3d 02h)
Sensor Wear (per week)	95% (6d 16h)	96% (6d 17h)
Average SG ± SD	9.8 ± 3.2 mmol/L	12.1 ± 4.9 mmol/L
Estimated A1C	7.8%	9.2%
Average BG	11.0 ± 3.2 mmol/L	14.3 ± 6.4 mmol/L
BG / Calibration (per day)	4.2 / 2.8	5.9 / 4.0
Total daily dose (per day)	56 units	67 units
Bolus amount (per day)	33U (59%)	39U (58%)
Auto Basal / Basal amount (per day)	23U (41%)	28U (42%)
Set Change	Every 3.0 days	Every 2.0 days
Reservoir Change	Every 3.0 days	Every 2.0 days
Meal (per day)	9.0	9.1
Carbs entered (per day)	259 ± 49 g	246 ± 55 g
Active Insulin time	4:00 hrs	4:00 hrs

District NHS

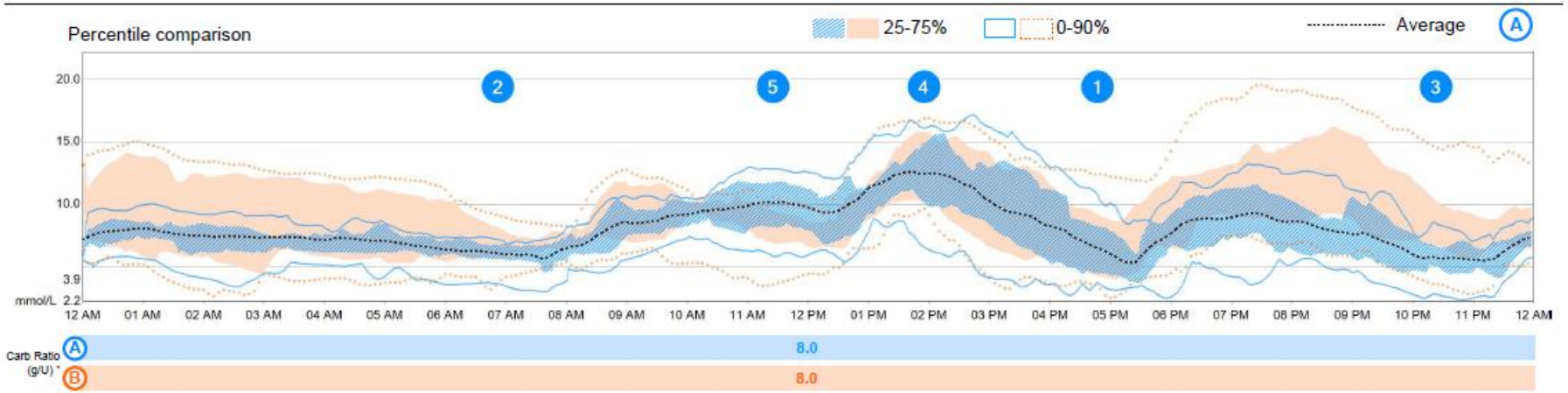
NHS Foundation Trust

Medtronic

A 25/01/19 - 07/02/19 (14 Days)

B 11/01/19 - 24/01/19 (14 Days)

Data Sources: MiniMed 670G, MMT-1782 (NG1697859H)



A

Hypoglycemic patterns (4)**

1 03:24 PM- 06:11 PM (5 occurrences)

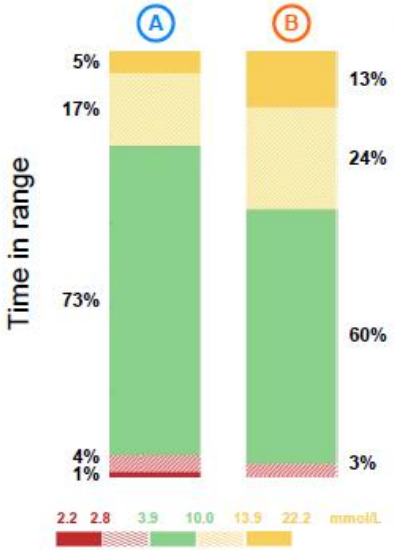
2 05:44 AM- 08:01 AM (2 occurrences)

3 09:16 PM- 11:30 PM (2 occurrences)

Hyperglycemic patterns (2)

4 12:45 PM- 03:05 PM

5 11:05 AM- 11:45 AM



* Most recent pump settings are displayed

** Only highest priority shown.

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

Statistics	A	B
Auto Mode (per week)	97% (6d 20h)	57% (4d 01h)
Manual Mode (per week)	3% (04h)	43% (2d 23h)
Sensor Wear (per week)	98% (6d 20h)	97% (6d 18h)
Average SG ± SD	8.0 ± 3.0 mmol/L	9.2 ± 3.8 mmol/L
Estimated A1C	6.7%	7.4%
Average BG	8.5 ± 4.1 mmol/L	9.4 ± 4.5 mmol/L
BG / Calibration (per day)	9.9 / 4.1	10.2 / 3.6
Total daily dose (per day)	46 units	55 units
Bolus amount (per day)	30U (65%)	33U (60%)
Auto Basal / Basal amount (per day)	16U (35%)	22U (40%)
Set Change	Every 3.0 days	Every 2.8 days
Reservoir Change	Every 3.0 days	Every 2.8 days
Meal (per day)	6.2	6.0
Carbs entered (per day)	228 ± 30 g	238 ± 40 g
Active Insulin time	4:00 hrs	3:30 hrs

