PUSHING THE LIMITS of WHAT SENSING CAN DO for Type 1 and Type 2 DIABETES

ATTD
Advanced Technologies & Treatments for Diabetes

Focus on Pivotal Advantages in **Dual Monitoring—Glucose and Ketones**—for Improving Glycemic Metrics and Reducing the Risk of DKA

*Leveraging Dual Analyte Sensing to **Optimize Therapeutic Interventions in Diabetes***

Fernando Gómez-Peralta, MD, PhD

Coordinator of the SCLEDyN Diabetes Group
and Diabetes Area of the Spanish Society of
Endocrinology and Nutrition (SEEN)
Endocrinology and Nutrition Unit
General Hospital of Segovia (Spain)

Disclosures

F. Gomez-Peralta has taken part in advisory panels for Insulcloud S.L., Abbott Diabetes, Dexcom, Novartis, Astra Zeneca, Sanofi and Novo Nordisk; has participated as principal investigator in Clinical Trials funded by Sanofi, Novo Nordisk, Boehringer Ingelheim Pharmaceuticals, and Lilly; and has acted as a speaker for Abbott Diabetes, Novartis, Sanofi, Novo Nordisk, Boehringer Ingelheim Pharmaceuticals, AstraZeneca Pharmaceuticals LP, Bristol-Myers Squibb Co., and Lilly.

- I may present recommendations regarding the use of drugs or devices from companies with which I have a financial relationship.
- Additionally, my presentation will adhere to the following criteria:
  - My recommendations will be based on data and findings from peer-reviewed sources OR in the absence of adequate peer-reviewed material, my recommendations will rely on the best available evidence-based medicine.
  - Content will be fair and balanced, and if any product, specific drugs, or devices are discussed, alternate drugs or devices will also be discussed when appropriate.

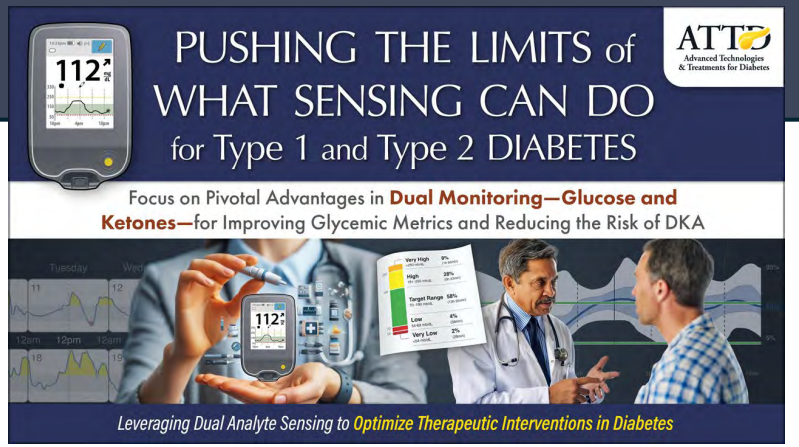
This CME-certified simulcast symposium is jointly provided by the UMASS Chan Medical School and CMEducation Resources.

Commercial Support: Supported by an educational grant from Abbott Diabetes Care

My Task Today: Introducing…

- Introducing the **agenda and speakers**
- Introducing the **main protagonists: THE KETONES!**
- Introducing **DKA**
- Introducing **KB and T2D…**

Program Agenda



14:40 – 15:10

Ketones, What They Are and What They Can Tell Us About Preventing DKA

Dr Fernando Gomez-Peralta, MD, PhD - Program Chair

Coordinator Diabetes Area, Spanish Endocrinology and Nutrition Society
Head of Endocrinology and Nutrition Unit
Segovia General Hospital
Segovia, Spain

15:10 – 15:35

Beyond CGM: Dual Sensing Technology as a Cornerstone of DKA Prevention

Professor Ketan Dhatariya, MBBS, MSc, MD, MS, FRCP, PhD

Consultant Diabetes & Endocrinology / Honorary Professor, Endocrinology & Diabetes
Norwich, Norfolk UK
Norwich Medical School, University of East Anglia
Elsie Bertam Diabetes Centre
Chair, Association of British Clinical Diabetologists

15:35 – 16:00

CGM for Transforming Clinical Outcomes in Non-Intensive T2D Therapy

Dr Emma Wilmot MB ChB BSc (hons) PhD FRCP

Associate Professor, University of Nottingham
Honorary Consultant Diabetologist, University Hospitals of Derby and Burton NHS FT
Founder, Diabetes Technology Network UK

Interactive Question and Answer Session

Ketones: What They Are and What They Can Tell Us About Preventing DKA

Fernando Gómez-Peralta, MD, PhD

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General Hospital of Segovia (Spain)

Relationship of Blood Acetoacetate and 3-Hydroxybutyrate in Diabetes

Jennifer M. Stephens, B.Sc., M. J. Sulway, M.R.A.C.P., and P. J. Watkins, M.D., M.R.C.P., Birmingham, England

SUMMARY

The ratio of blood ketone bodies 3-hydroxybutyrate to acetoacetate, once thought to be fairly constant, has been shown to vary from 0.6:1 to 4.8:1. In untreated, ketoacidotic patients, it is directly related to the plasma free fatty acid level. Administration of insulin lowers the ratio because the fall of blood 3-hydroxybutyrate occurs earlier and more rapidly than that of acetoacetate. During the treatment of ketoacidosis there is usually an initial increase of the acetoacetate which may persist at a high level f
hours despite improvement o
hydroxybutyr
July, 19

DIABETES 20:485-89,
July, 1971.

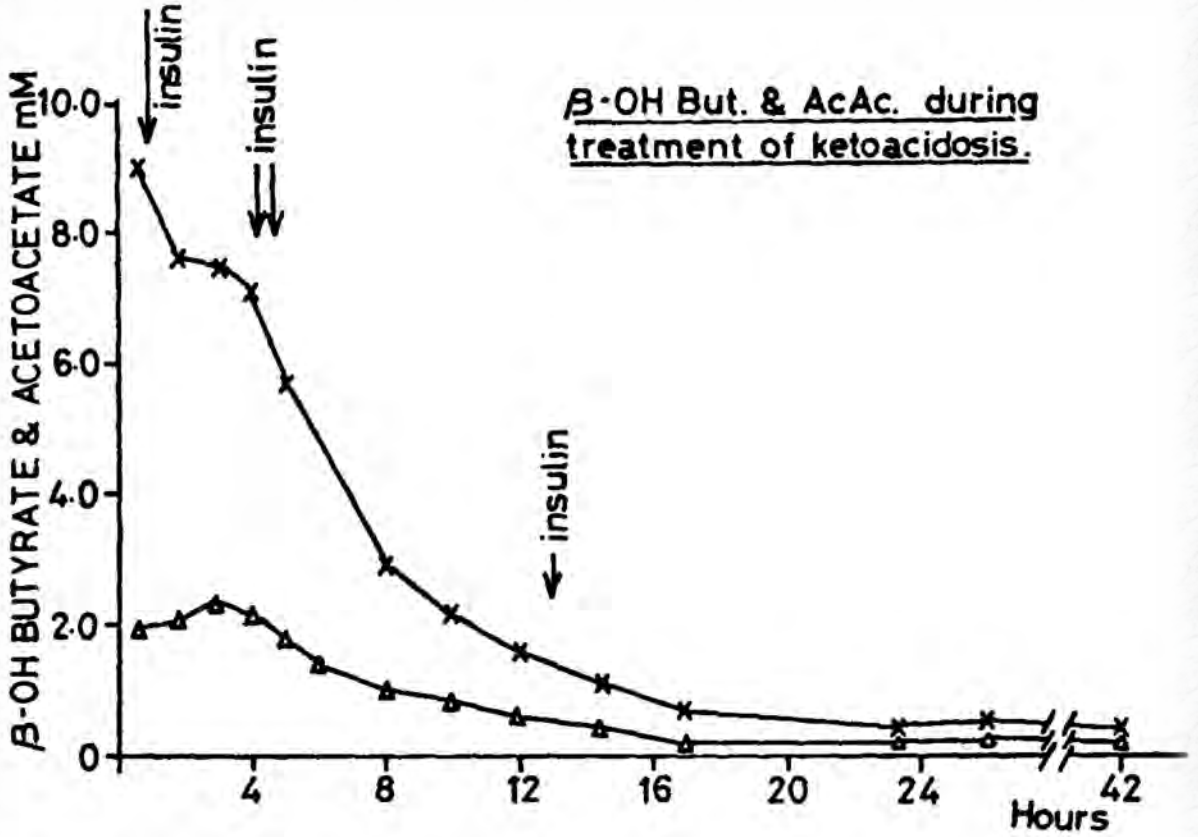
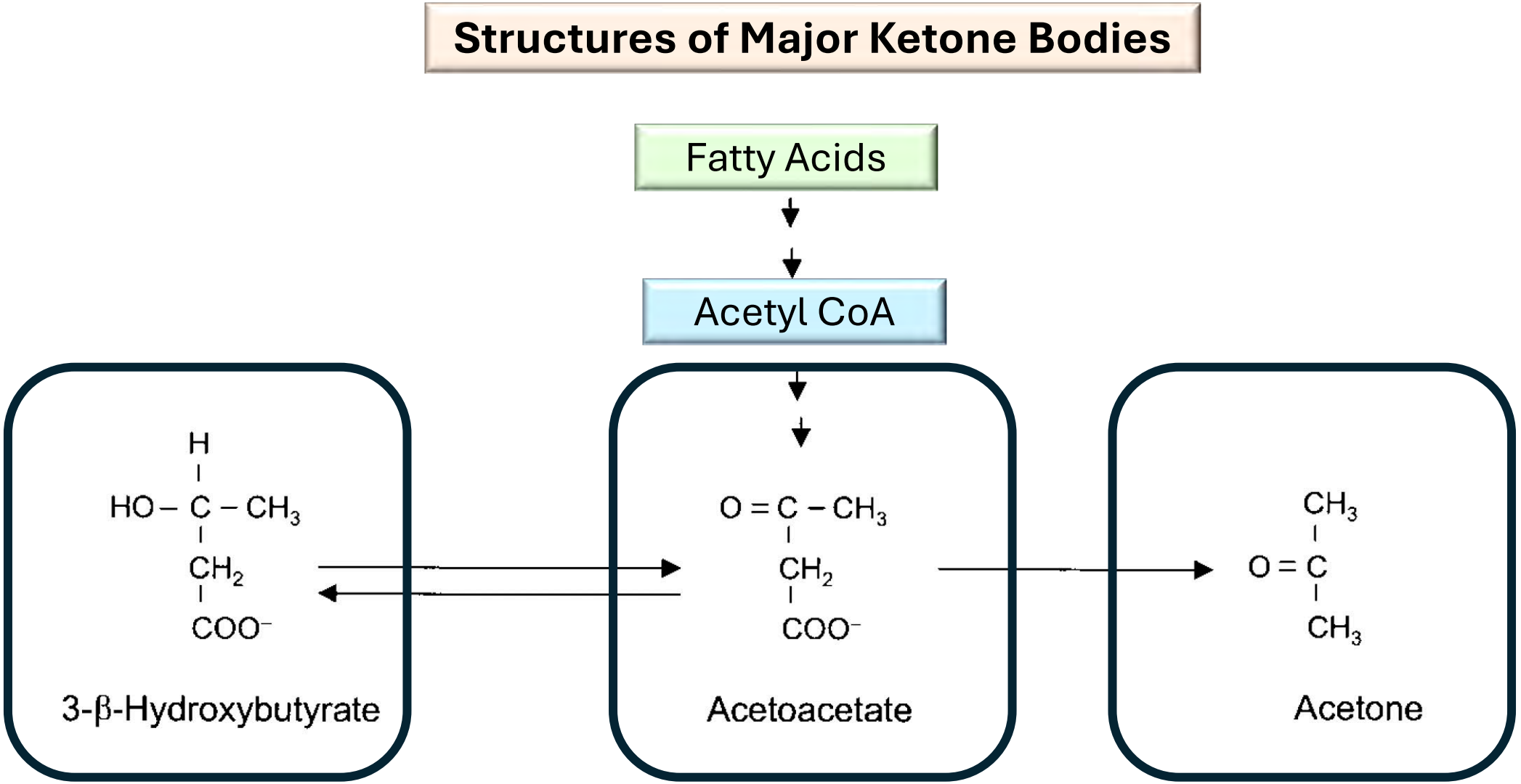


