

Open Source APS

#wearenotwaiting

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Disclosures

AM has received speaker fees from:

Eli Lilly, Novo Nordisk, DTN-UK, Nottingham Trent University

Overview

- Open Source Closed Loop Systems
 - What are they?
 - What options are out there?
 - How have they progressed?
 - Who is using them and why?



About Alasdair

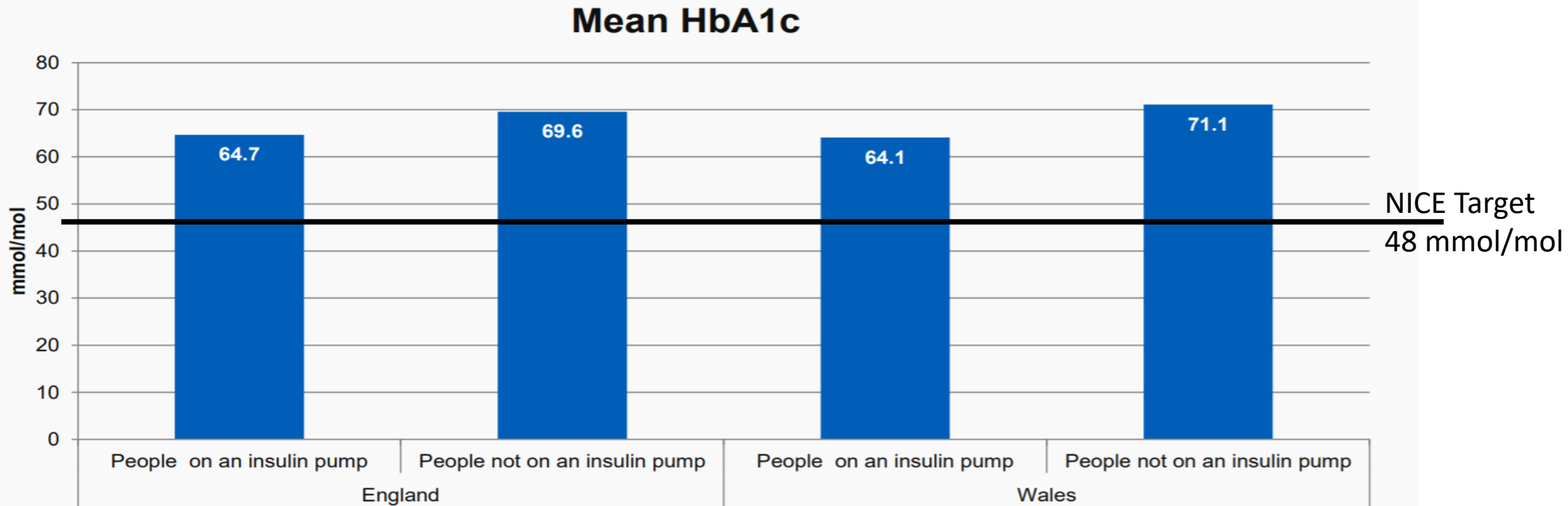
- T1DM for > 30 years
- Pump user > 14 years
- Open Source Closed Looping > 2 years
- I enjoy some interesting hobbies including offshore yachting; motorcycling; mountaineering



