Technology and T1 Diabetes Care

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Portsmouth Hospitals University NHS Trust

Agenda

- Partha Kar — Where are we now and how did we get here?
- Iain Cranston — Technology “Nuts & Bolts”
- All — Discussion

Where are we now?

Partha Kar

August 2017

- Total Libre uptake: 0%
- Total CGM uptake: 4%
- Pump uptake: Children 30%; Adults: 9%

NICE TA151 2008

- Socioeconomic gaps
- Ethnicity gaps

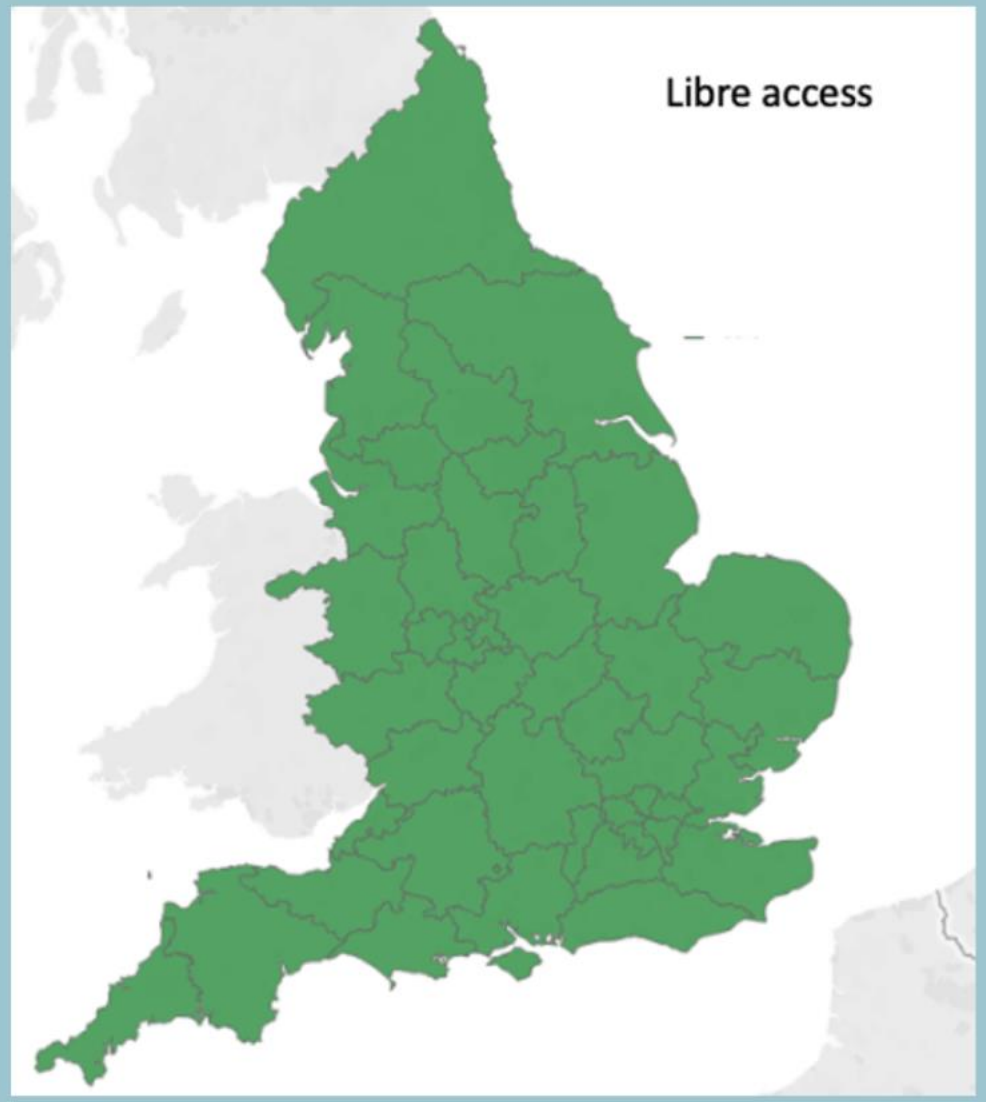
NICE

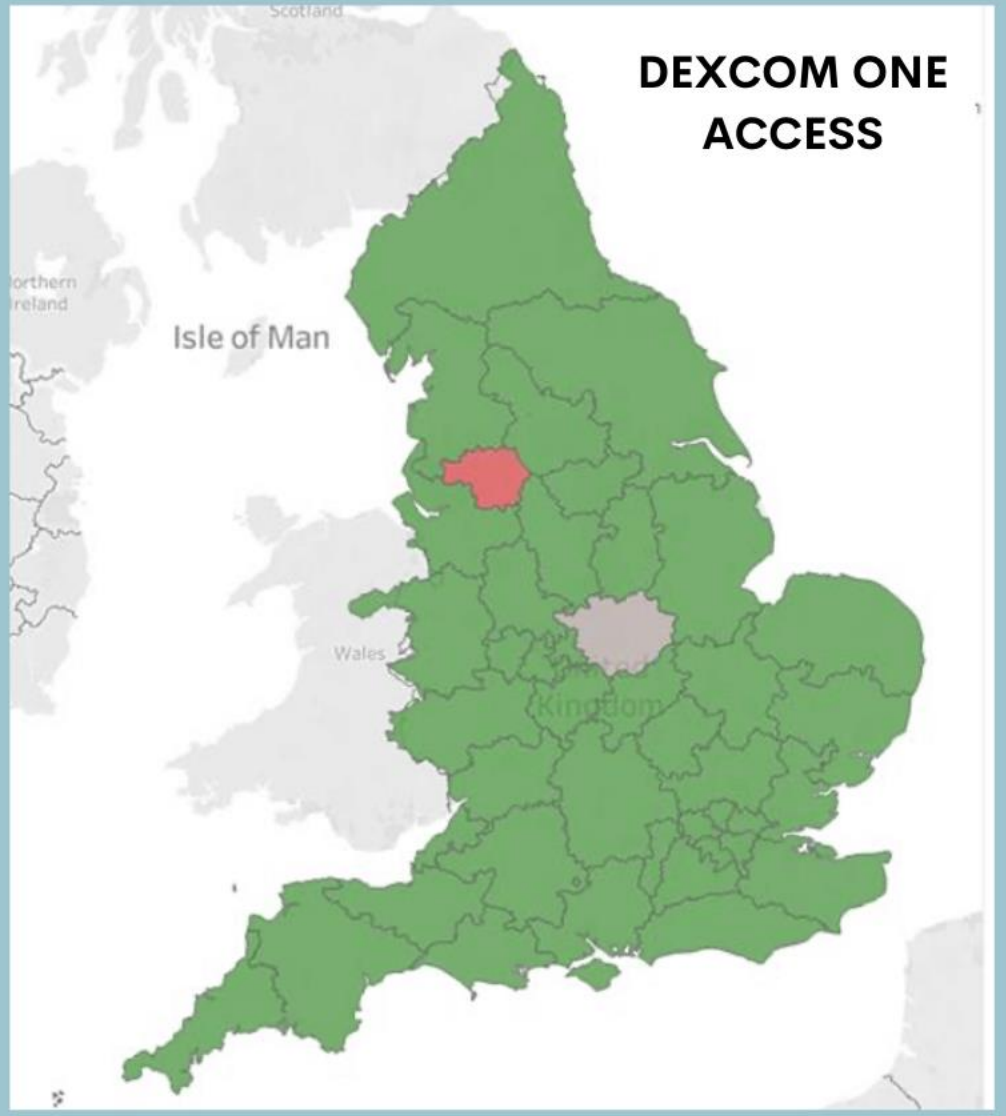
NG 17

NG 18

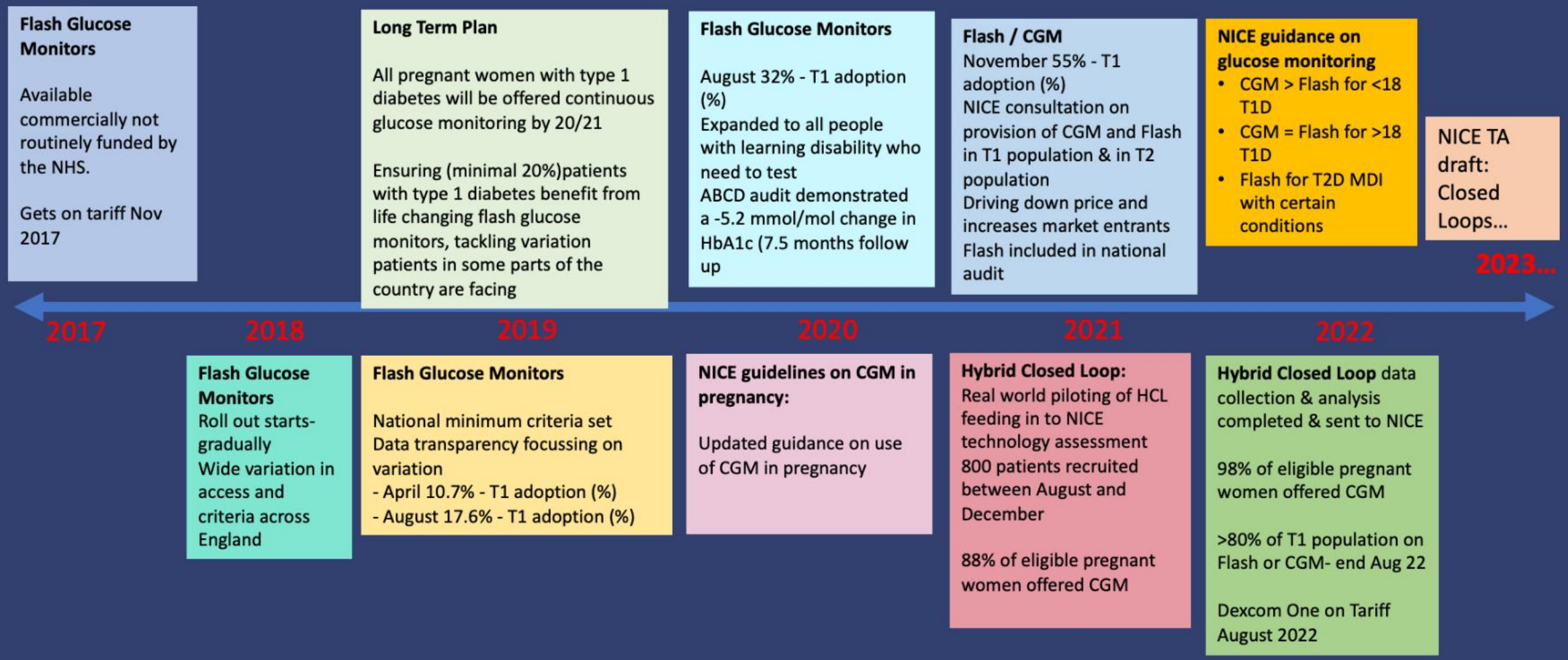
NG 28

ACCESS...WITHOUT VARIATION





EVOLUTION OF TECHNOLOGY PROVISION



AUGUST 2023

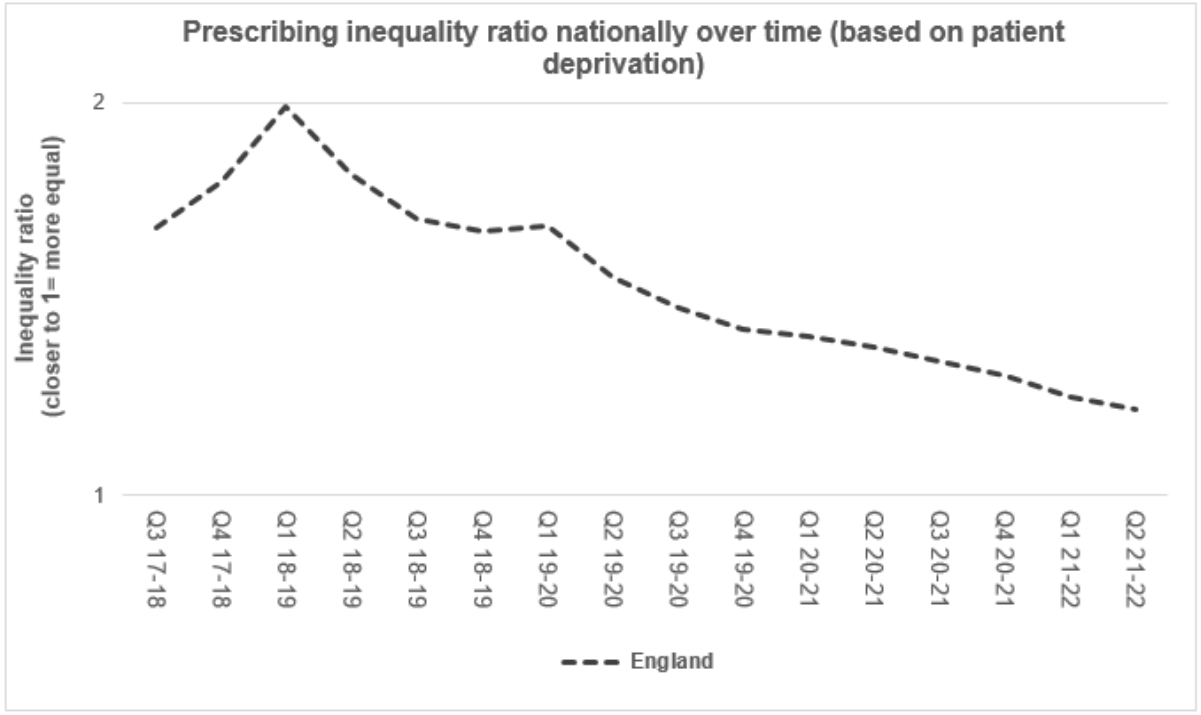
- 94 % of all type 1 diabetes on CGM

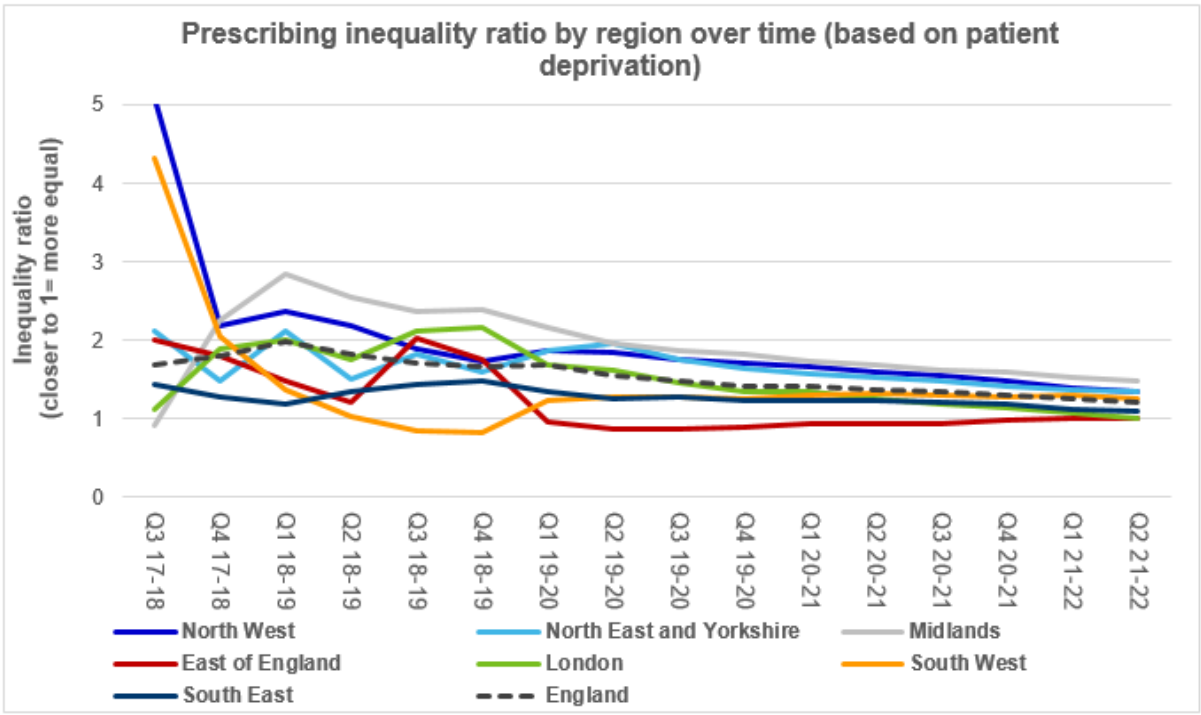
- 98% of type 1 diabetes pregnancy offered CGM
- Pediatric type 1 diabetes audit: best A1c achievement < 7.5% since records began