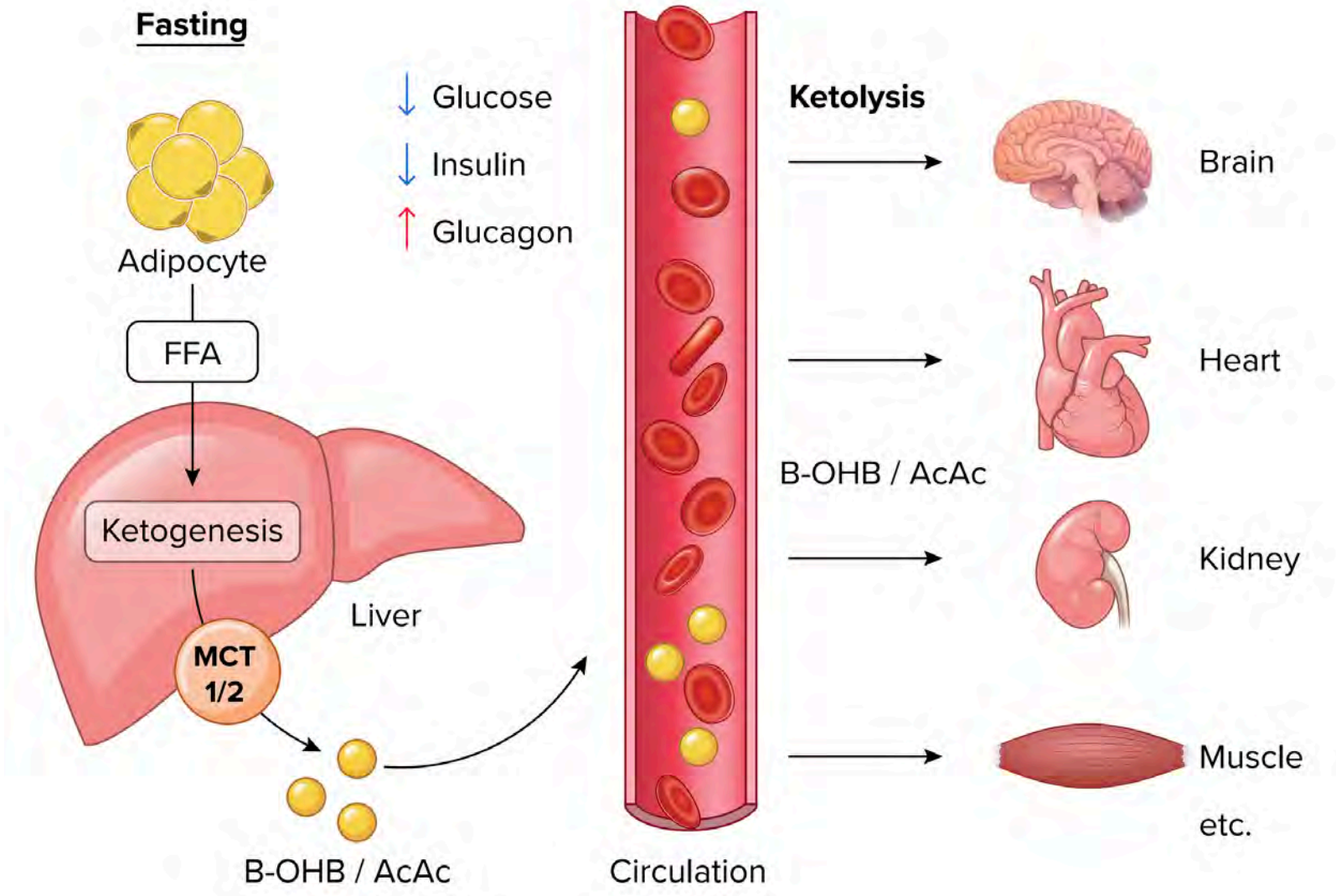
FIG. 4. Blood 3-hydroxybutyrate and acetoacetate changes in a woman of fifty-three years admitted in severe diabetic ketoacidosis precipitated by a respiratory infection. The initial blood glucose was 635 mg. per 100 ml. and the blood pH 7.02.

Introducing the Main Protagonists



L. Laffel. Diabetes Metab Res Rev 1999; 15: 412±426.

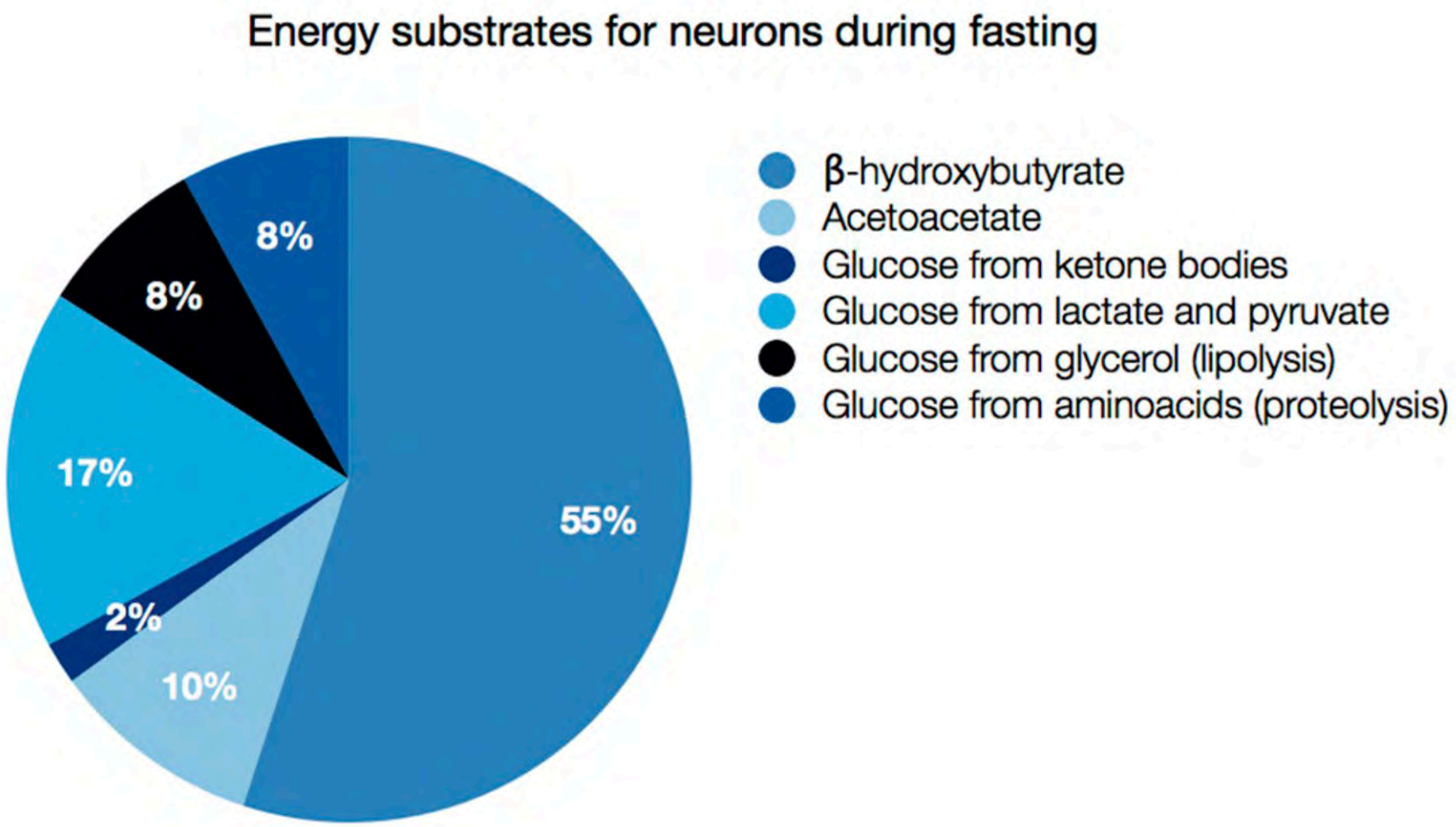
Ketone Body Production and Utilization During Fasting



Tsuruta qt al. Physiology 2024 39:3, 167-177

Introducing the Main Protagonists

Ketone bodies provide nearly 2/3 of the brain's energy needs during periods of prolonged fasting and starvation.