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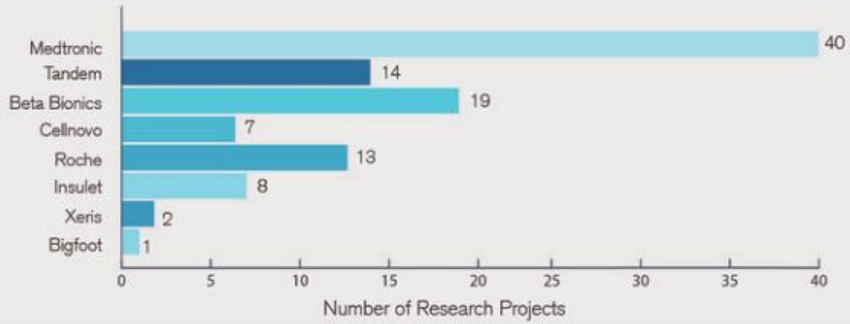
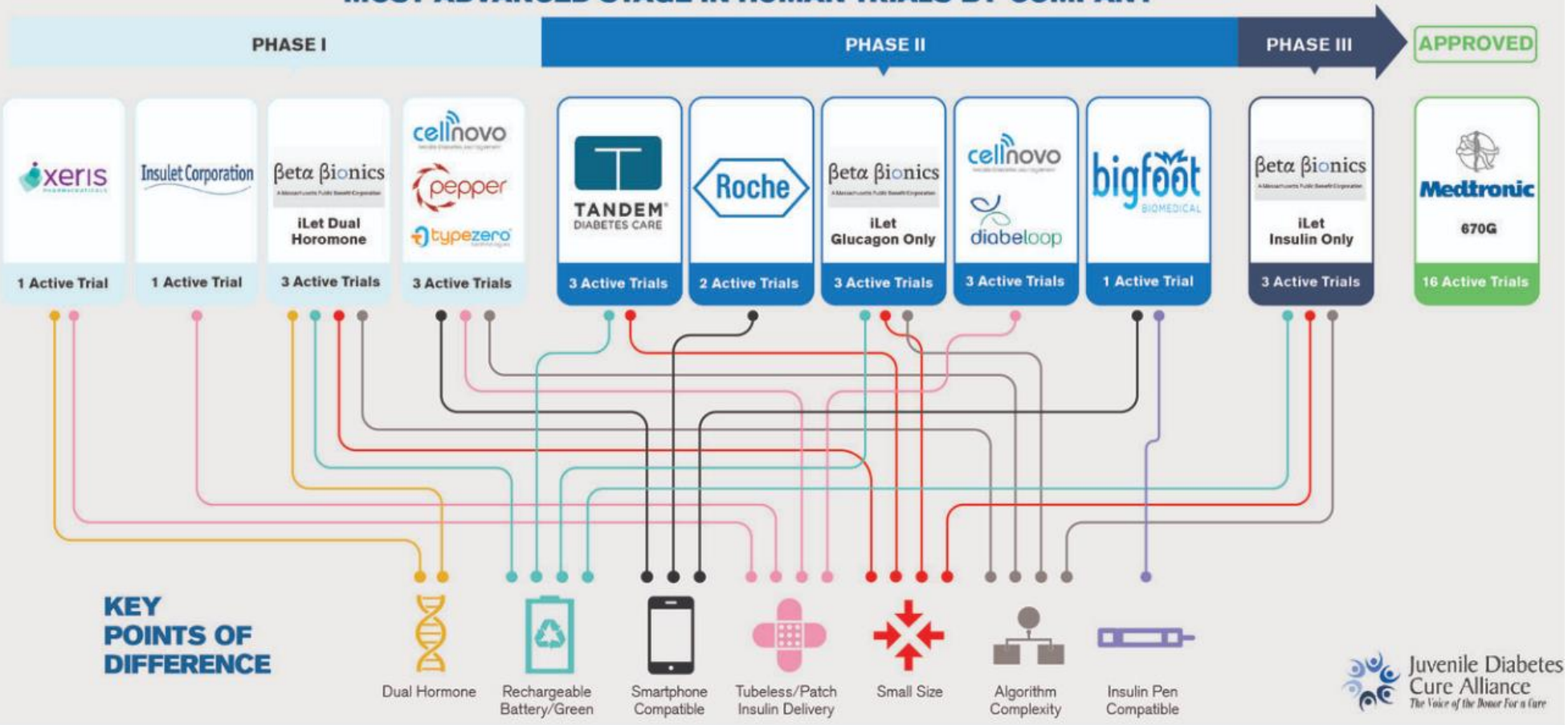
OUT OF 471 **ACTIVE T1D PROJECTS IN HUMAN TRIALS**
39 ARE ARTIFICIAL PANCREAS