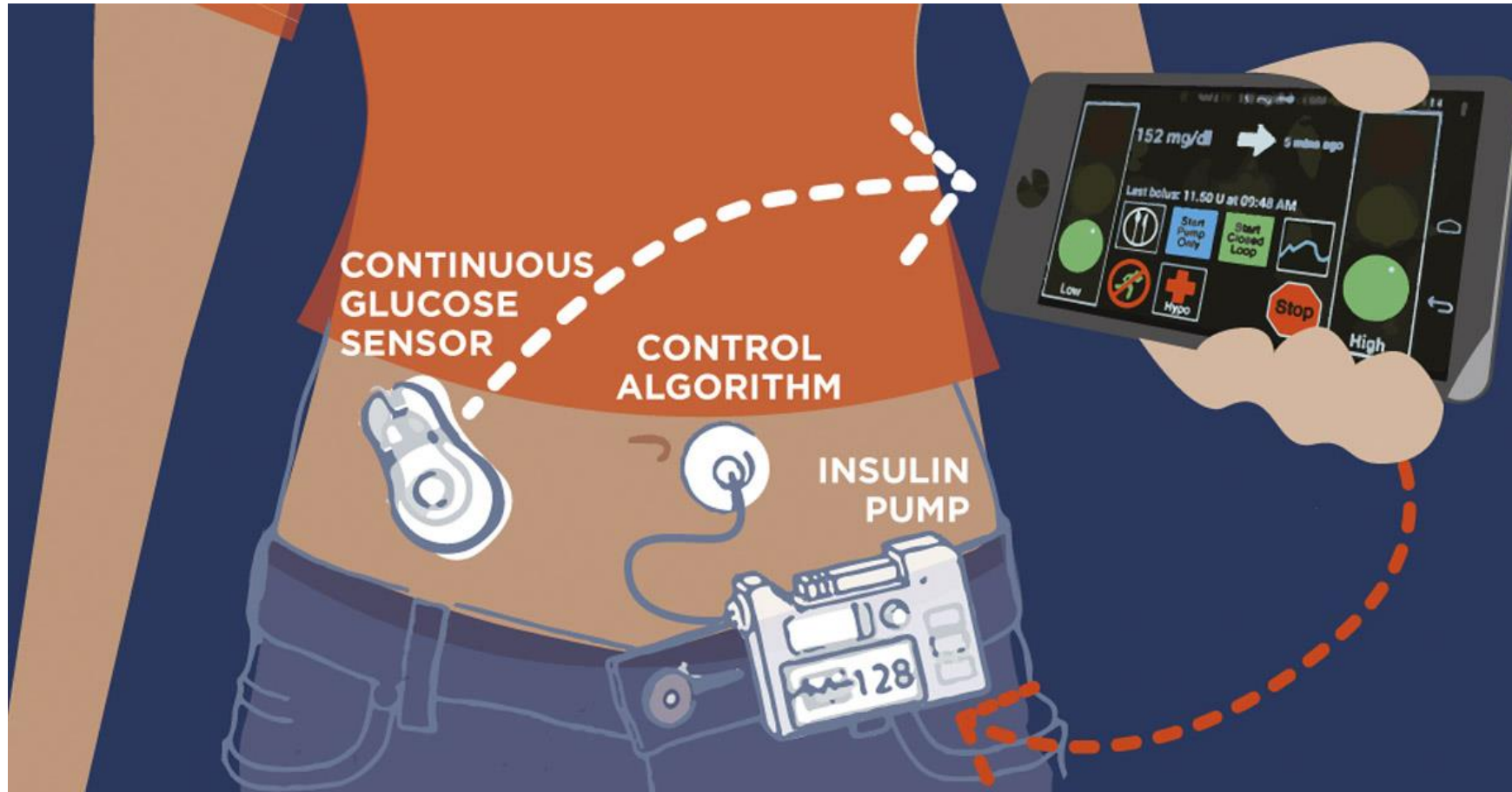
© Rolex / Daniel Forster – Rolex Fastnet Race 2015