Grabacka et al. Int. J. Mol. Sci. 2016, 17, 2093

Relationship of Blood Acetoacetate and 3-hydroxybutyrate in Diabetes

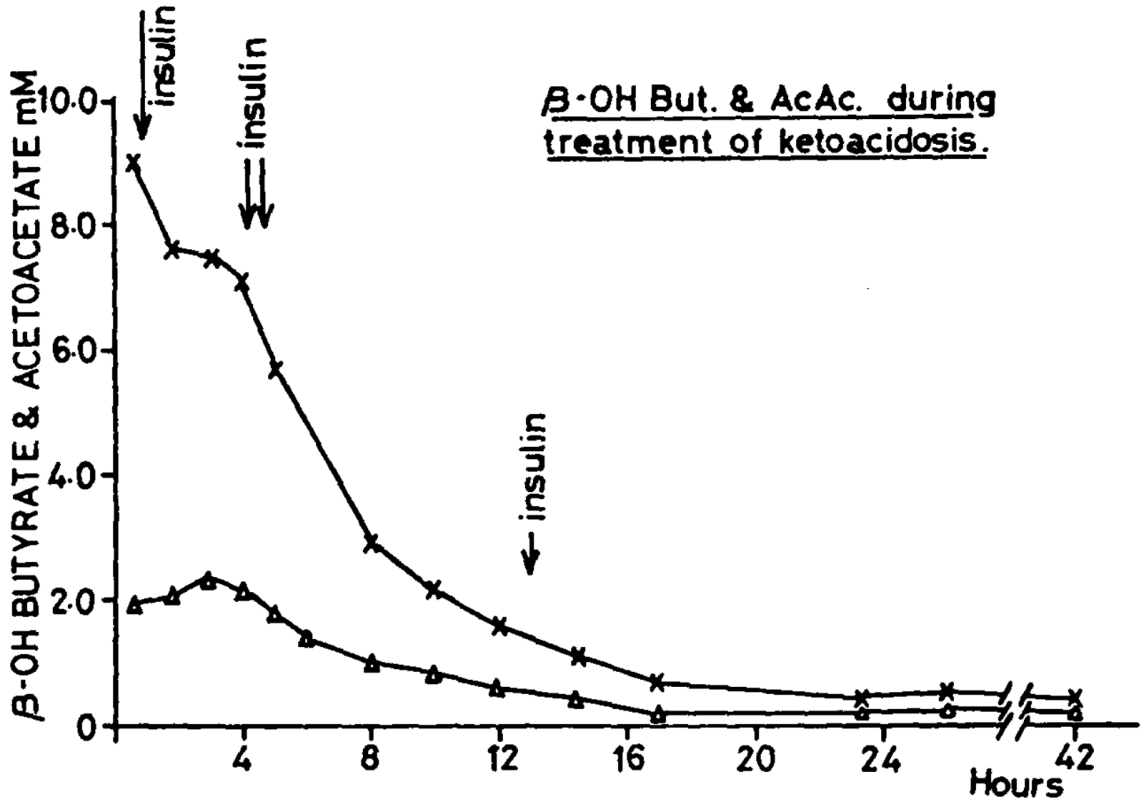


FIG. 4. Blood 3-hydroxybutyrate and acetoacetate changes in a woman of fifty-three years admitted in severe diabetic ketoacidosis precipitated by a respiratory infection. The initial blood glucose was 635 mg. per 100 ml. and the blood pH 7.02.

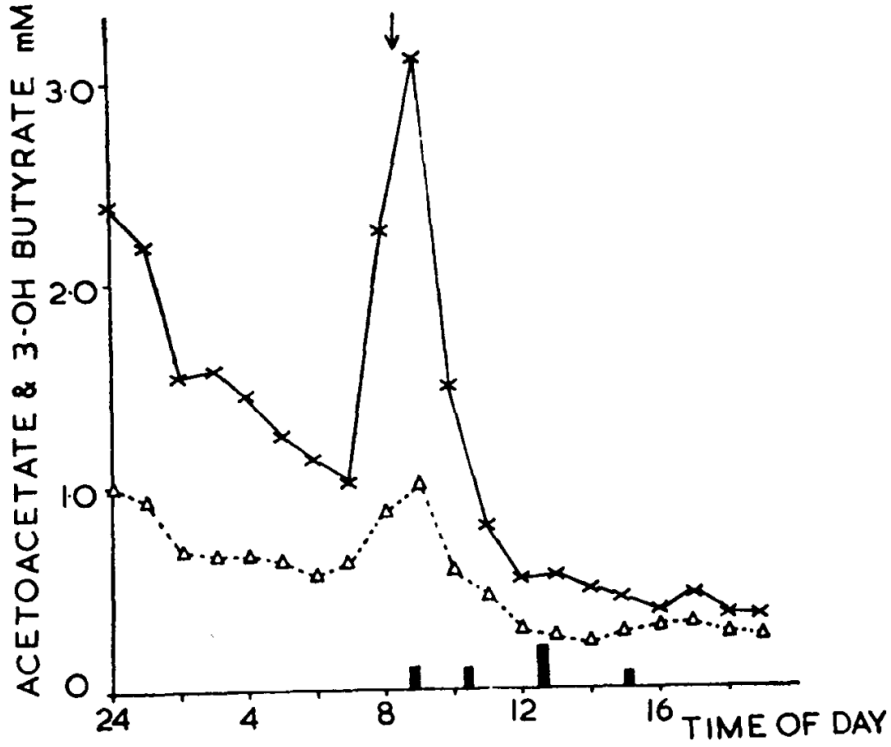


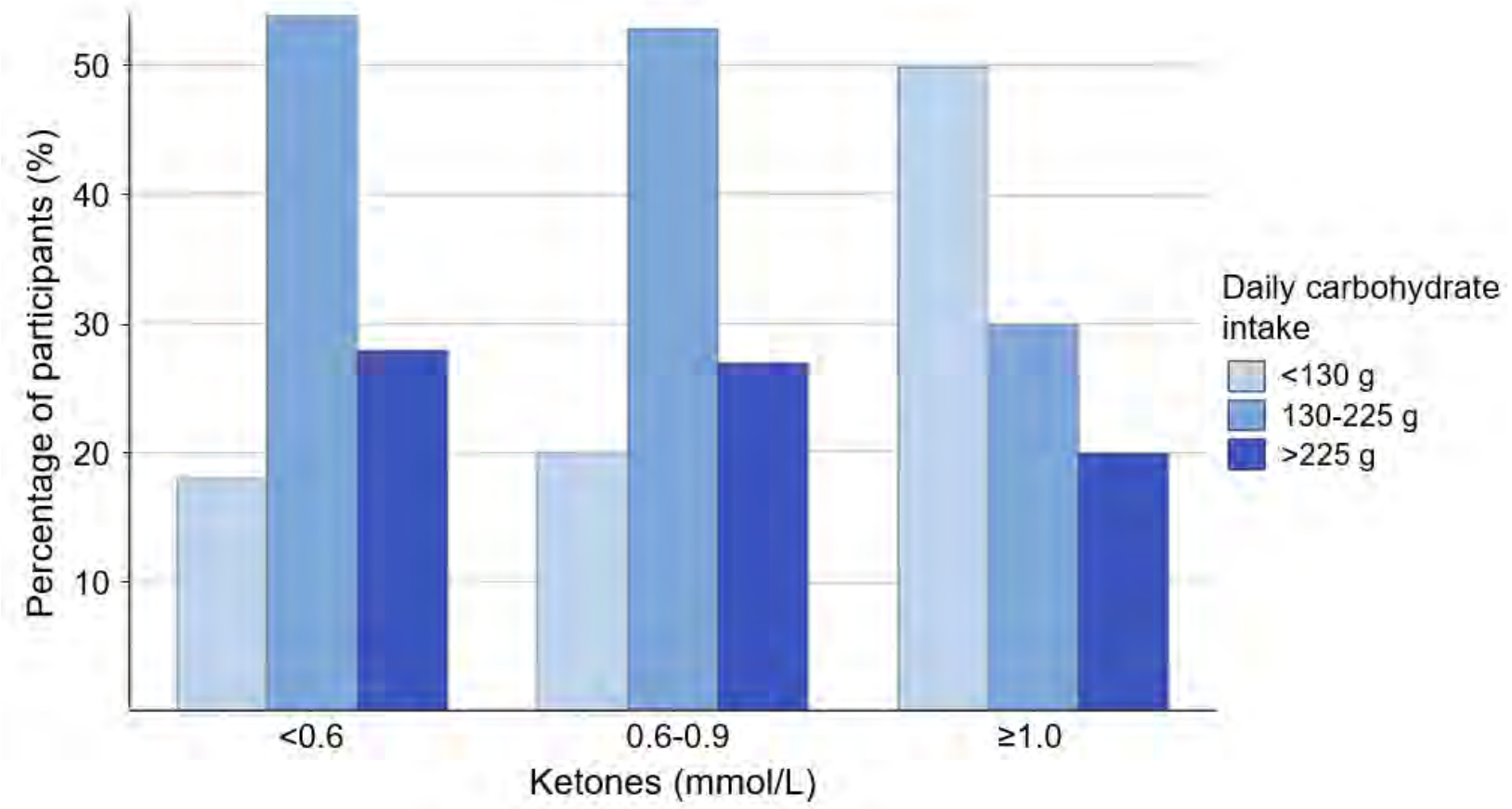
FIG. 5. Blood 3-hydroxybutyrate and acetoacetate changes in an ambulant patient of twenty years, admitted for stabilization of diabetes. The vertical arrow indicates administration of 80 units of soluble insulin subcutaneously and the black bars show mealtimes and their relative carbohydrate content. The blood glucose at 8 a.m. was 320 mg. per 100 ml.

X ——— X 3-hydroxybutyrate
△ ——— △ acetoacetate

Stephens JM et al. Diabetes. 1971 Jul;20(7):485-9.

Ketone Profiles in Community-Dwelling Adults with T1D Using Continuous Ketone Monitoring

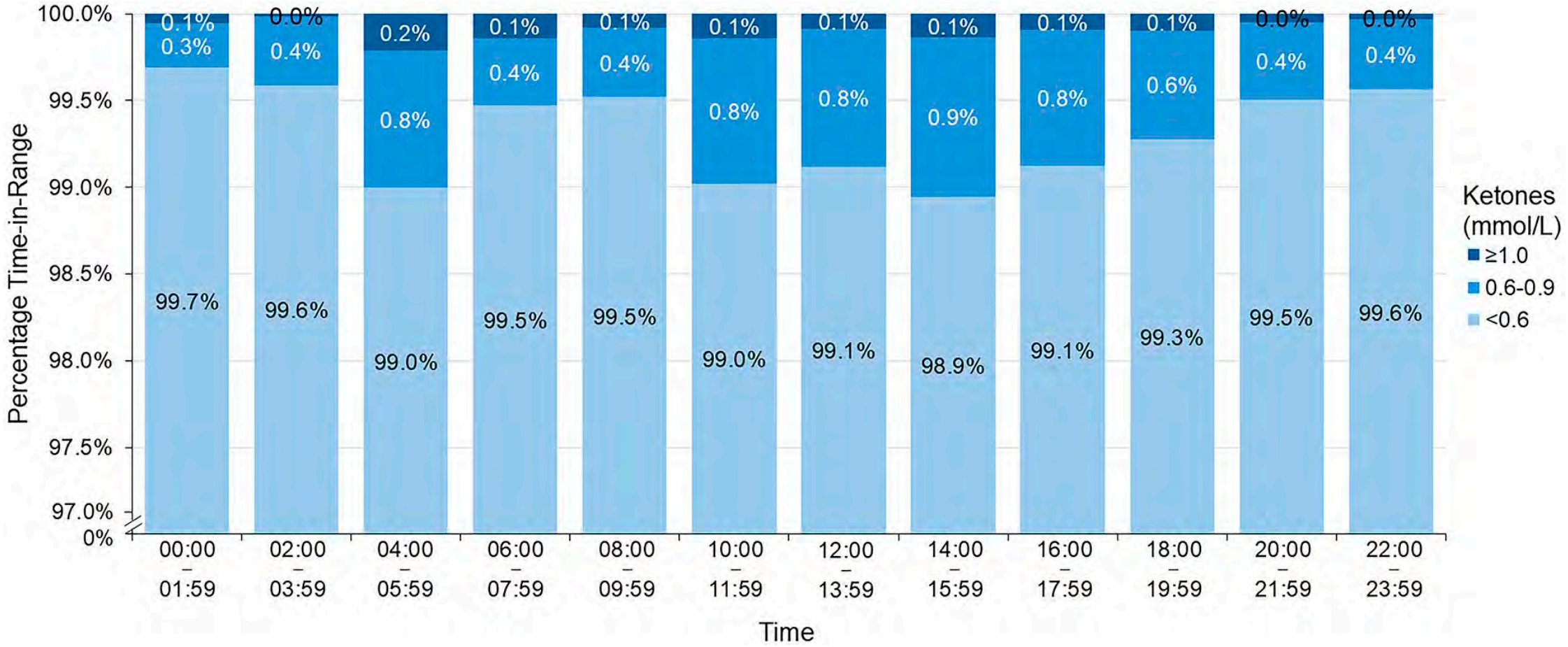
Distribution of average daily carbohydrate intake by maximum CKM ketone level measured