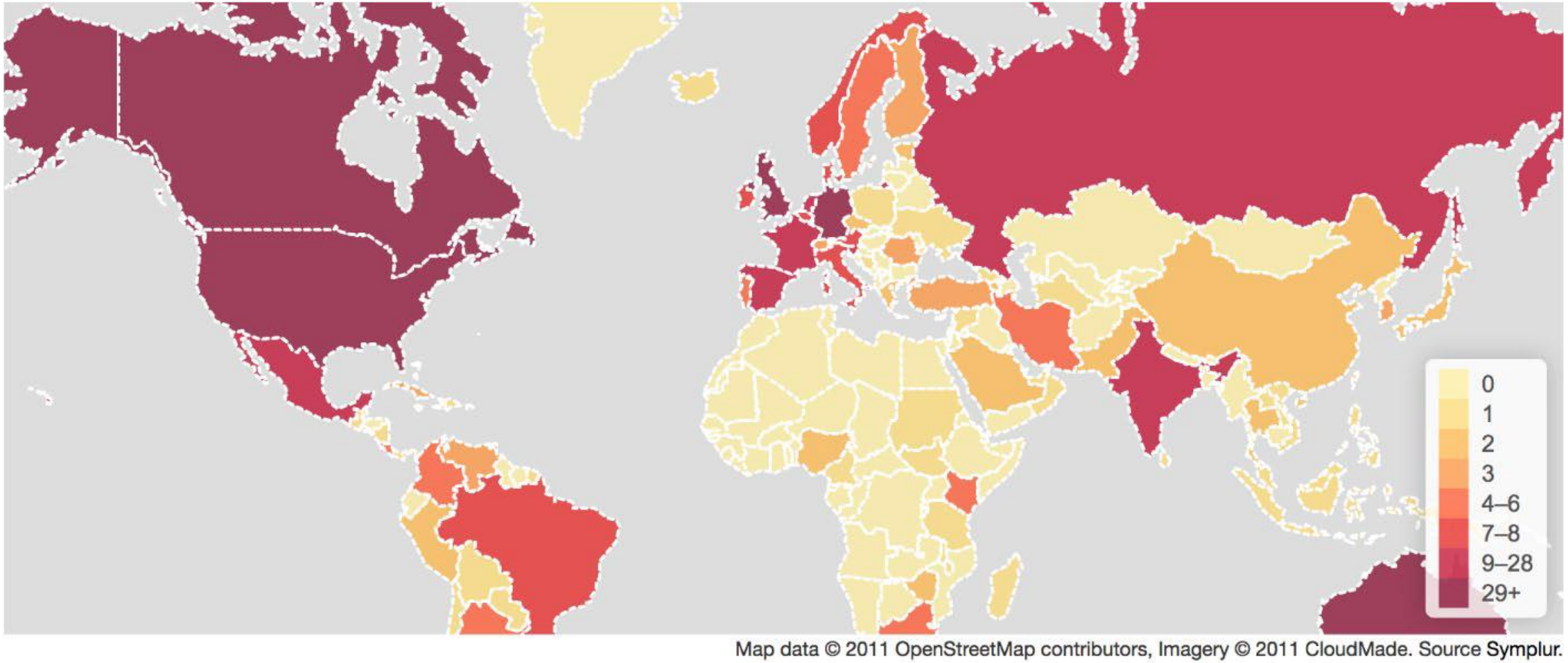


MOST ADVANCED STAGE IN HUMAN TRIALS BY COMPANY



My insulin #Pump
(link: https://bionicwookiee.com/2018/10/12/my-insulin-pump/)
bionicwookiee.com/2018/10/12/my-… #AccuChek #Android #AndroidAPS #Dexcom #Diabetes #G5 #Looping #OpenAPS #OzDOC

Open APS twitter users



Litchman et al. *J Diabetes Sci Technol 2018:* ePub before print

Open APS twitter analysis

Overarching theme: OpenAPS changes lives

Subthemes
1. OpenAPS use suggests self-reported A1C and glucose variability improvement
2. OpenAPS improves sense of diabetes burden and improves quality of life
3. OpenAPS is perceived as safe
4. Patient/caregiver–provider interaction related to OpenAPS
5. Technology adaptation for user needs

“For those who are afraid of a A1c of 5.3, I would be too w/out loop.”

“My endo totally loooved #OpenAPS. My endo said he’s not waiting either #wearenotwaiting. So happy.”

Litchman et al. *J Diabetes Sci Technol 2018:* ePub before print

Closed loop in suboptimally controlled T1

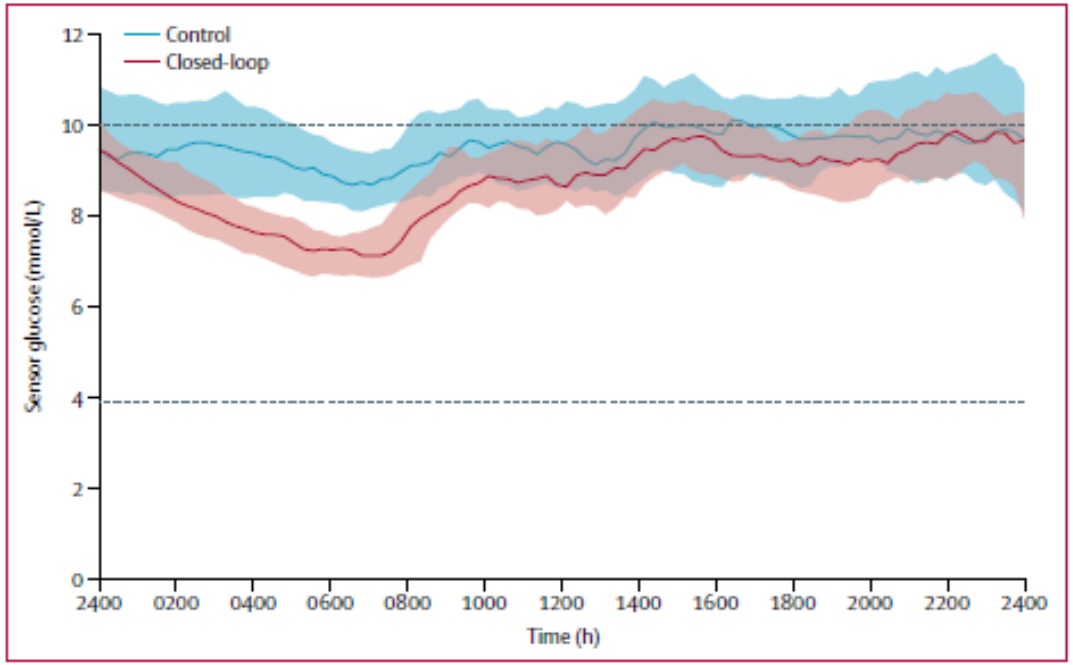


Figure 2: **Sensor glucose**
Median (IQR) concentrations in the closed-loop group (red line and shaded area; n=46) and the control group (blue line and shaded area; n=40) are shown. Dashed lines indicate the target glucose range (3·9–10·0 mmol/L).