Type 1 diabetes in England & Wales

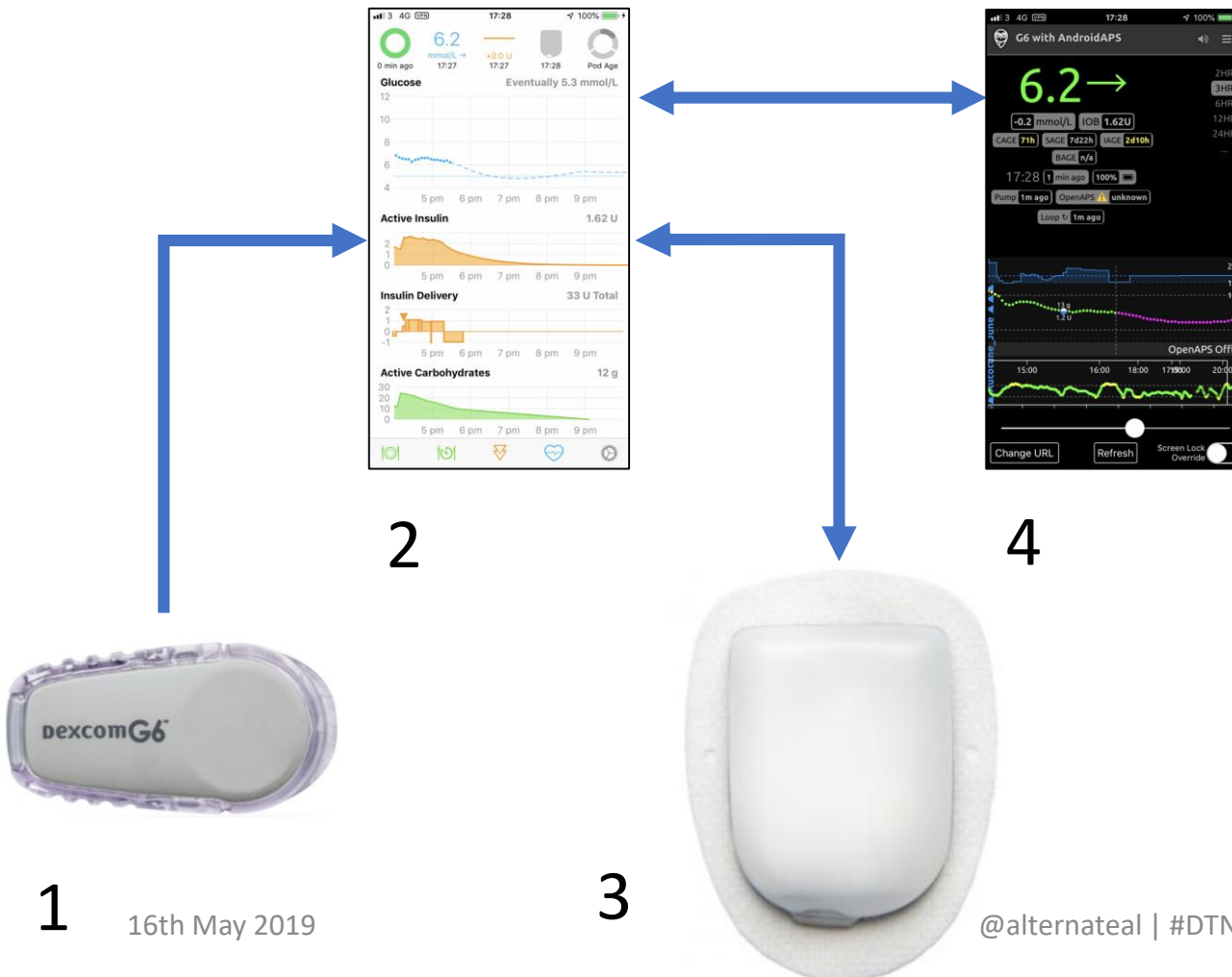
Figure 15: Mean HbA1c (mmol/mol) for those with Type 1 diabetes on an insulin pump compared to those not on a pump, by country, England and Wales, 2016-2017



What is a closed loop system?



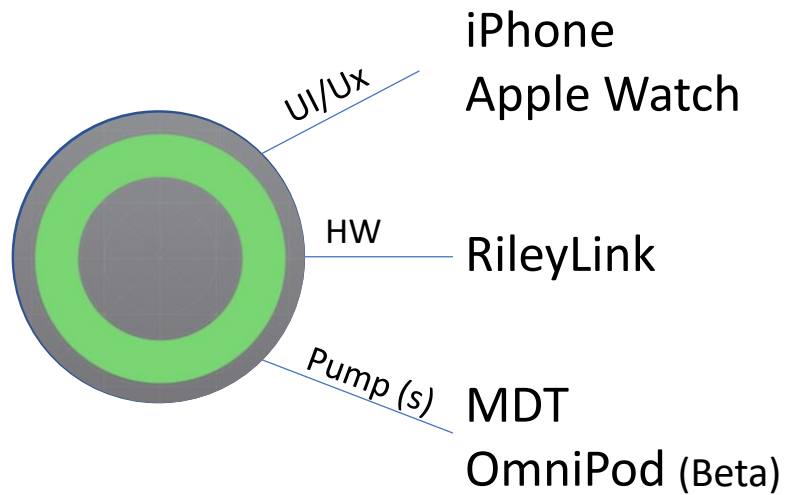
So what are the components of an Open Source Closed Loop System?