Ngan et al. Diabetes Technology & Therapeutics Volume 00, Number 00, 2026

Ketone Profiles in Community-Dwelling Adults with T1D Using Continuous Ketone Monitoring

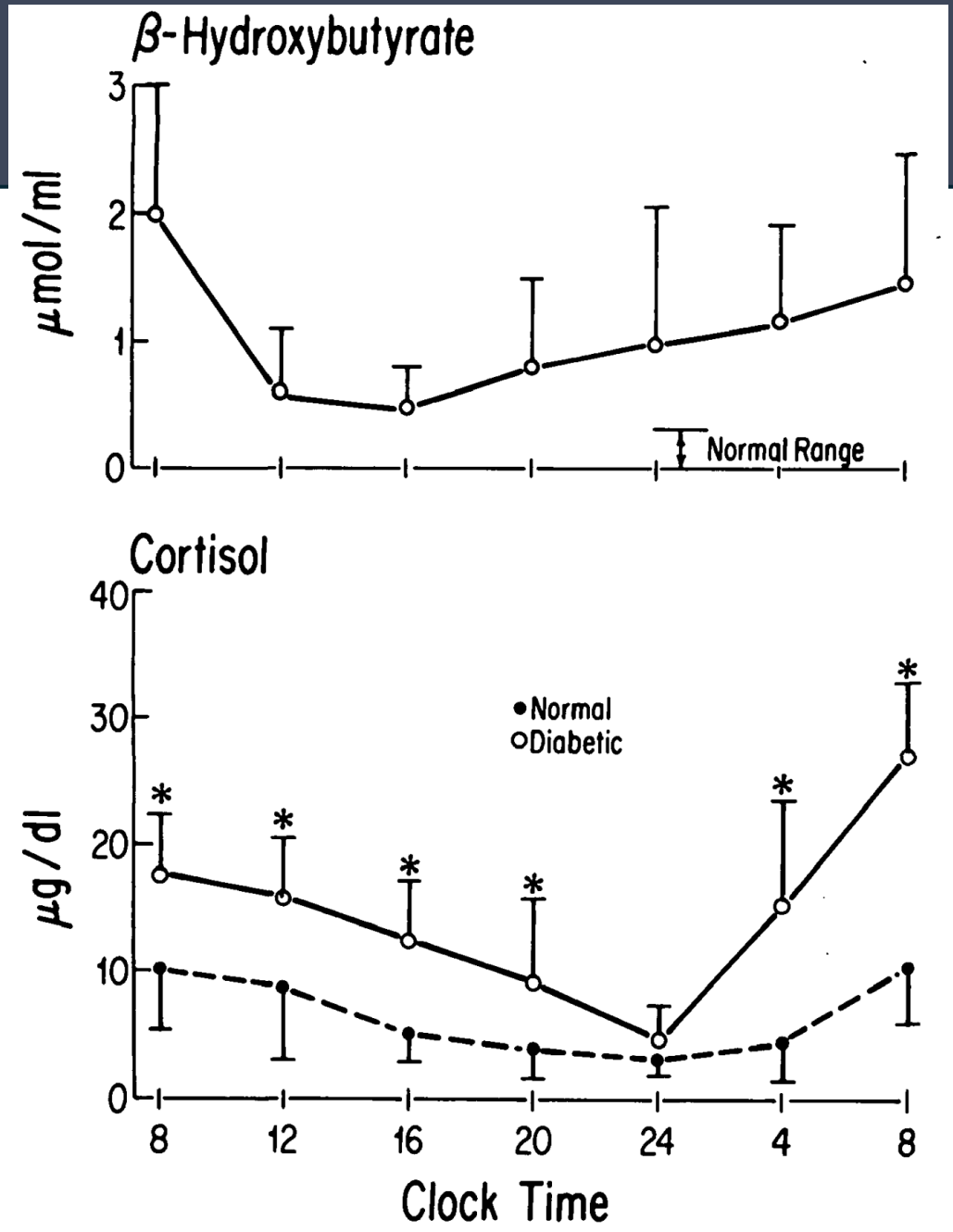
CKM ketone percentage time-in-range over the 24 h period



Percentage time-in-range in 64 participants over a 2-week period (median CKM wear duration was 13.4 [IQR: 13.1–13.5] days). CKM, continuous ketone monitor.

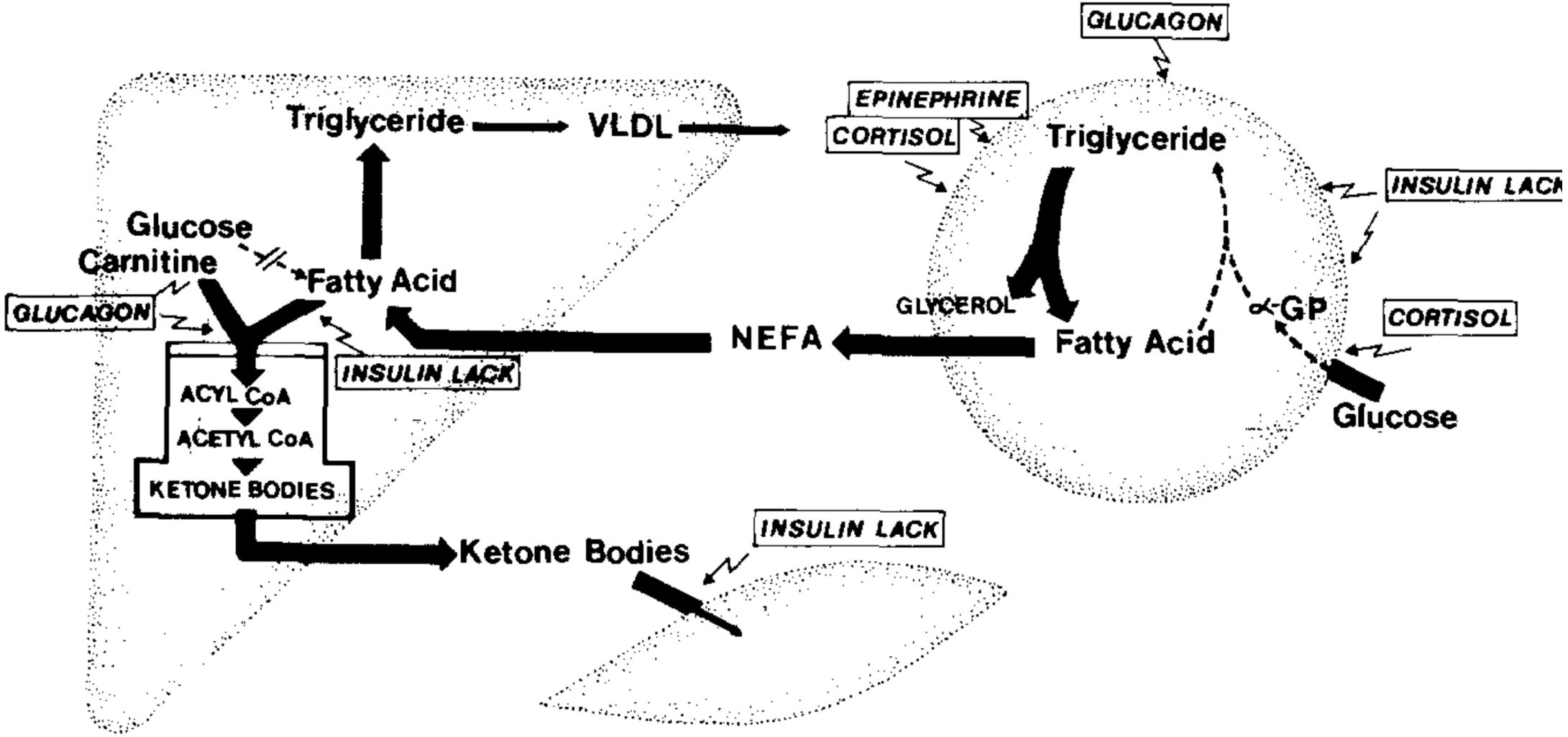
Ngan et al. Diabetes Technology & Therapeutics Volume 00, Number 00, 2026

"The association of elevated plasma BHB levels and hypercortisolemia in our diabetic patients suggests that KB kinetics may be influenced by abnormalities in glucocorticoid production as well as insulin availability."