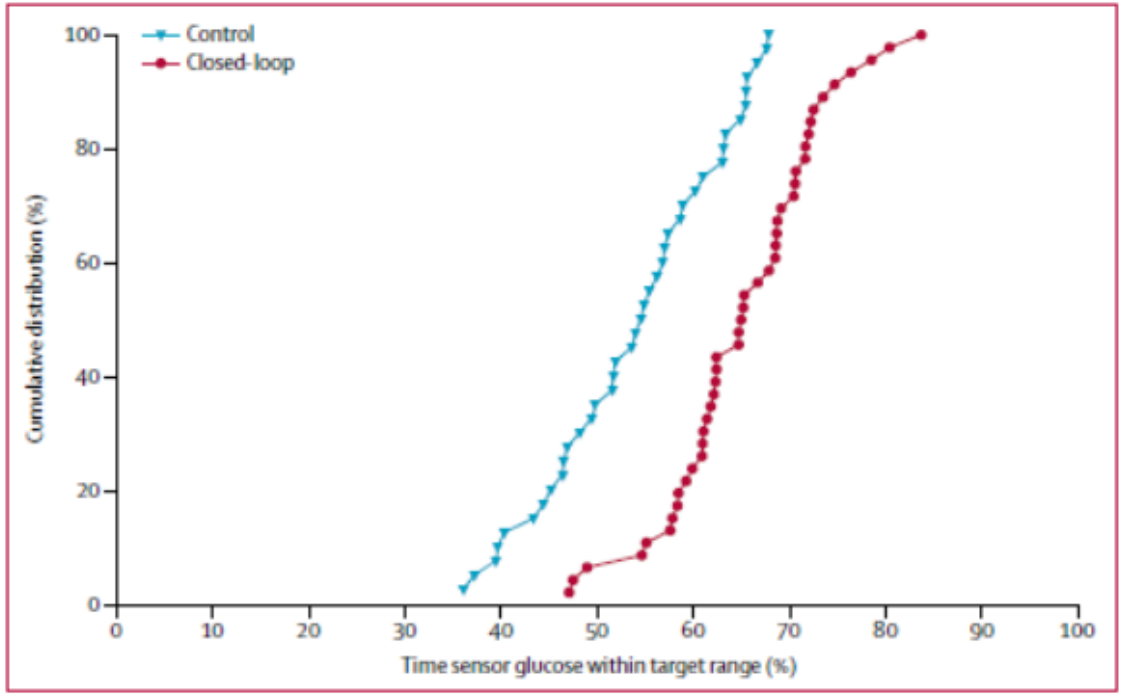


Figure 3: **Cumulative distribution of percentage of time that sensor glucose was within the target range (ie, 3·9–10·0 mmol/L) over 12-week intervention phase by treatment group**

HbA1c reduction 0.36% greater p < 0.0001

Tauschmann M et al. *Lancet* 2018;392:1321-29.