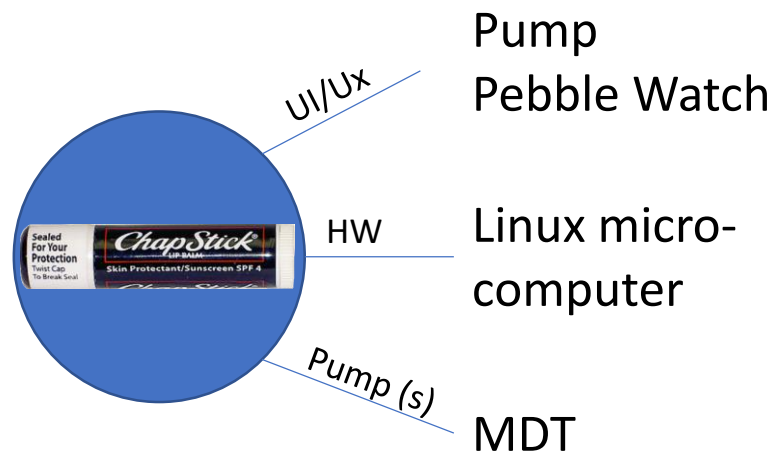
1. Continuous Glucose Monitor
2. Closed Loop Algorithm and communication mechanism
3. Insulin Pump
4. Nightscout "Cloud Storage"

There are different systems out there....

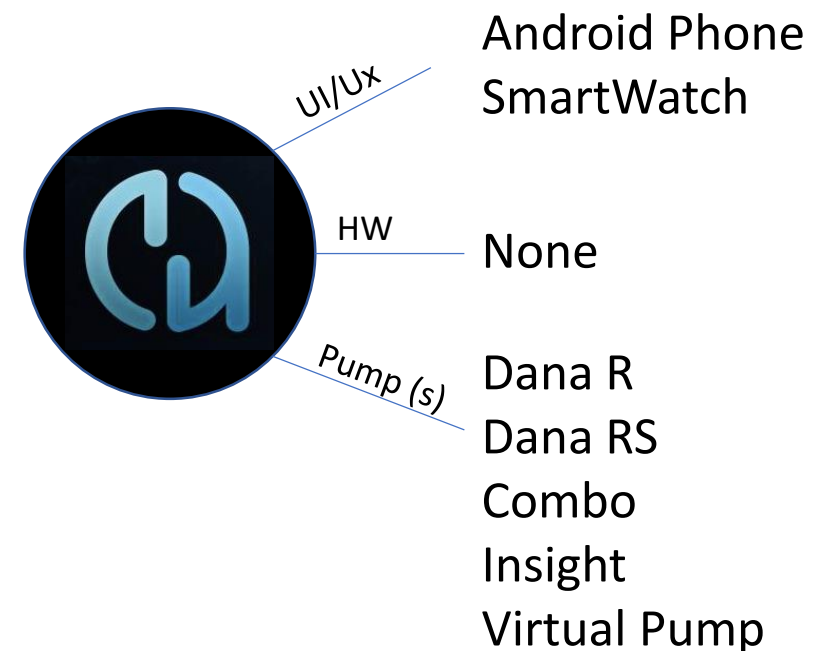
...mostly driven by what pumps are available



DIY Loop



OpenAPS



AndroidAPS

Work in development with RileyLink to allow MDT and OmniPod usage

Progression of Open Source Closed Loop algorithms

2016

2017

2018

First Generation

Second Generation

Third Generation



Very Low Glucose Insulin Off Pump
Pump Shuts off when user not responding to low-glucose alarm



Hypoglycemia Minimizer
Predictive hypoglycemia causes alarms followed by reduction or cessation of insulin delivery before someone gets low



Hypoglycemia/Hyperglycemia Minimizer
Same as #2 but added feature allowing insulin dosing above high threshold

Oref0



Automated Basal/Hybrid Closed Loop
Closed loop at all times with meal-time manual assist bolusing

**AMA
Autosens**



Fully Automated Insulin Closed Loop
Manual meal-time bolus eliminated

**Oref1
SMB/UAM
Autotune
FIAsp**



Fully Automated Multi-Hormone Closed Loop

How safe is it??