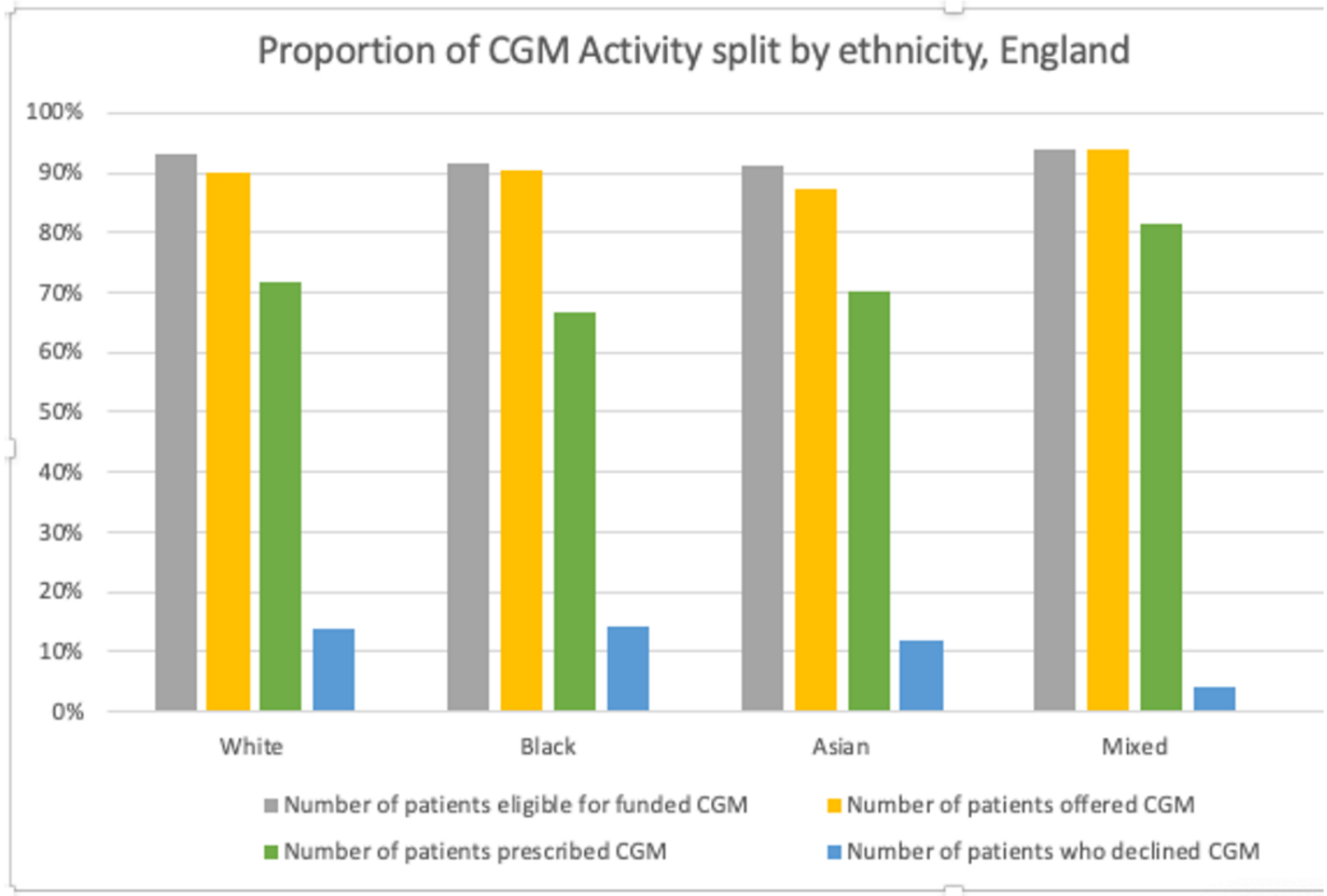
- Adult type 1 diabetes audit: Best 1c achievement < 7.5% since records began

- DKA rates in type 1 diabetes dropping

Is it possible?






Proportion of CGM Activity split by ethnicity, England
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
White
Black
Asian
Mixed
Number of patients eligible for funded CGM
Number of patients offered CGM
Number of patients prescribed CGM
Number of patients who declined CGM

NICE National Institute for Health and Care Excellence

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New “artificial pancreas” technology set to change the lives of people having difficulty managing their type 1 diabetes

Around 105,000 people with type 1 diabetes could benefit from NICE’s draft recommendation

10 January 2023

Real world data…working WITH NICE

DIABETIC Medicine

DiABETES UK
KNOW DIABETES. FIGHT DIABETES.

RESEARCH: Healthcare Delivery

Real world use of hybrid-closed loop in children and young people with type 1 diabetes mellitus—a National Health Service pilot initiative in England

Sze May Ng, Neil P. Wright, Diana Yardley, Fiona Campbell, Tabitha Randell, Nicola Trevelyan, Atrayee Ghatak, Peter C. Hindmarsh

First published: 24 November 2022 | https://doi.org/10.1111/dme.15015 | Citations: 5

Diabetes Care

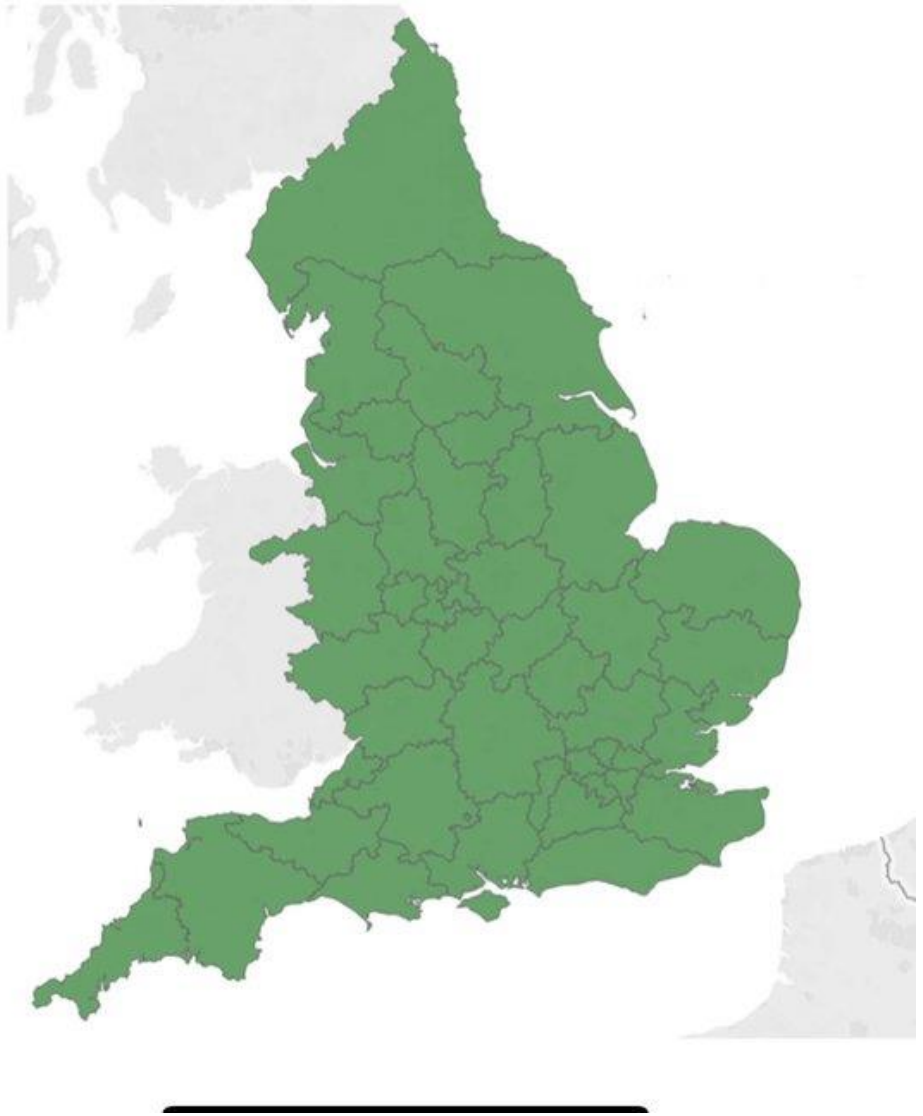
American Diabetes Association

Hybrid Closed Loop Therapy in Adults With Type 1 Diabetes and Above-Target HbA_{1c}: A Real-World Observational Study