MacGillivray MH, et al. Clin Endocrinol Metab. 1982 Mar;54(3):665-8

Effects of Major Catabolic Hormones on Ketone Body Metabolism in Insulin Deficiency



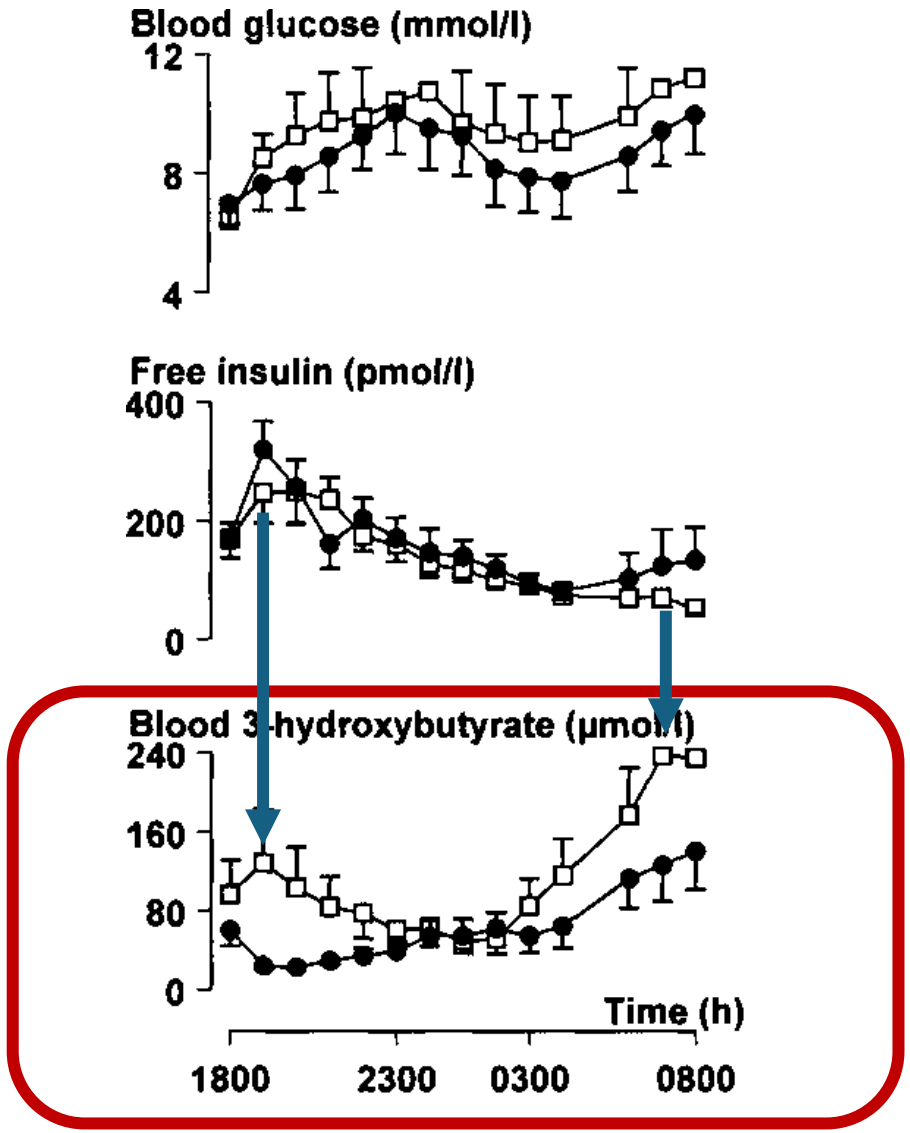
L. G. Johnston And K. G. M. M. Alberti. Clinics in Endocrinology and Metabolism -- Vol. 11, No. 2, July 1982

Quantification of BHB Levels in Type 1 Diabetes

Can quantification of BHB levels in Type 1 diabetes be used to help monitor diabetes control and guide insulin therapy?

Evening and nighttime (6:00 RM. to 8.00 A.M.):

- ✓ blood glucose
- ✓ plasma free insulin
- ✓ blood 3-hydroxybutyrate



□ human insulin

■ lispro

Ahmed AB et al. Diabetes Care. 1998 Jan;21(1):32-7

Ketosis

Physiological (in response to fasting)

- Starvation
- Infancy or pregnancy
- Prolonged exercise
- Ketogenic (high-fat) diet

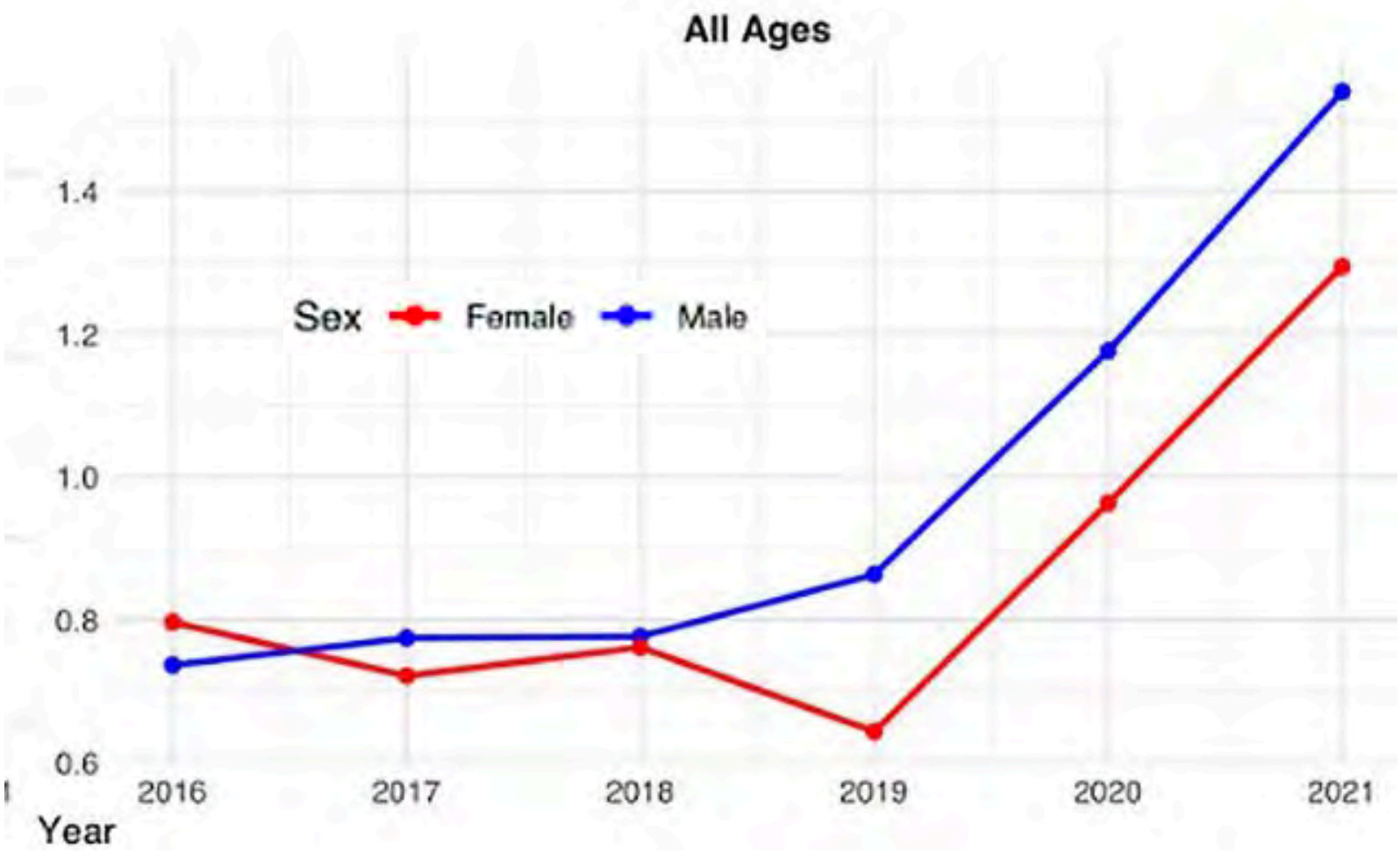
Pathological Processes

- Obesity
- ***Diabetes mellitus***
  - ***Diabetic ketoacidosis (DKA)***
  - ***SGLT2 use: "Euglycemic DKA"***
- Cortisol / growth hormone deficiency
- Hyperthyroidism
- Toxic ingestions of ethanol or salicylates
- Certain rare inborn errors of metabolism

Modified from L. Laffel. Diabetes Metab Res Rev 1999; 15: 412±426.

Trend of In-Hospital Mortality Among Hospitalizations with DKA 2016-2021

*"Global reports clearly show an **increase in the number of DKA admissions** during the past decade, with a 55% increase in the rate of DKA hospitalizations"*



USA n=594 230

Umpierrez GE et al. Diabetes Care 2024;47:1257–1275

Chia JE, et al. BMJ Open Diab Res Care 2026;14:e005817

ATTD 2026 Late-Breaking Abstracts

Rising Burden of Diabetic Ketoacidosis in the UK

21-Year Trends, Recurrence, and Predictors from Linked Primary–Secondary Care Data

- Long-term real-world data on diabetic ketoacidosis (DKA) in UK adults remain limited.
- Adults ≥18 years with diabetes and ≥1 glucose-lowering prescription (thus excluding most newly diagnosed individuals) for at least a year.
- Recurrent DKA was defined as ≥2 episodes during follow-up.
- **Results:** **Recent DKA was the strongest predictor of recurrence** (IRR 11.4 and 109 in T1DM and T2DM). Other predictors of DKA included female sex, younger age, socioeconomic deprivation and multimorbidity.

Conclusion

DKA rates have increased steadily in both diabetes types, with evidence of health inequalities and unmet clinical need, clustering in younger, socioeconomically deprived, and medically complex adults.

Given the strong association of recent DKA with future events, proactive strategies – such as **personalised education and access to real-time ketone monitoring** – are warranted.

Seidu S, et al. ATTD 2026

Rising Burden of Diabetic Ketoacidosis in the UK

21-Year Trends, Recurrence, and Predictors from Linked Primary–Secondary Care Data