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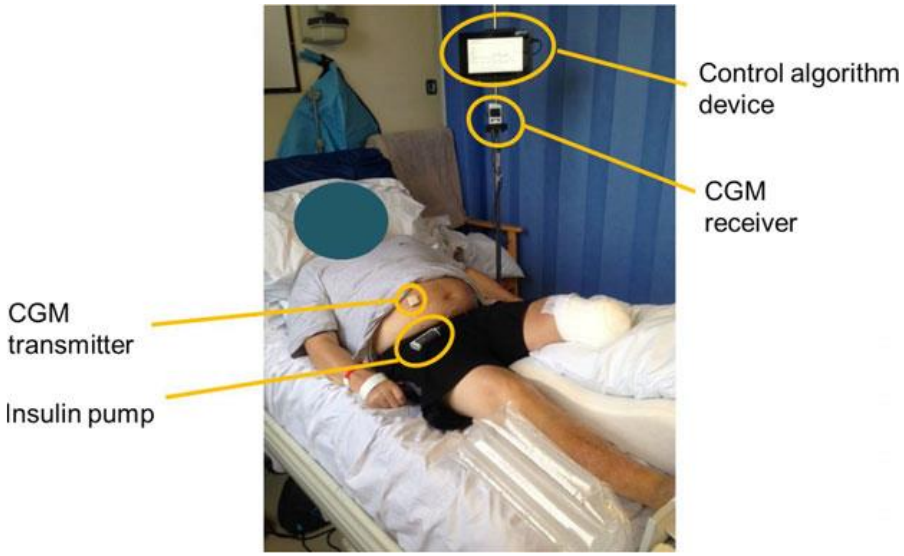
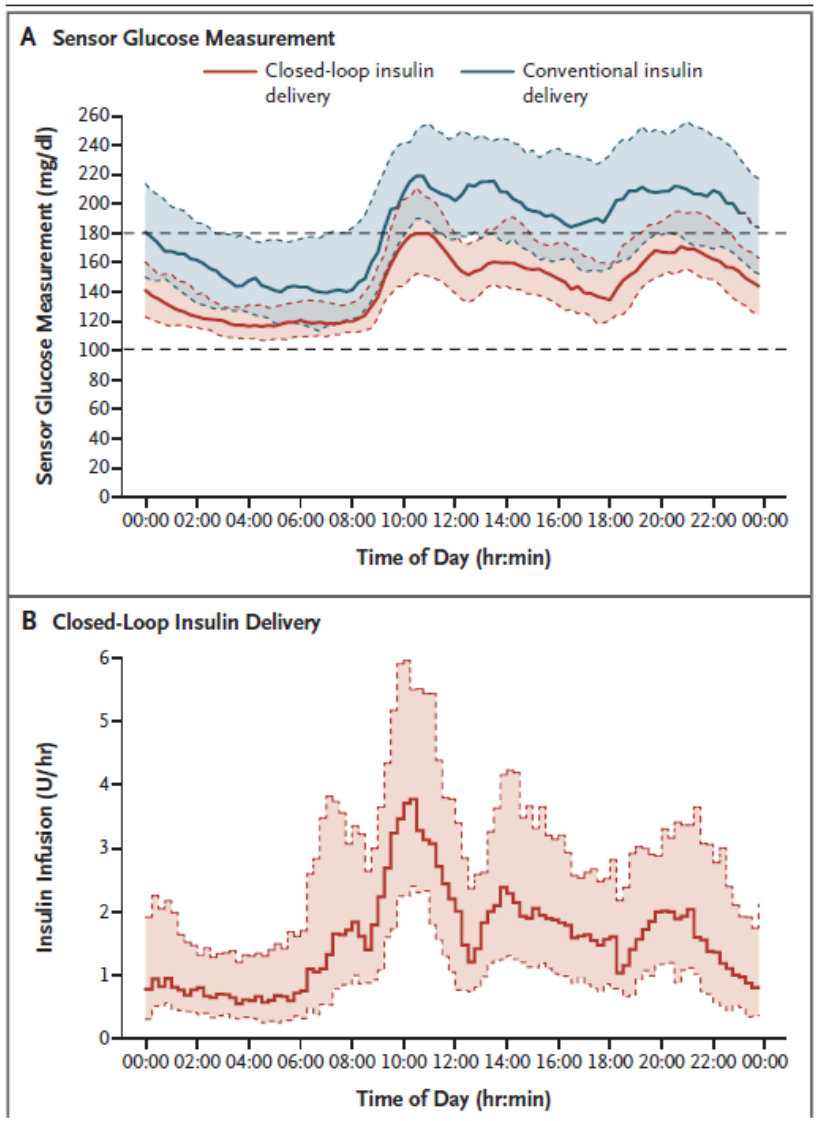
Closed loop in noncritical in-patients





Bally L et al. *N Engl J Med* 2018;379:547-56.

Harrogate and District NHS Foundation Trust

Closed loop in in-patients on nutritional support

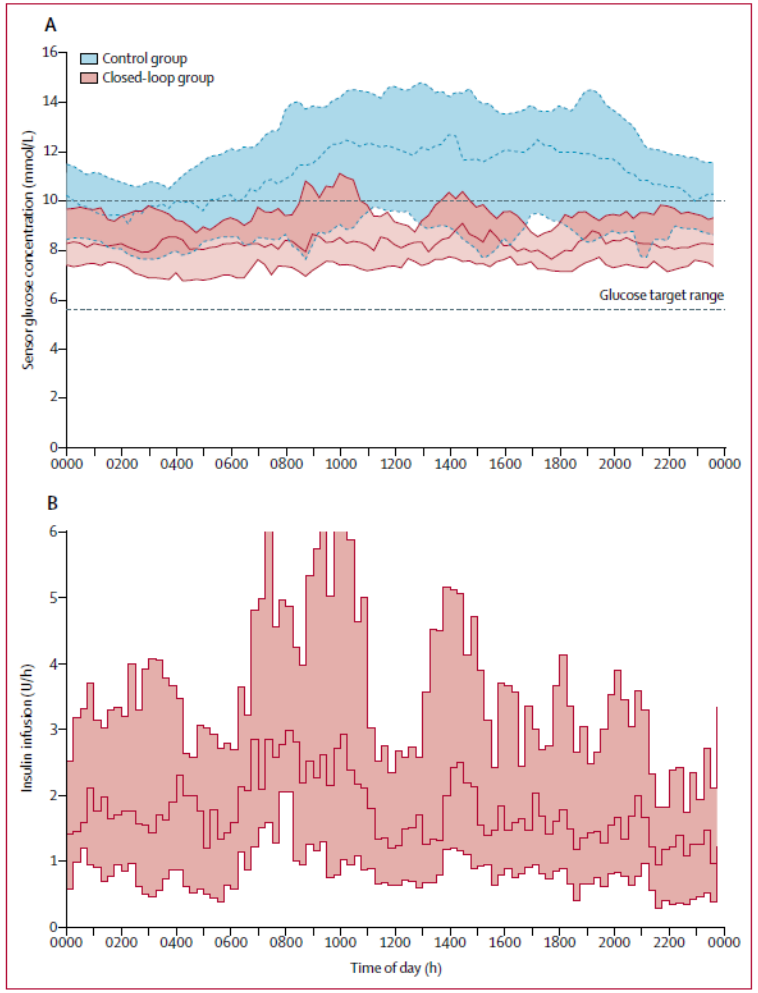


***Figure 2*: Sensor glucose concentration and insulin delivery profiles**
(A) Sensor glucose concentration during closed-loop and control interventions from midnight to midnight (lines indicate median, shaded areas indicate IQRs). The glucose target range is 5·6–10·0 mmol/L.
(B) Algorithm-directed insulin delivery during closed-loop intervention (line indicates median, shaded area indicates IQR).