Thomas S.J. Crabtree, Tomás P. Griffin, Yew W. Yap, Parth Narendran, Geraldine Gallen, Niall Furlong, Iain Cranston, Ali Chakera, Chris Philbey, Muhammad Ali Karamat, Sanjay Saraf, Shafie Kamaruddin, Eleanor Gurnell, Alyson Chapman, Sufyan Hussain, Jackie Elliott, Lalantha Leelarathna, Robert E.J. Ryder, Peter Hammond, Alistair Lumb, Pratik Choudhary, Emma G. Wilmot, on behalf of the ABCD DTN-UK Closed Loop Audit Contributors

Diabetes Care 2023;46(10):1–8 | https://doi.org/10.2337/dc23-0635

CGM access / Dexcom One / Freestyle Libre




Diabetes Tech “Nuts & Bolts”
Iain Cranston

GLUCOSE CONTROL IN T1 DIABETES IS THE MOST CHALLENGING TASK IN ALL CHRONIC DISEASE MANAGEMENT

42 Factors That Affect BG

Food
- ↑↑ 1. Carbohydrate quantity
- →↑ 2. Carbohydrate type
- →↑ 3. Fat
- →↑ 4. Protein
- →↑ 5. Caffeine
- ↓↑ 6. Alcohol
- ↓↑ 7. Meal timing
- ↑ 8. Dehydration
- ? 9. Personal microbiome

Medication
- →↓ 10. Medication dose
- ↓↑ 11. Medication timing
- ↓↑ 12. Medication interactions
- ↑↑ 13. Steroid administration
- ↑ 14. Niacin (Vitamin B3)

Activity
- →↓ 15. Light exercise
- ↓↑ 16. High-intensity and moderate exercise
- →↓ 17. Level of fitness/training
- ↓↑ 18. Time of day
- ↓↑ 19. Food and insulin timing

Biological
- ↑ 20. Insufficient sleep
- ↑ 21. Stress and illness
- ↓ 22. Recent hypoglycemia
- →↑ 23. During-sleep blood sugars
- ↑ 24. Dawn phenomenon
- ↑ 25. Infusion set issues
- ↑ 26. Scar tissue and lipodystrophy
- ↓↓ 27. Intramuscular insulin delivery
- ↑ 28. Allergies
- ↑ 29. A higher glucose level
- ↓↑ 30. Periods (menstruation)
- ↑↑ 31. Puberty
- ↓ 32. Celiac disease
- ↑ 33. Smoking

Environmental
- ↑ 34. Expired insulin
- ↑ 35. Inaccurate BG reading
- ↓↑ 36. Outside temperature
- ↑ 37. Sunburn
- ? 38. Altitude

Behavioral & Decision Making
- ↓ 39. Frequency of glucose checks
- ↓↑ 40. Default options and choices
- ↓↑ 41. Decision-making biases
- ↓↑ 42. Family relationships and social pressures

diaTribe

How can technology help?

What Technology is there?

- Glucose Monitoring Technology
  - CGM / Flash (isCGM)
- Insulin Delivery Technology
  - Connected Pens / Insulin Pumps / Patch Pumps
- Insulin Technology
  - New longer-acting basal insulins / New Shorter-acting meal-time insulins
- Other Stuff (mainly computer or phone-related!)
  - AI-influenced dosing algorithms → Closed Loop Algorithms
  - Data Projection Software / Educational On-line Materials
  - Bolus Calculators

Smart Phones and diabetes tech

A phone is central to most of modern diabetes tech, so encourage your consultees to learn about the communications features of their device, if they are to benefit. Some common useful tips are…

Leave the app running in the background – don't shut it down!

Settings

Bluetooth (NFC) 'always on'
Battery saving 'off'
buy a back-up charger! SAVE passwords !!!

Wi-Fi

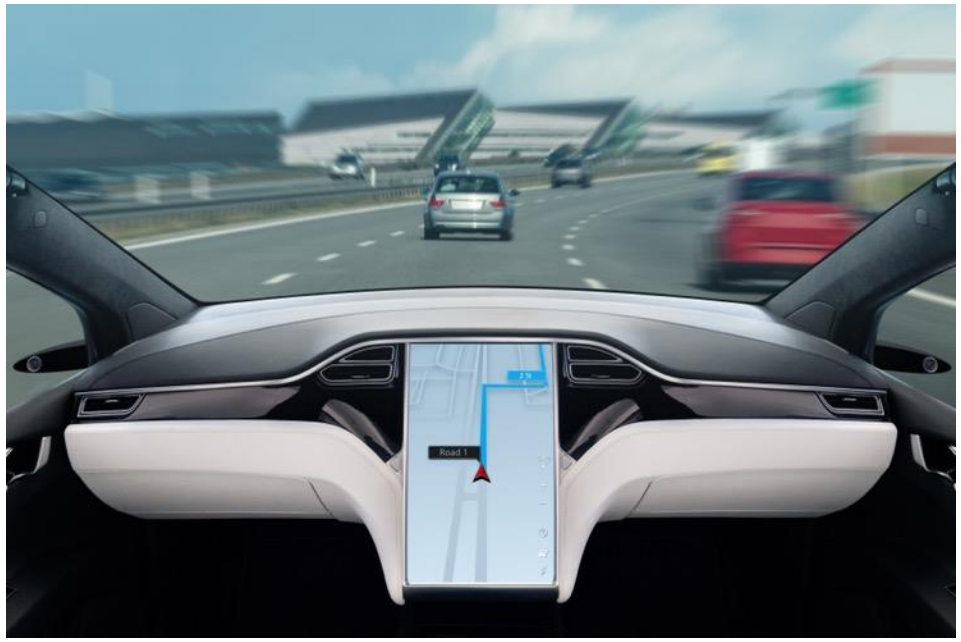
When entering the hospital, encourage to join NHS wifi as a routine

Security

Location 'always allow' generally required to set up device links

What is technology for?

Simplicity or *Performance*



or does it vary from person to person?

Is all technology the same?

- Appearances can be deceptive
- Testing in practice is critical
- What features do I want?
- How do I use it?
- Do I need a PhD to understand it?

- Choices Matter!

Can technology sometimes be a barrier?

Technology is now involved in all aspects of diabetes care, from information gathering to effector medication administration

Inputs

Smart Watch

Heart Rate
Activity
Note-keeping

Medical Device

CGM device
SMBG data
Alarms
Atrial ECG sensor

Analytics and decisions

Human vs Algorithmic vs Machine Learning

Outputs

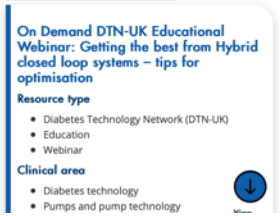
Medical Device

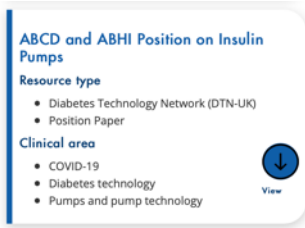
Insulin Pump
Pacing Wire
Connected Pen
Bolus Advisor

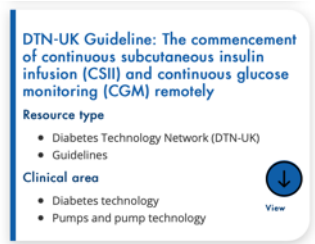
Consultation

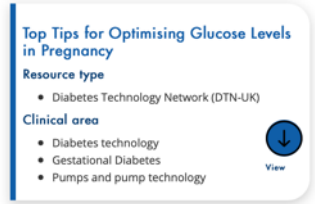
Assessment of Progress
Change Strategies
Didactic Therapy Advice

Where can I find information?