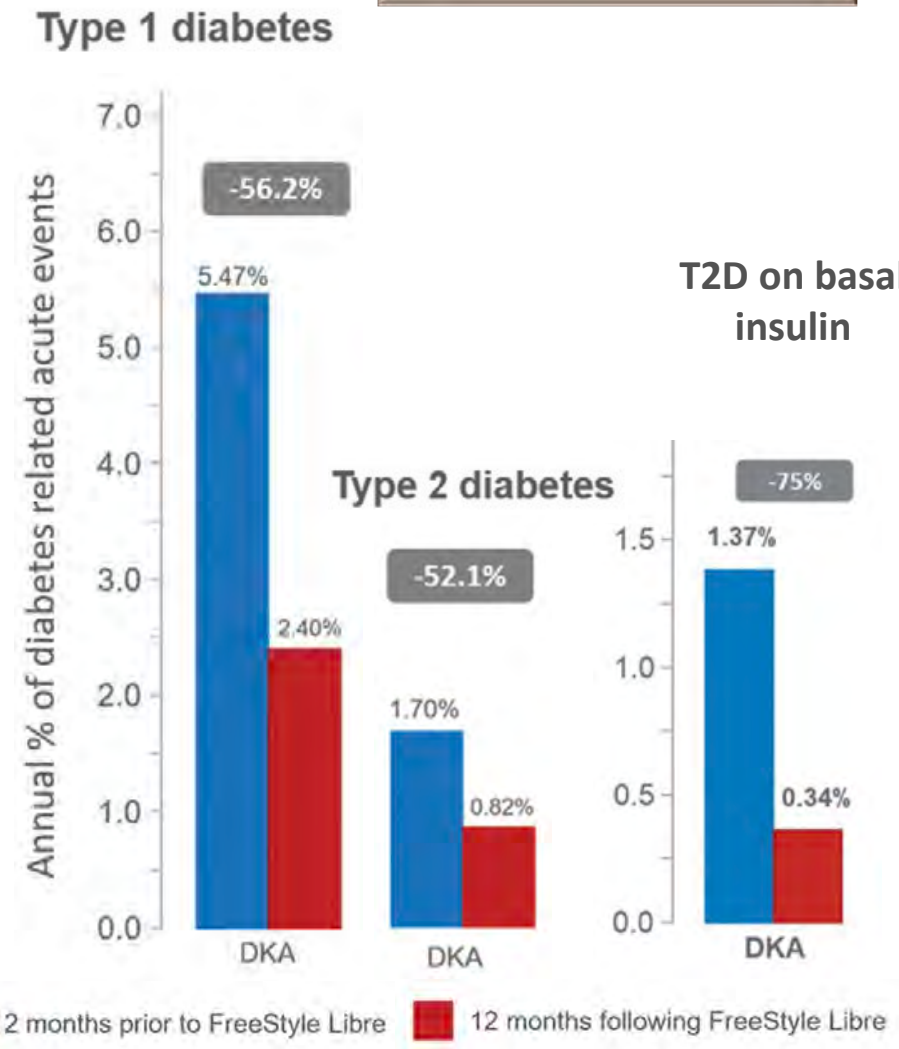
Adjusted predictors of first DKA

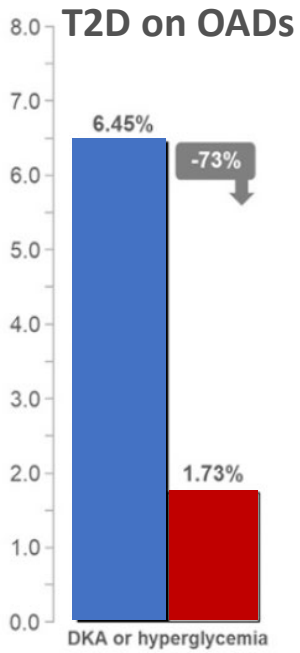
Predictor	T1DM IRR (95 % CI)	T2DM IRR (95 % CI)
Female vs male	1.42 (1.34–1.50)	1.27 (1.19–1.35)
Age 40–64 y vs 18–39 y	0.47 (0.43–0.50)	0.40 (0.35–0.45)
Age ≥ 75 y vs 18–39 y	0.48 (0.36–0.62)	0.41 (0.30–0.55)
IMD quintile 5 vs 1	2.66 (2.42–2.93)	1.47 (1.33–1.63)
CCI ≥ 3 vs 0	2.25 (1.99–2.53)	1.46 (1.33–1.61)
Recent DKA ≤ 28 d	11.4 (10.1–12.8)	108.7 (88.5–133.5)

Seidu S, et al. ATTD 2026

FreeStyle Libre Use: Decrease in Hospitalizations for DKA

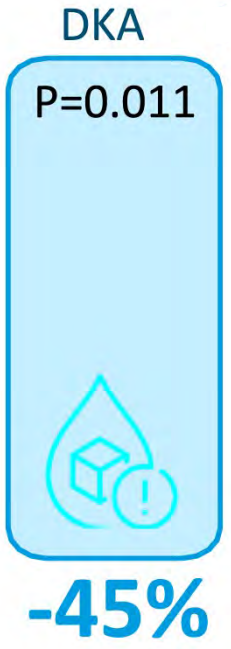
RELIEF study (France)





Eeg-Olofsson study (Sweden)

T1DM vs BGM



-45%

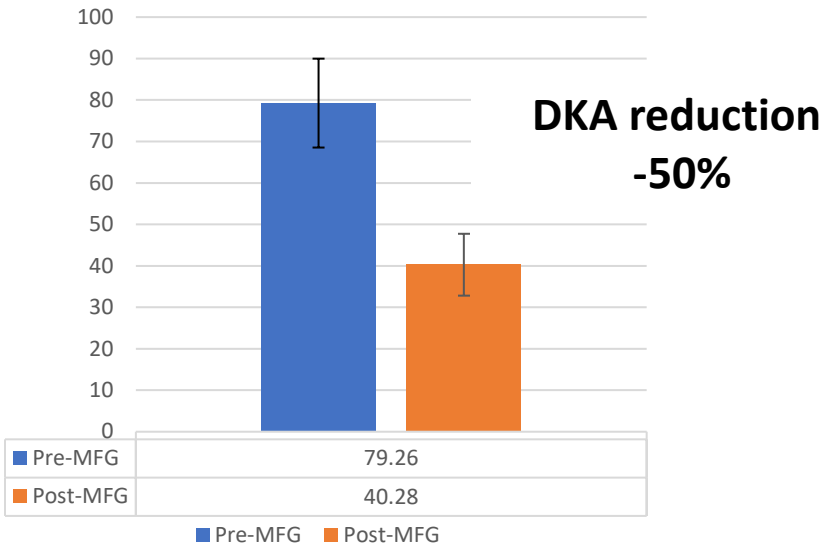
DKA: Diabetic Ketoacidosis; OADs: oral antidiabetic agents.

Eeg-Olofsson K et al, Diabetes Care. 2024 Dec 1;47(12):2164-2171;Roussel R, et al. Diabetes Care. 2021 Jun;44(6):1368-1376; Riveline JP et al. Diabetes Technol Ther. 2024 Dec;26(12):932-938; Guerci B et al. Diabetes Technol Ther. 2023 Jan;25(1):20-30

FreeStyle Libre Use: Decrease in Hospitalizations for DKA

Andalucia Study (Spain)

T1D



DKA reduction -50%

DKA Events/10,000 person- years

n = 13,616

T2D on MDI

DKA reduction -27,6%

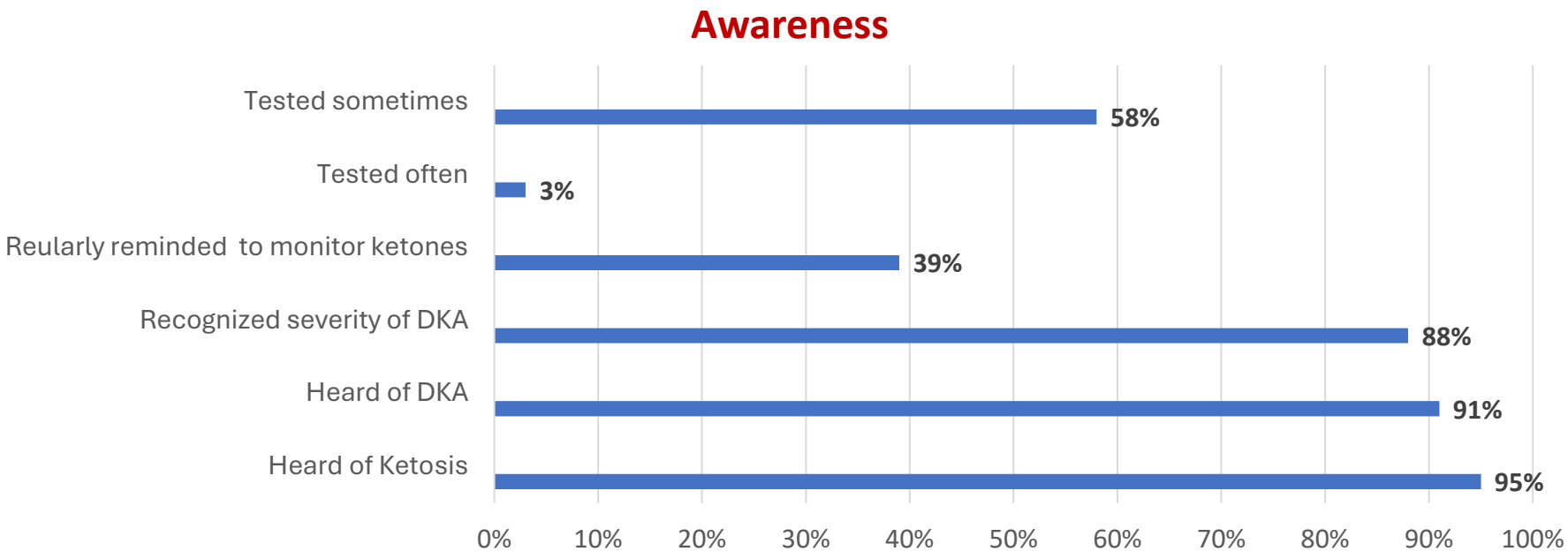
DKA: Diabetic Ketoacidosis; OADs: oral antidiabetic agents.

Rodríguez de Vera Gómez P, et al. Diabetes Res Clin Pract. 2025 Aug;226:112372.

Patients' Knowledge and Barriers to Ketone Self-Monitoring

Results From a Prospective Survey of T1DM Patients From the French SFDT1 Cohort

- International guidelines recommend ketone monitoring in specific situations. This study assessed patients' awareness of ketosis and DKA, and identified barriers to self-monitoring.
- A total of 553 adults surveyed. 62% reported prior DKA.



Interest in a dual glucose-ketone sensor was high (82%)

Cosson E, et al. ATTD 2026

Conclusion

Despite strong awareness, challenges remain around symptom recognition, equipment, and time.

Leading barriers were: poor symptom recognition (56%); lack of equipment (52%), and time constraints (52%), particularly among CSII/AID users or those with TIR<70%.

High interest in dual glucose-ketone sensors highlights limitations of current methods and the need for accessible, patient-centric solutions to support DKA prevention.

Provider Perspectives on Hyperketonemia, Diabetic Ketoacidosis Healthcare Burden and Ketone Monitoring in T1D and T2D

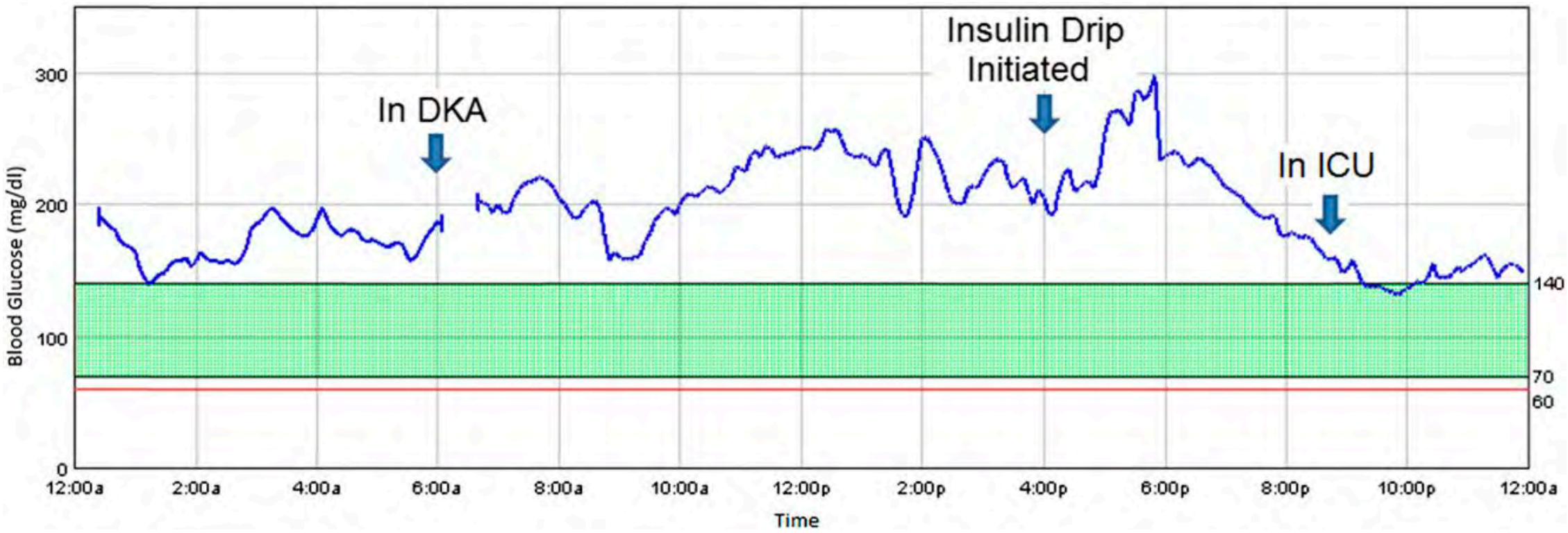
- Ketone monitoring is an essential step in early detection of hyperketonemia and prevention of DKA, but previous research has revealed barriers amongst PWD; clinical perspectives on ketone management and monitoring require further investigation.
- **Results:** Qualitative findings will highlight providers' clinical perspectives and knowledge gaps regarding ketone monitoring and management.
- Additional findings will highlight current approaches to preventing and managing ketosis, hyperketonemia, and diabetic ketoacidosis, as well as their implications for clinical practice.