Boughton CK et al. *Lancet Diabetes Endocrinol* 2019;7:368-77.

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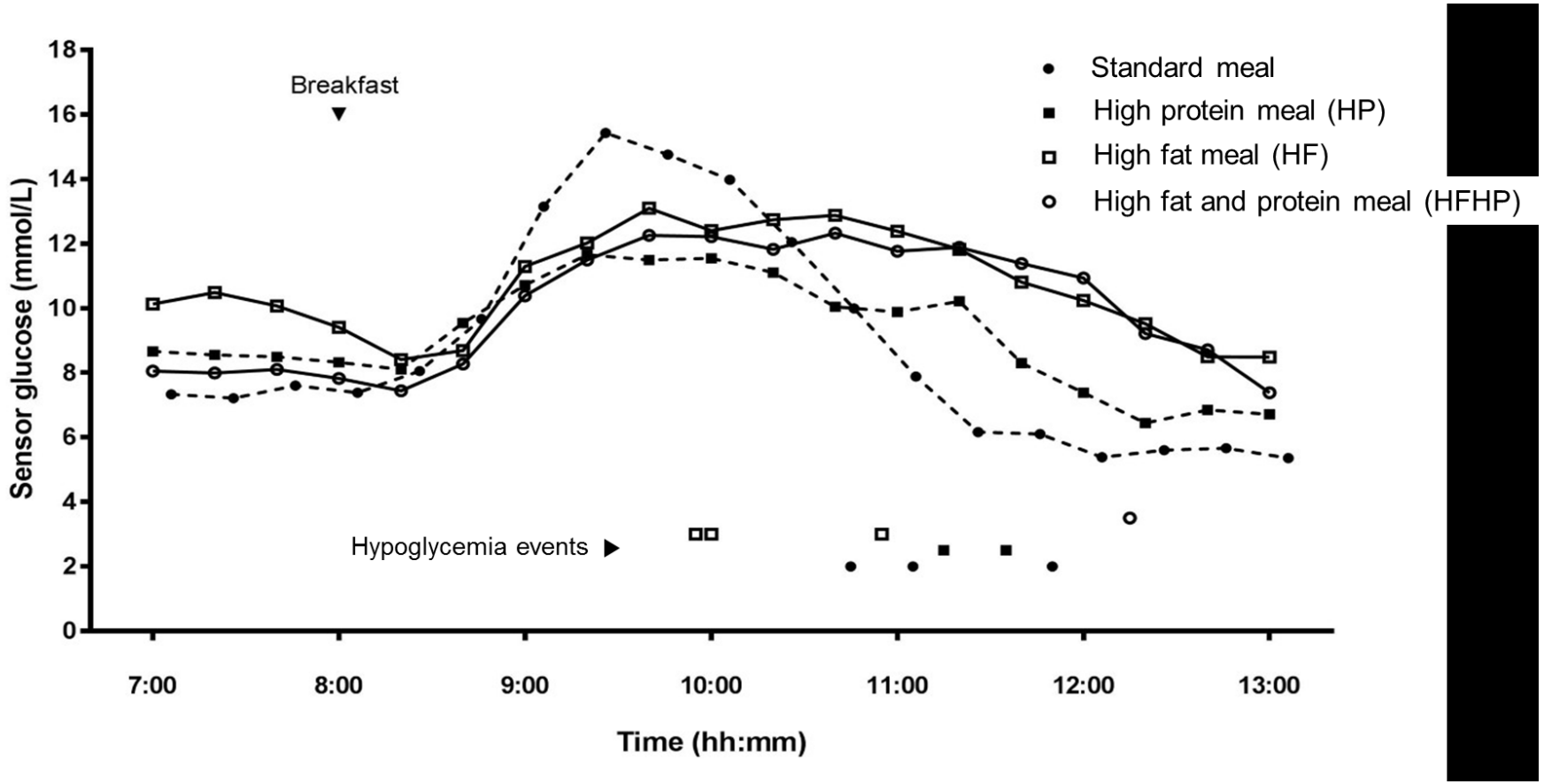
Macronutrient effects on BG control in Closed Loop



Gingra V et al. *Diabetes Obes Metab* 2018;20:2695-9.