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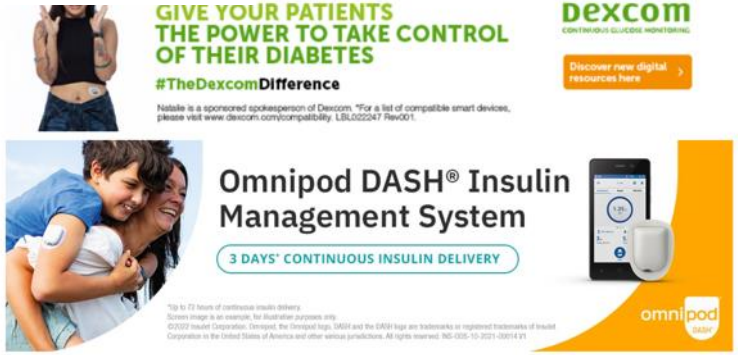
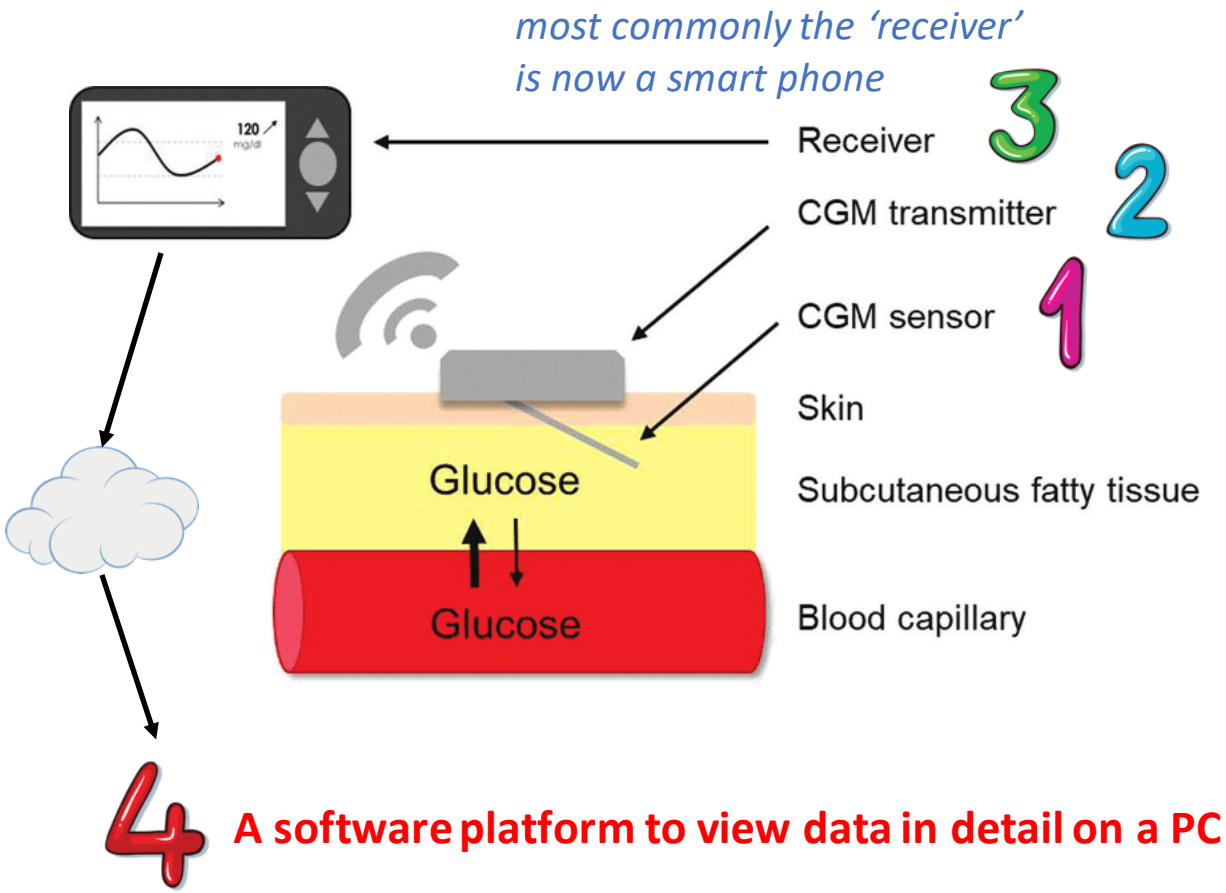


What is CGM? (& how does it work?)

ALL systems have 4 main components:



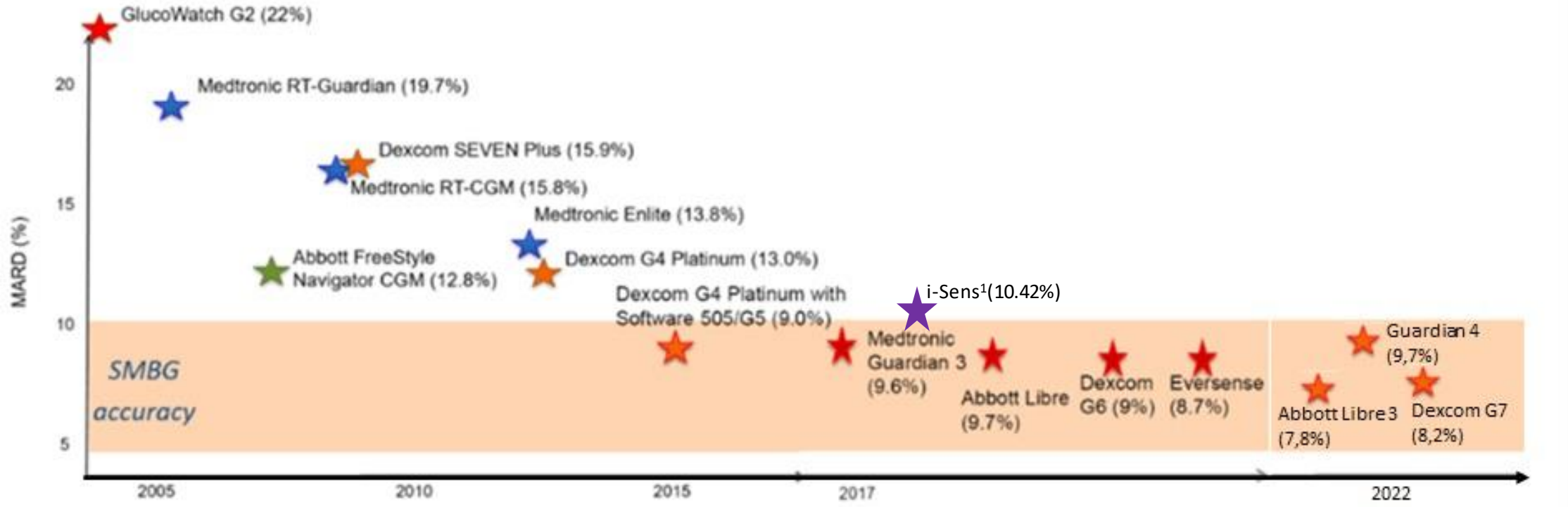
Dexcom (rt-CGM)

Medtronic (rt-CGM)

FreeStyle Libre (flash)

FreeStyle Libre 2 (flash)