Conclusion

This qualitative study will capture the perspectives, beliefs, and values that influence provider behaviors around ketone management. **These insights will highlight needs around ketone management, which could include increased awareness and access to ketone monitoring tools to help fill the current gaps in ketone management for PWD**.

Euglycemic Diabetic Ketoacidosis (euDKA)

A Potential Complication of Treatment With SGLT2i

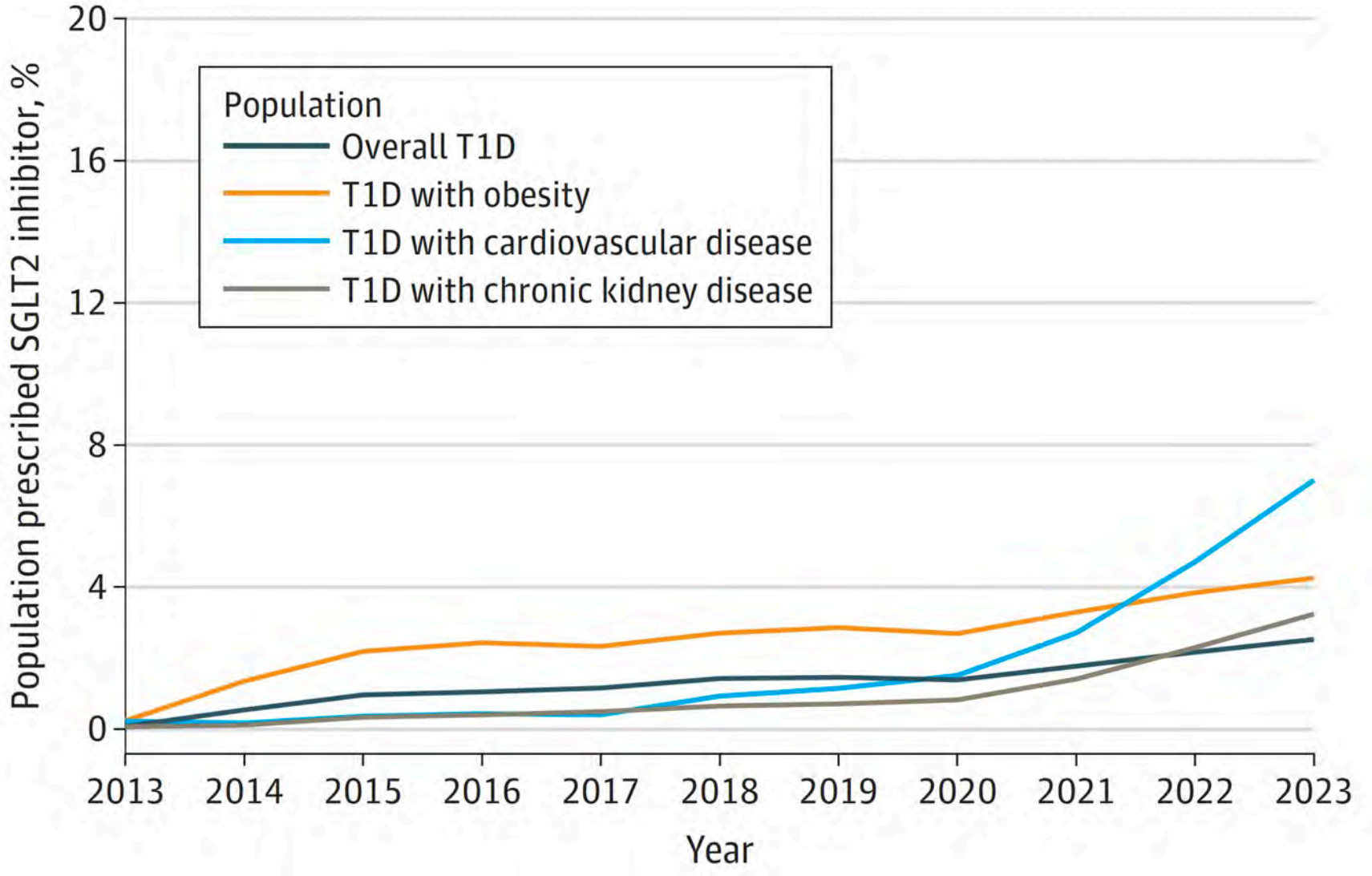


*One-day **CGM reading** of a case patient in the day of admission to the **ICU in euDKA**.*

Peters AL, et al. Diabetes Care. 2015 Sep;38(9):1687-93

T1D Population Prescribed SGLT2i

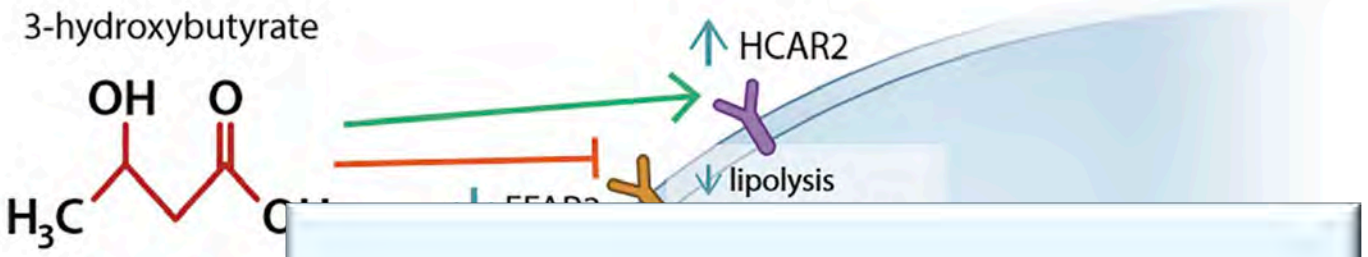
Pooled cross-sectional analysis of EHRs from an integrated database including **257 million across 50 USA states**



Li P, et al. Diabetes. JAMA. 2024;332(19):1667–1669

Ketones Role in T2D, Long-Term Complications, Heart Failure,…

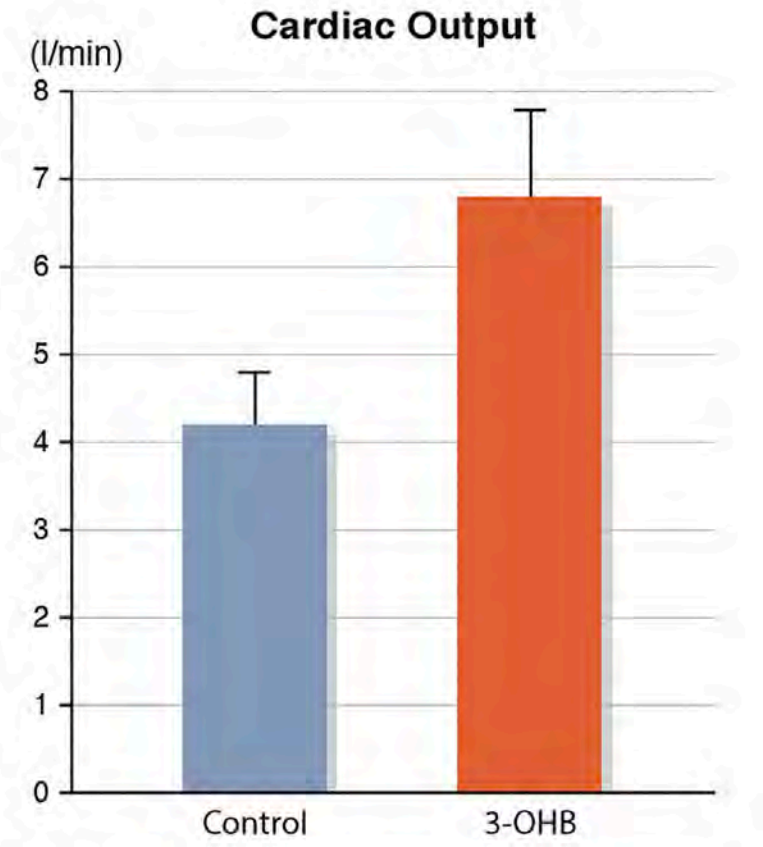
Intracellular signaling mediated by 3-hydroxybutyrate (3-OHB).