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Apps

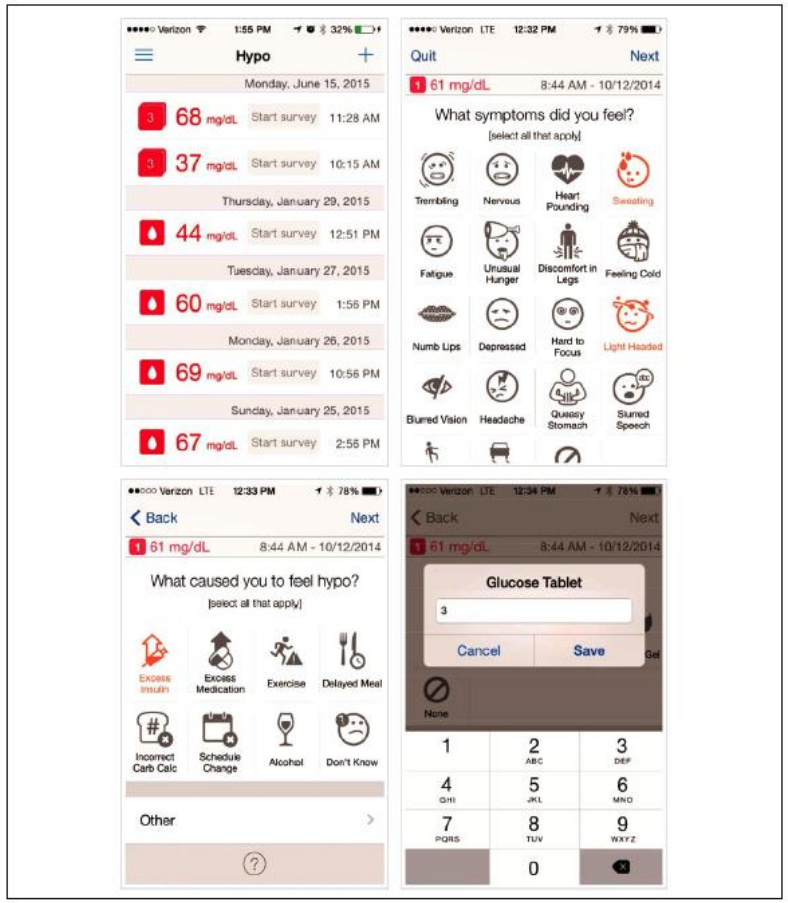
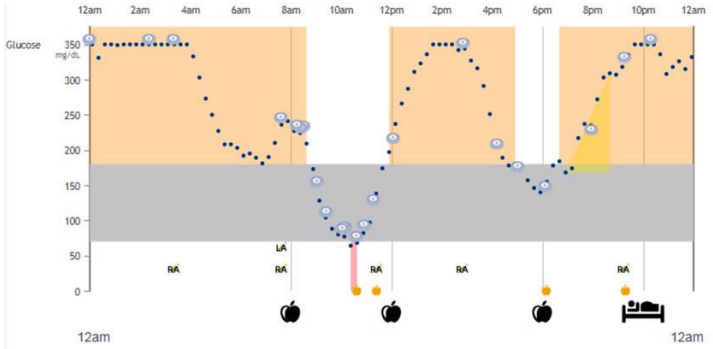
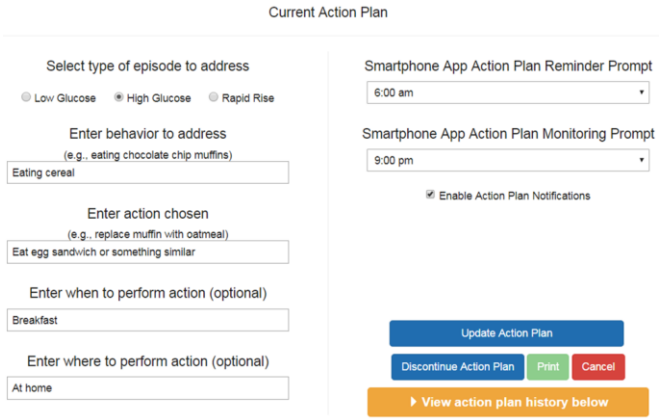


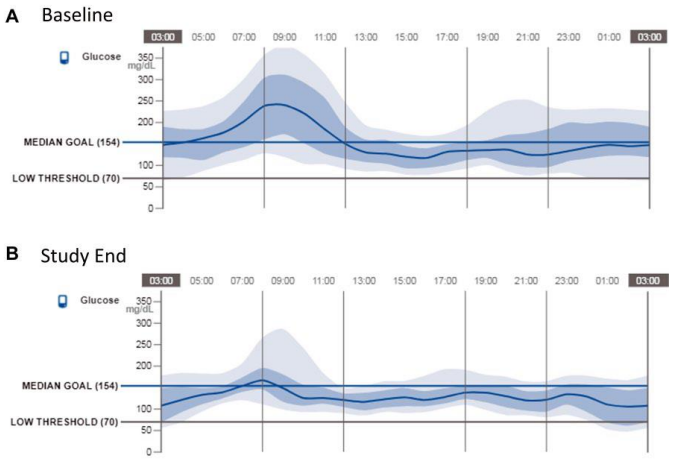
Figure 1. Joslin HypoMap™ App.

Feuerstein-Simon C et al. *J Diabetes Sci Technol* 2018:12:1192-9.



Time	Episode	Response(s)
03:20 AM Wednesday 28-Oct-2015		RA Insulin: 4.0U
07:37 AM Wednesday 28-Oct-2015		RA Insulin: 4.0U
		LA Insulin: 16.0U
10:22 AM Wednesday 28-Oct-2015	Low Glucose	
10:37 AM Wednesday 28-Oct-2015		Food
		half smoothie
11:26 AM Wednesday 28-Oct-2015		Food
		RA Insulin: 2.0U
		DD choc chip muffin top
11:53 AM Wednesday 28-Oct-2015	High Glucose	
02:50 PM Wednesday 28-Oct-2015		RA Insulin: 4.0U
06:10 PM Wednesday 28-Oct-2015		Food: 20.0g
		can progresso soup
06:40 PM Wednesday 28-Oct-2015	High Glucose	
06:55 PM Wednesday 28-Oct-2015	Rapid Rise	
09:15 PM Wednesday 28-Oct-2015		RA Insulin: 6.0U
09:19 PM Wednesday 28-Oct-2015		Food
		popcorn 1/3cup un popped and 6-7 pop cakes with chocolate drizzle





Toschi E et al. *J Diabetes Sci Technol* 2018:12:1143-51.