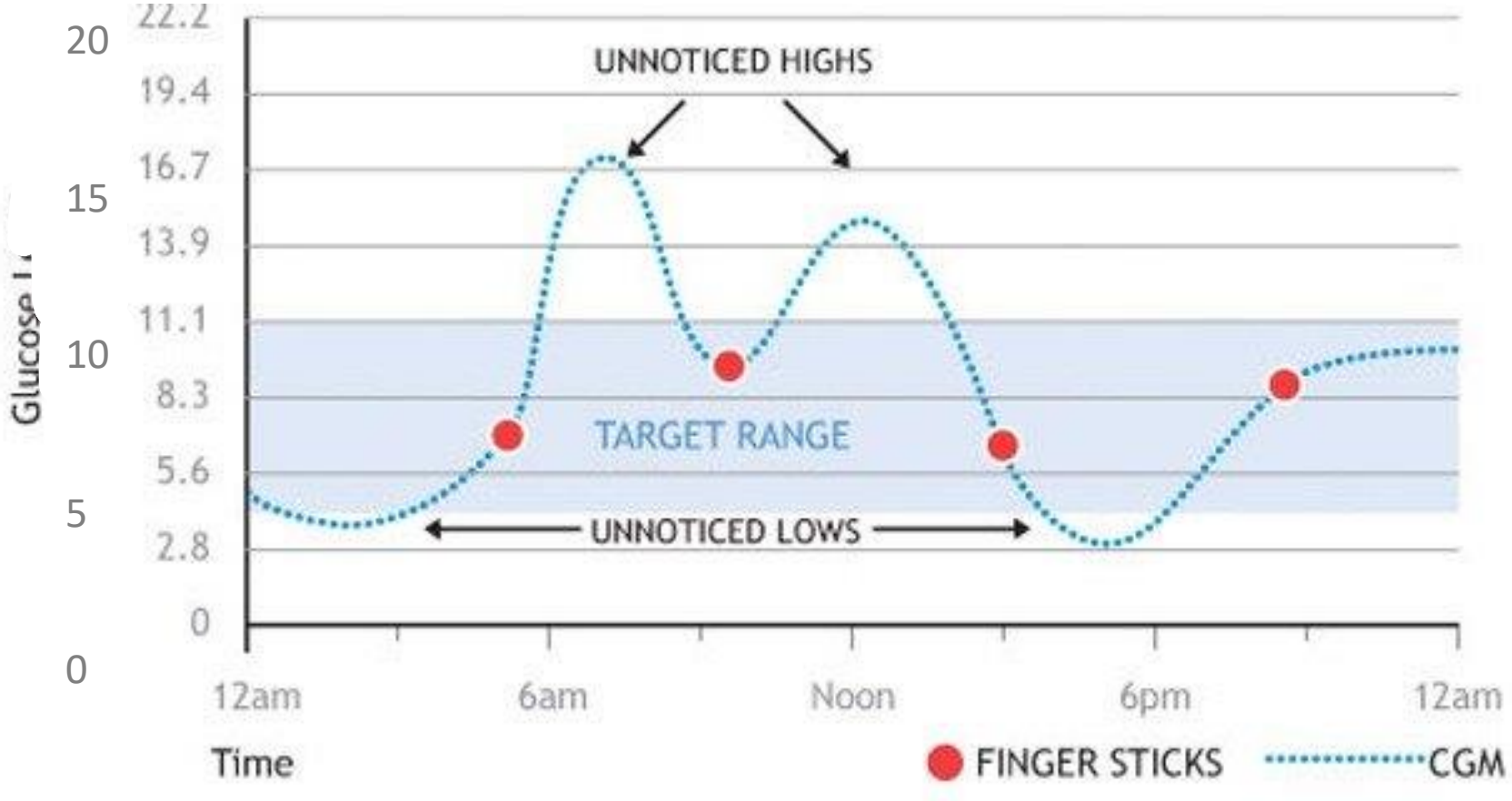
CGM accuracy has improved over the last 15 years and is now similar to SMBG accuracy*



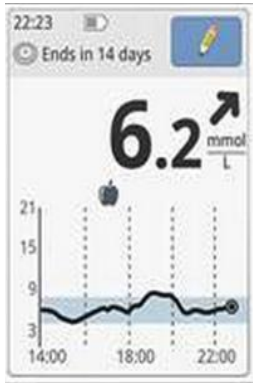
* although now similar overall, the *sources* of inaccuracy are different between SMBG and CGM

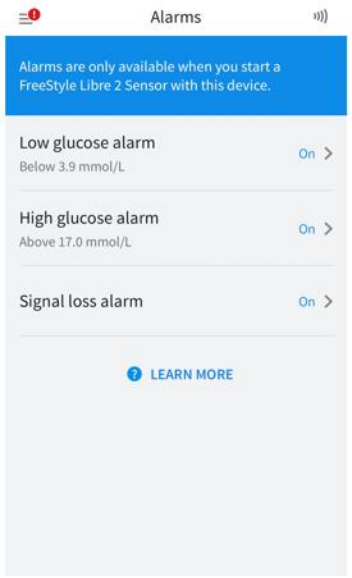
What additional data can CGM offer over SMBG?

CGM devices show a full pattern across the day AND can given information regarding which way the glucose is going



Using CGM to create benefit…

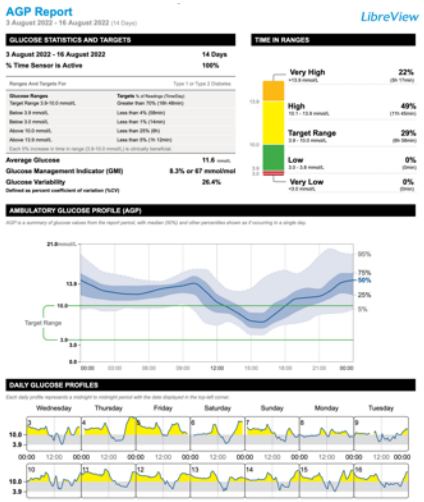




Immediate benefit

- More frequent scanning
- using the arrows &..
- using the line – to predict change
- setting alarms to warn regarding extremes of glucose
- avoiding admissions!

“reactive action”



Long-term benefit

- using display software at home and in consultations to review previous patterns and plan changes
- progressively altering my targets to achieve more time in range and less time below range

”pro-active action”

What do the arrows mean?

	Rate of change	How long to change by 1 mmol/L	How much will it change in 30 mins
↑	> 0.11 mmol/L / min	Average 7 mins	at least 3 mmol/L
↗	Between 0.11 and 0.06 mmol/L / min	Average 15 mins	2-3 mmol/L
→	Less than 0.06 mmol/min	More than 20 mins	< 2 mmol/L
↘	Between 0.11 and 0.06 mmol/L / min	Average 15 mins	2-3 mmol/L
↓	> 0.11 mmol/L / min	Average 7 mins	at least 3 mmol/L

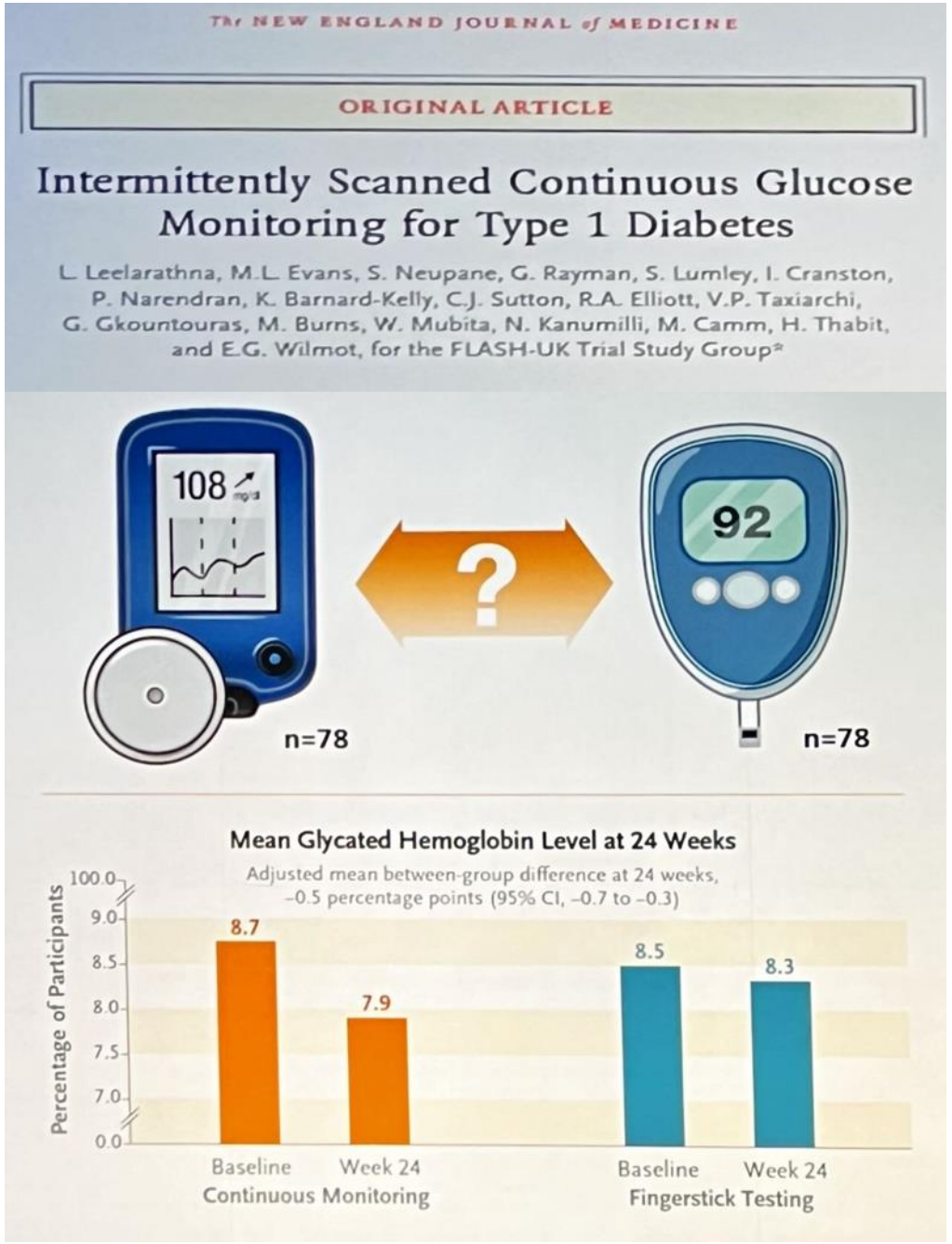
Kudva, Y. C., Ahmann, A. J., Bergenstal, R. M., Gavin, J., Kruger, D. F., Midyett, L. K., Miller, E., & Harris, D. R. (2018). Approach to Using Trend Arrows in the FreeStyle Libre Flash Glucose Monitoring Systems in Adults. Journal of the Endocrine Society, 2(12), 1320–1337. https://doi.org/10.1210/js.2018-00294
The Academy | ABCD (Diabetes Care) Ltd. (n.d.). https://abcd.care/dtn/academy