1. Objective

Setting up visualization and monitoring, and analyzing basals and ratios

Verify that BG is available in Nightscout, and pump insulin data is being uploaded

2. Objective

Starting on an open loop

Run in Open Loop mode for a few days and manually enact lots of temp basals. Set up and use temporary and default temporary targets (e.g. for activity or hypo treatment carbs)

3. Objective

Understanding your open loop, including its temp basal recommendations

Based on that experience, decide what max basal should be, and set it on the pump and preferences

4. Objective

Starting to close the loop with Low Glucose Suspend

Run in closed loop with max IOB = 0 for a few days without too many LGS events

5. Objective

Tuning the closed loop, raising max IOB above 0 and gradually lowering BG targets

Run for a few days, and at least one night with no low BG alarms, before dropping BG

6. Objective

Adjust basals and ratios if needed, and then enable auto-sens

1 week successful daytime looping with regular carb entry

7. Objective

Enabling additional features for daytime use, such as advanced meal assist

8. Objective

Enabling additional features for daytime use, such as SMB

You must read the wiki and rise maxIOB to get SMBs working fine! A good start is maxIOB=average mealbolus + 3 x max daily basal

- AndroidAPS is alone in "forcing" users through a set of timed gates.
- Each gate unlocks functionality provided the previous is correctly passed
- It takes approx. 35 days to complete discouraging casual users!

How many people are using these Systems?

- Some data points as of Friday 10th May:
- 114 Medtronic & 104 Ominpod RileyLinks sent to unique addresses in GB
- From 148 users answering Tim Street's survey:
 - 63% using AAPS
 - 26% using DIY Loop
 - 10% using OpenAPS
- From Kate Farnsworth survey:
 - 67 users in the UK
- So essentially we have no idea as a community how many people are using Open Source Closed Loop Systems

What results do the users get?

“Knowing your kid will wake up, and wake up in range and on target is priceless.”

“Managing this condition anxiety free. Being in control with a 1 year old. So NOT possible without looping.”

“He’s said he’s not felt diabetic & his time in range has improved incredibly!”

“We have normal glucose levels.”

“I can now work 4 days a week, have a social life and a daughter who is in range 90% of the time”

“improved quality of life...helped my daughter’s anxiety over her BGs...now she only taps at her watch whilst in school to bolus”

What results do the users get?

“I am not doing anything and I can't remember the last low I had! This looping is phenomenal. It's changed my life, given me more freedom and much more time free from worry.”

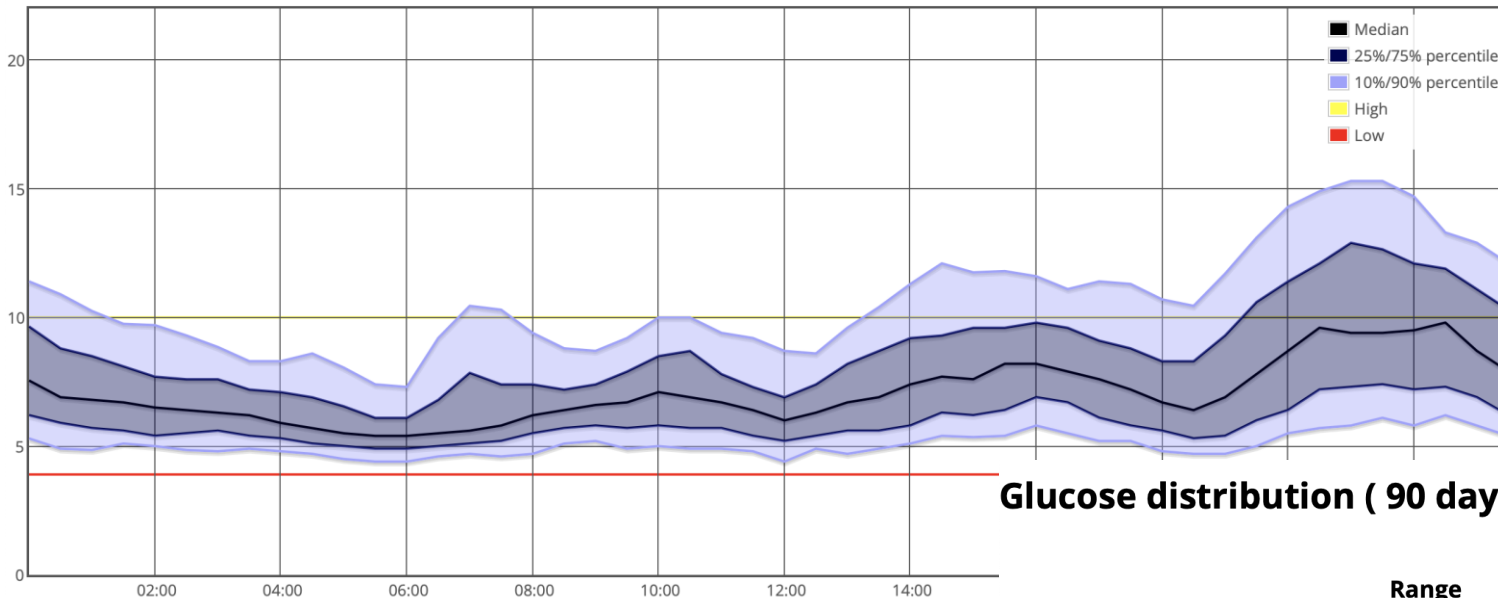
“I have better time in range, a slightly better HbA1c, more importantly I get a full night's sleep and almost always a perfect result, with a massive improvement in peace of mind”