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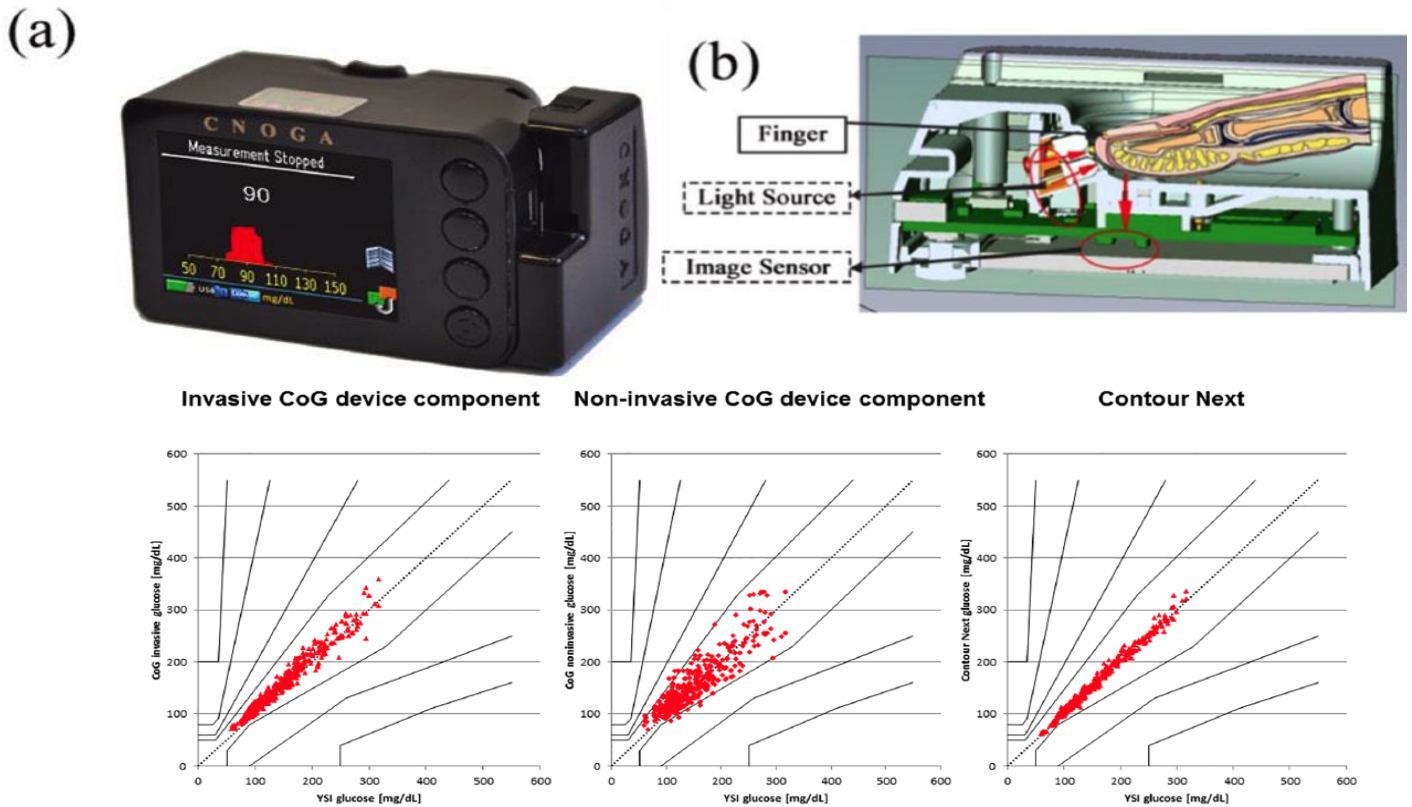
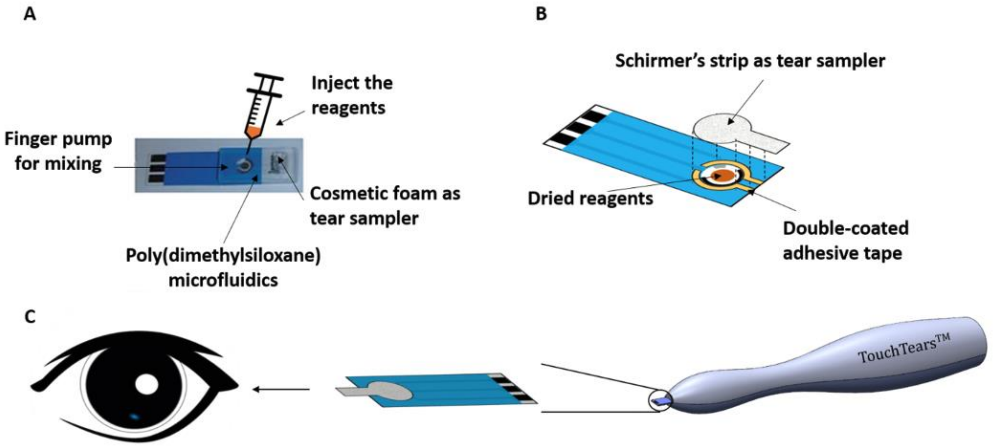
Non-invasive sensors



Pfutzner A et al. *J Diabetes Sci Technol* 2018:12:1178-83.



D

	Published Design (A)	Improved Design (B)	Advantages/Comments about B
Sampling Mechanism	Absorption + Mechanical Pumping	Absorption	Improved convenience and reduced potential user error
Sampling Material	Cosmetic Foam + Rigid Microfluidics	Soft Schirmer's Strip	Substantial equivalence and manufacturing friendliness
Sample Volume	5.8 µL	17.7 µL	Need to miniaturize to ≤ 1 µL
Reagents	Wet Reagents	Dried Reagents*	Improved Convenience

Lin CE et al. *J Diabetes Sci Technol* 2018:12:842-6.

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