Evidence for CGM use

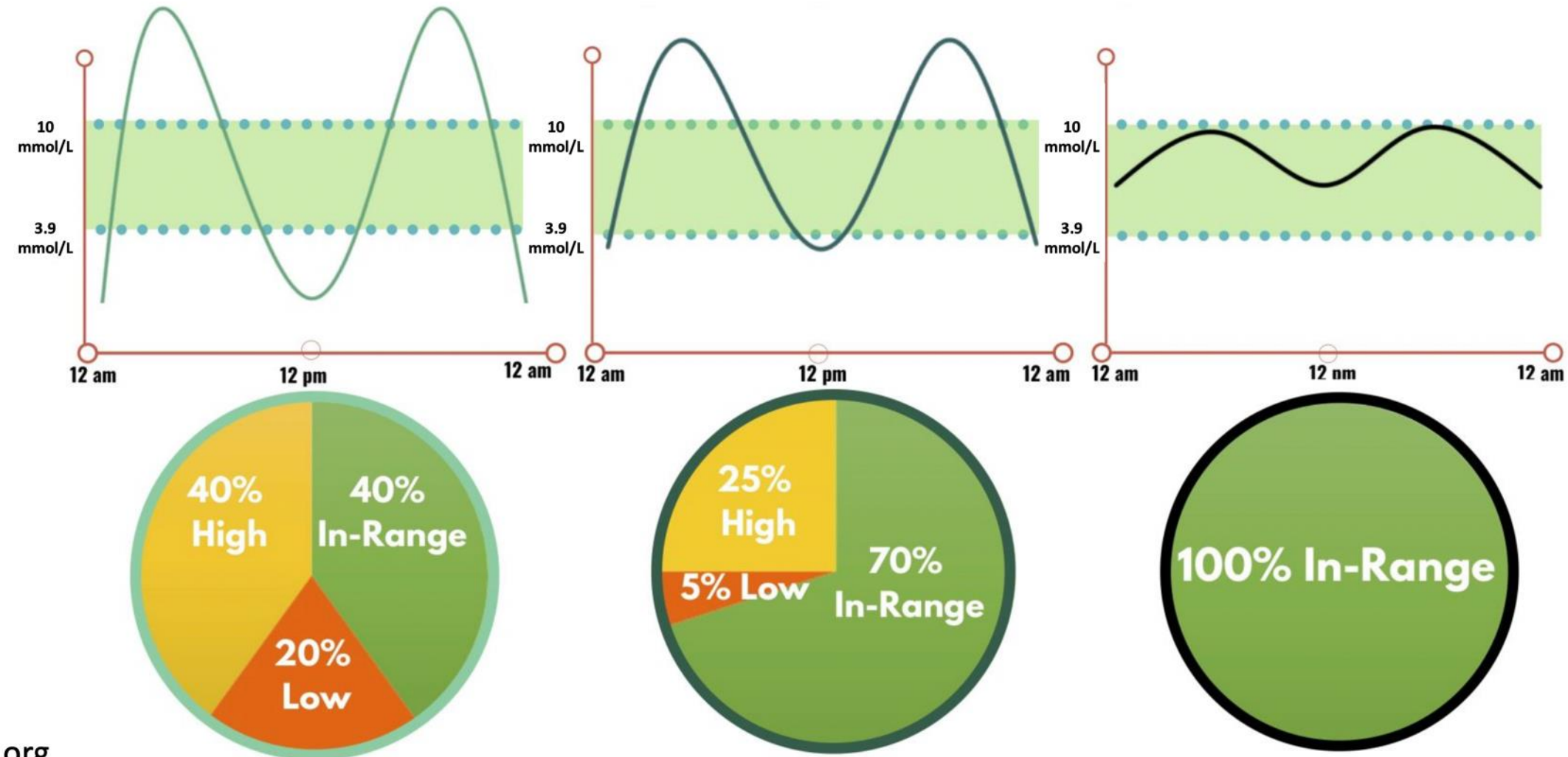
Using CGM (flash and r-t) instead of SMBG has been associated with:

- reduced risk for hypoglycaemia
- improved overall control (time in range and HbA1c)
- improved well-being / confidence / treatment satisfaction
- reduced risk for hospital admission

mainly in people with diabetes using multiple daily doses of insulin



All averages are not equal: The Time in Range Concept



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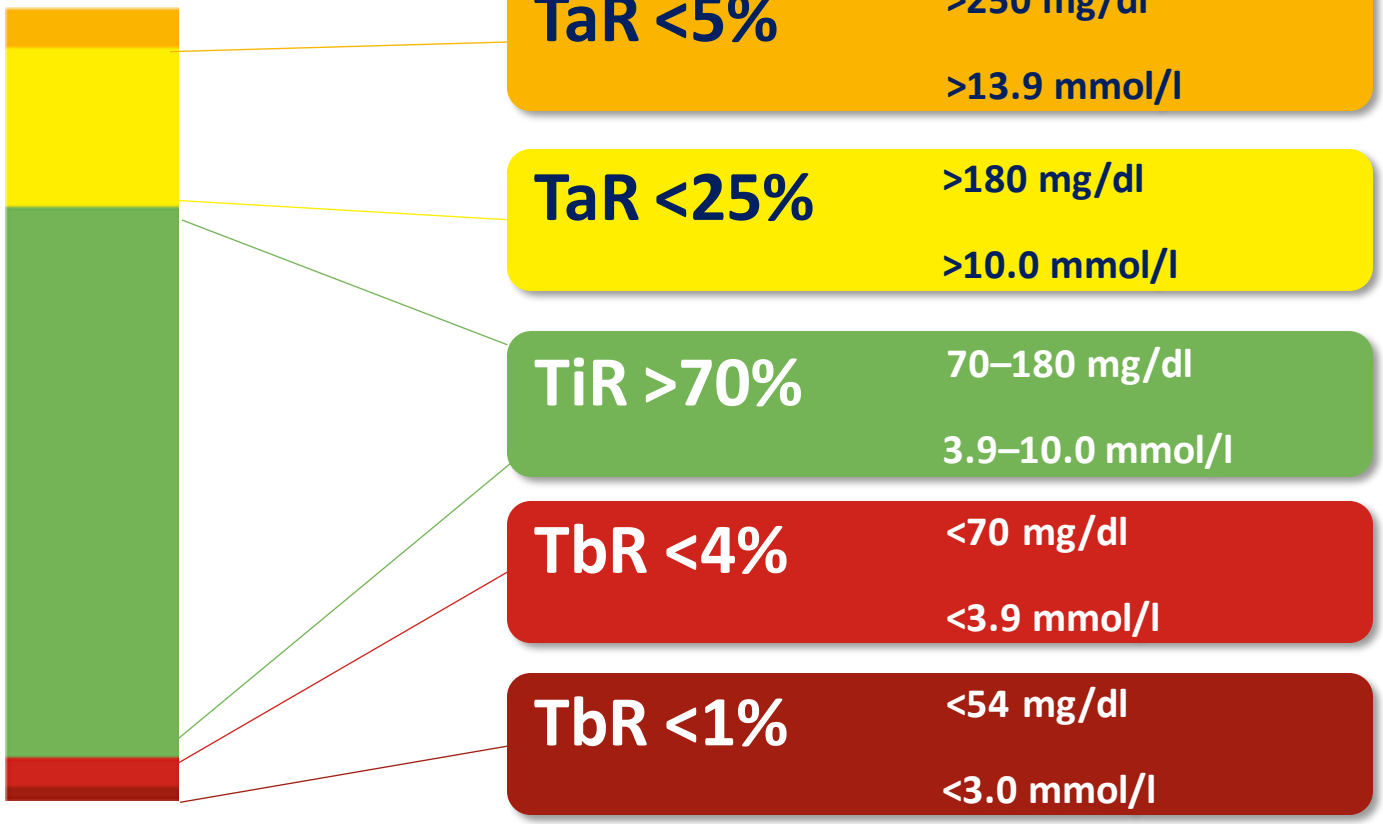
CGM TiR targets for most with T1D and T2D