“the huge psychological benefit this has provided. I felt as if I was 'failing' so much of the time before – however much effort I made - I am no longer 'failing'.”

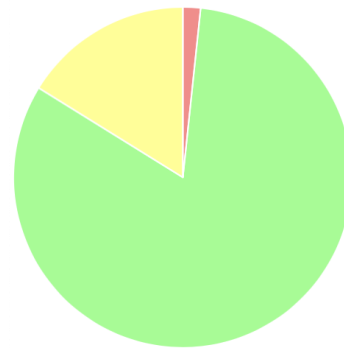
“My worry has gone, I feel free.
I have a HbA1c of 46 mmol/mol with no hypos and, finally, no fear of the dreaded complications.
I feel like I no longer have diabetes.”

What results do the users get?

Glucose Percentile report



Glucose distribution (90 days total)



Range	% of Readings	# of Readings	Average	Median	Standard Deviation	A1c estimation*
Low (<3.9):	1.7%	426	3.3	3.6	0.4	6.4% _{DCCT} 46 _{IFCC}
Normal:	82.2%	20813	6.6	6.4	1.4	
High (>=10):	16.1%	4107	12.3	11.6	2.2	
Overall:		25548	7.5	6.8	2.7	

Mean Total Daily Change	Time in fluctuation (>0.27 mmol/l/5m)	Time in rapid fluctuation (>0.55 mmol/l/5m)
62.59 mmol/L	24.0%	6.0%
Mean Hourly Change	GVI	PGS
2.61 mmol/L	1.37	32.92

Data from alternateal.herokuapp.com
 Dates: 2019-01-24 to 2019-04-23

Potential user: barriers to Open Source Closed Loop Systems

- DIY learning curve
- How do I get hold of suitable pumps or consumables?
- Ability to get hold of CGM?
- What will my HCPs say?
- Risk perception?
- “I will forget how to manage normally”

Summary

- The number of Open Source Closed Loop users in the UK is growing rapidly
- Often those with the best HbA1c in clinic
- Often children because their parents are keen to improve the lot of their children

Useful Links

- More information about looping:
 - A guide to looping- <http://bit.ly/loopguide>
 - A guide to looping for HCPs - <http://bit.ly/hcp-loop-guide>
- Documentation, safety, design and fine tuning guides:
 - OpenAPS guide for clinicians - <http://bit.ly/hcp-openaps-guide>
 - OpenAPS documentation - <http://bit.ly/openapsdocs>
 - AndroidAPS documentation- <http://bit.ly/androidapsdocs>
 - Loop documentation - <http://bit.ly/loopdocs>
- What do all those acronyms mean? <http://bit.ly/t1rdictionary>
- Facebook groups: Looped UK, Looped, AndroidAPS Users
- Twitter: #WeAreNotWaiting, #OpenAPS, #GBDOC