T1D and T2D



Level 2 Hyperglycemia

Level 1 + Level 2 Hyperglycemia

In target

Level 1 + Level 2 Hypoglycemia

Level 2 Hypoglycemia

High risk individuals (with complications or comorbidities & pregnancy) have different targets

Battelino T, Danne T, Bergenstal RM, et al. *Diabetes Care* 2019;42:1593–1603

TaR = Time Above Range
TiR = Time In Range
TbR = Time Below Range

Connected Pens (as Available 2023)

Medtronic InPen

Bluetooth Connections

Bespoke App
For use with Medtronic CGM
Bolus Calculator
CareLink

NovoPen 6 / EchoPlus

Widely available in UK
NFC connection
Glooko / LibreLink compatible

Putting it All together – ‘UK loops evidence’

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American Diabetes Association®

Hybrid Closed Loop Therapy in Adults With Type 1 Diabetes and Above-Target HbA_{1c}: A Real-World Observational Study

Thomas S.J. Crabtree, Tomás P. Griffin, Yew W. Yap, Parth Narendran, Geraldine Gallen, Niall Furlong, Iain Cranston, Ali Chakera, Chris Philbey, Muhammad Ali Karamat, Sanjay Saraf, Shafie Kamaruddin, Eleanor Gurnell, Alyson Chapman, Sufyan Hussain, Jackie Elliott, Lalantha Leelarathna, Robert E.J. Ryder, Peter Hammond, Alistair Lumb, Pratik Choudhary, Emma G. Wilmot, on behalf of the ABCD DTN-UK Closed Loop Audit Contributors

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Hybrid Closed Loop Therapy in Adults With Type 1 Diabetes and Above-Target HbA_{1c}: A Real-World Observational Study

Inclusion

- Pump therapy
- FreeStyle Libre
- HbA_{1c}>8.5%

Any commercially available HCL in the U.K.

31 centers

N=520

Methods

- 6-month follow-up
- Pragmatic real world design
- Outcomes

HbA_{1c}	Weight
GMI	DDS Score
TIR	Gold Score
TBR	Acute Events
TAR	User Opinion

Key Results

Improved TIR

+27.6%

% with Diabetes Distress (DDS≥3)

69.2%→22.8%

Reduction in HbA_{1c}

-1.7%

Increased numbers meeting recognized glucose and HbA_{1c} targets

ABCD
Association of British Clinical Diabetologists

DTN UK
collaborate · evolve · support

Are all loops the same?

Table 5 DTN Best Practice Guide (ABCD.care)

HCL system	SmartGuard	Tandem Control IQ	CamAPS FX
Pump	Medtronic MiniMed™780G	Tandem T:Slim	Dana RS/ Dana I Compatible YpsoMed pump
CGM	Medtronic Guardian sensor 3 and 4	Dexcom G6	Dexcom G6/Libre 3
License	• 7–80 years • TDD 8–250 units/day • Weight 10–300 kg • Rapid acting insulins	• >6 years • TDD 10–100 units/day • Weight 25–140 kg • Rapid acting insulins	• ≥1 year • Pregnancy • TDD 5–350 units/day • Weight 10–300 kg • Rapid and ultra-rapid acting insulins
Bolus route	Via pump	Via pump	Via pump or android app
Calculate			
Parameters for automated basal insulin delivery	• Uses total daily insulin calculated from last 2–6 days to determine algorithm parameters • Ongoing adjustment	• Requires 'Personal Profile' (which includes basal, IC and ISF) • Uses weight and total daily insulin input by user to determine algorithm parameters	• Uses weight and total daily insulin input by user to determine algorithm parameters • Ongoing learning
Target glucose	• 5.5 (default) • 6.1 or 6.7 mmol/L	Range: • 6.25–8.9 mmol/L daytime; Control-IQ • 6.25–6.7 mmol/L sleep; Sleep Activity • 7.8–8.9 mmol/L exercise; Exercise Activity	• Personalised target: 4.4–11.0 mmol/L – default 5.8 mmol/L • Can be changed across 24 h (in 30 min intervals)
Logic for insulin adjustments (simplified)	• Automated basal insulin delivery (au-to-basal) with auto-correction bolus if glucose >6.7 mmol/L and at maximum 'auto-basal' delivery	• Automated basal insulin delivery, which increases or decreases programmed basal rates, and auto-correction bolus if glucose predicted to be >10 mmol/L during Control-IQ (60% of calculated dose, 1 per hour maximum)	• Automated basal insulin delivery via extended bolus functionality of pump. Basal shut off when closed-loop running
Basal adjustments	• Basal insulin adjusted every 5 min	• Basal insulin adjusted only if SG predicted to exit range	• Basal insulin set to zero: extended bolus given every 10–12 min
Manual mode	• Based on last programmed basal • Can be used with predictive low glucose suspend (if CGM active)	• Based on active 'personal profile'	• Based on last programmed basal • Can still bolus via CamAPS FX app in manual mode
Education			
HCP education	• Company-delivered HCP training	• Company-delivered HCP training	• E-learning platform
User education	• e-Learning platform • Company provided training	• e-Learning platform	• e-Learning platform
Share			
User interface	• Pump	• Pump	• Android phone
Smartphone integration	• View only (Android and Apple)	• Only in U.S. at present	• Android
Remote follower function	• Carelink Connect App—real-time and notifications	• CGM via Dexcom Share	• SMS alarms and alert—need SIM card, mobile signal and data on phone for Dana users. Internet access for Ypso users as SMS sent via cloud • Diasend (5–10 mins time delay)[a] • CamAPS Fx Companion App—Follow app that links with the user's app and shows insulin and glucose data in real time on the guardian's phone but is unable to influence insulin delivery (bolus, boost, ease-off etc. blocked). The CamAPS companion can have different alerts to the ones set on the person's own CamAPS Fx app if appropriate
Data platform	• CareLink personal (manual or smartphone upload)	• Glooko or T:Connect (manual upload)	• Diasend (via smartphone)[a]
Adjust			
Adjustable parameters	• I:C ratios • Active insulin time (2–8 h) • • Target glucose as above	• I:C ratios • Basal rate • Insulin sensitivity factor • Target glucose as above • • Body weight	• I:C ratios • Target glucose as above • Body weight • Add meal—hypo notification, snacking or splitting of larger meals with or without high fat and high protein
Overrides	Temp Target (fixed at 8.3 mmol/L)	• Sleep and exercise modes • 'Sleep Activity' • 'Exercise Activity' • Alter Personal Profiles (e.g. template for sick day or exercise)	• Boost or Ease off modes
Revert			
Revert to manual mode	• Loss of CGM data • Sensor integrity concerns (e.g. insufficient calibration [only with Guardian 3 sensor])	• Loss of CGM data	• Loss of CGM data • Loss of connection with pump

NO!

Summary

- Technology in diabetes (as in other aspects of our lives) is all around us (and is increasingly tied to smart phone use)
- Which devices (and how) we choose to use depends on a range of personal factors
- For the first time technology in diabetes care has been focused on reducing burden / workload rather than just biomedical targets
- Combining CGM and insulin pump technologies intelligently offers the possibility for both improved outcomes and reduced self-management burden
- Effective use of technology requires us to understand and work with it


Questions / Discussion