Inflammation
- Type 2 diabetes
- Atherosclerosis
- Neurodegeneration

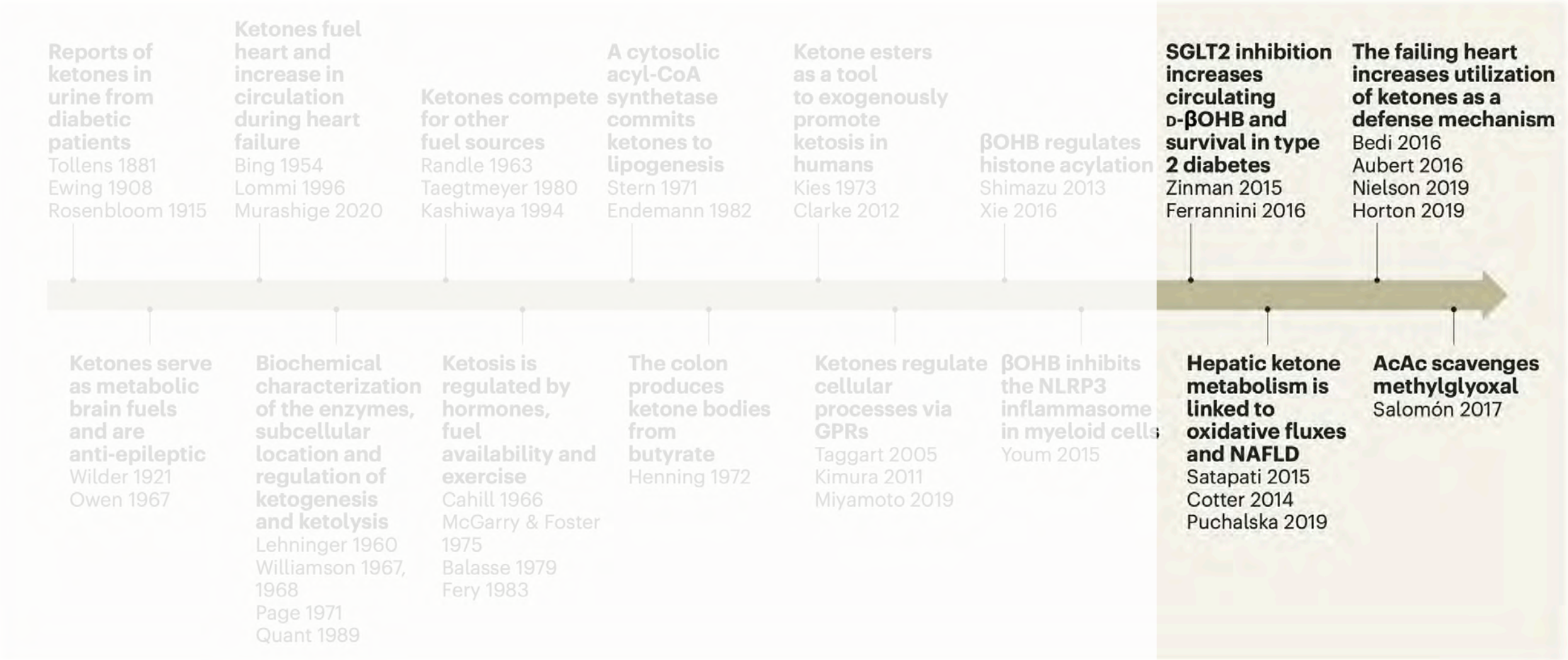
Møller J Clin Endocrinol Metab, September 2020, 105(9):2884–2892

Cardiovascular effects of treatment with the ketone body 3-hydroxybutyrate in chronic heart failure patients.



Nielsen R et al. Circulation. 2019;139(18):2129-2141.

Timeline of Major Discoveries Related to Ketone Bodies



GPR, G-protein-coupled receptor; NAFLD, nonalcoholic fatty liver disease; SGLT, sodium glucose cotransporter.

Nelson AB, et al. Nat Metab. 2023 Dec;5(12):2062-2074.

Thank you very much for your attention! ¡Muchas gracias!

fgomezp@saludcastillayleon.es

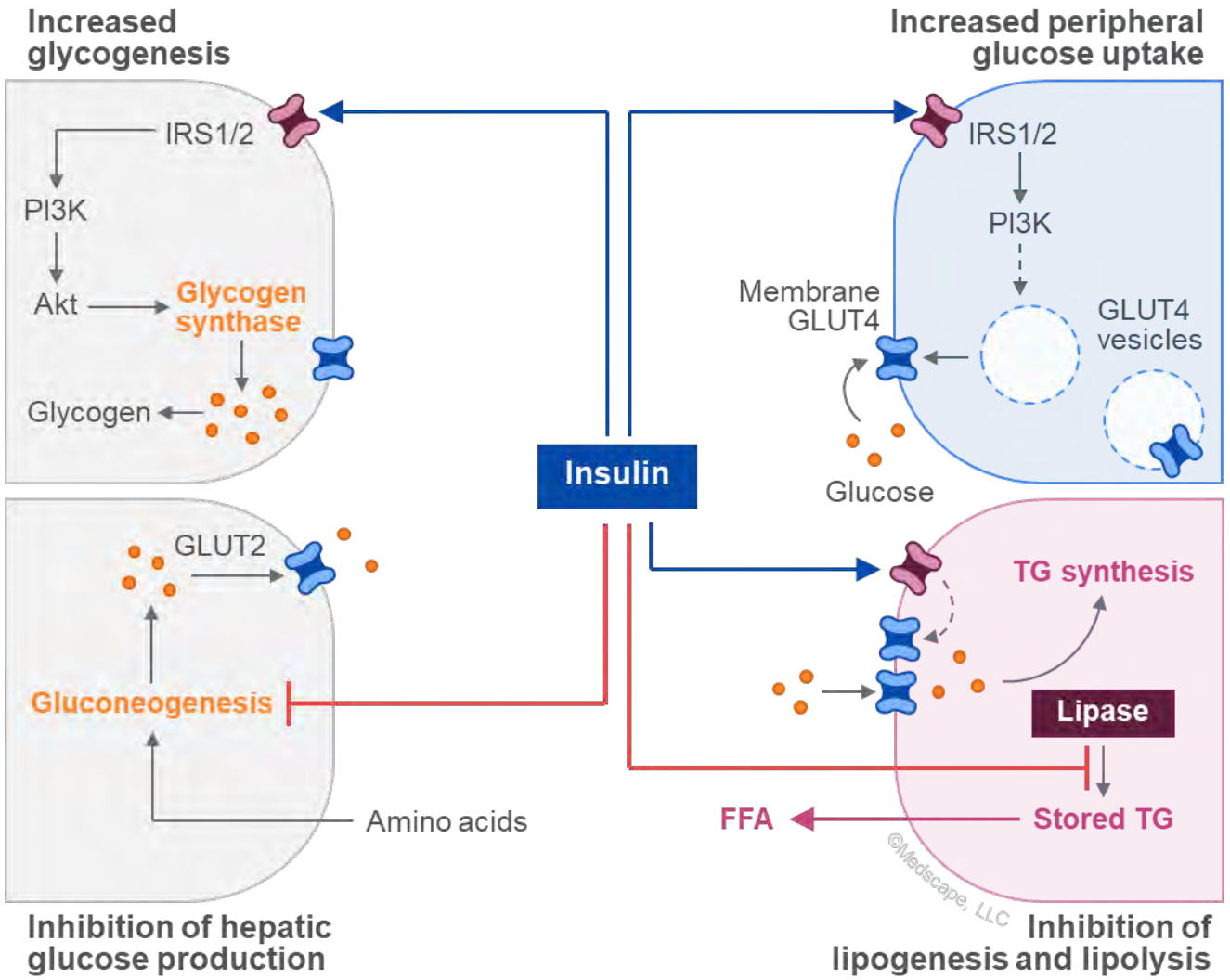
Beyond CGM: Dual Sensing Technology as a Cornerstone of DKA Prevention

Prof Ketan Dhatariya MBBS MSc MD MS FRCP PhD
Consultant in Diabetes and Endocrinology
Norfolk and Norwich University Hospitals

Disclosures

- In the last 12 months I have received honoraria, travel, fees for speaking or advisory boards from
  - Abbott Diabetes
  - AstraZeneca
  - Boehringer-Ingelheim
  - Eli Lilly
  - Menarini
  - Novo Nordisk
  - Roche
  - Sanofi Diabetes

Back to Basics

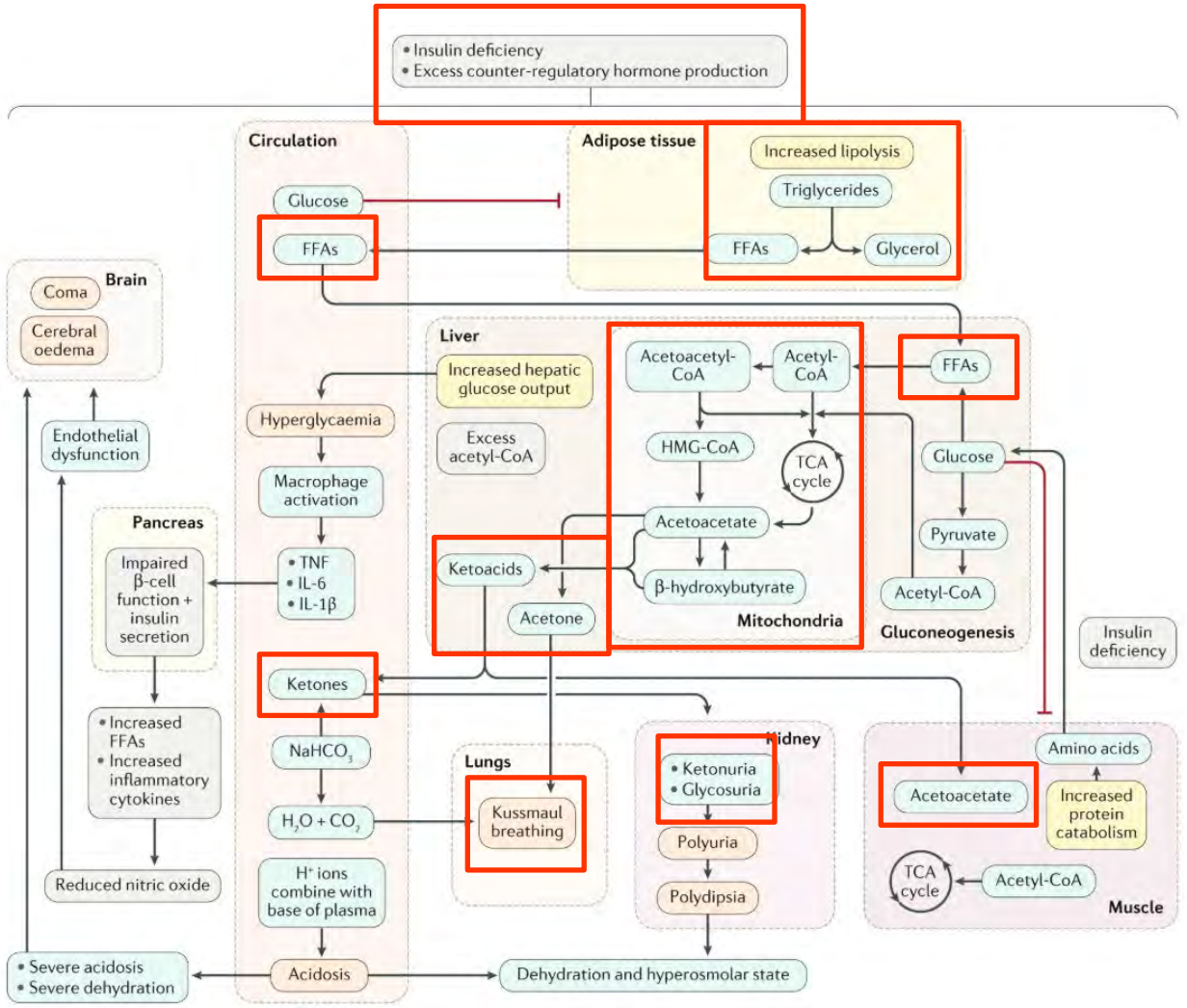


At different plasma concentrations, insulin has different effects

- At the very lowest concentrations, it suppresses ketogenesis
- Then it stops gluconeogenesis and skeletal muscle catabolism
- Then it causes glucose uptake and glycogen synthesis
- Finally, it is an anabolic hormone

Barwell ND et al Br J Cardiol 2011;18(5/6):224-228

Physiology



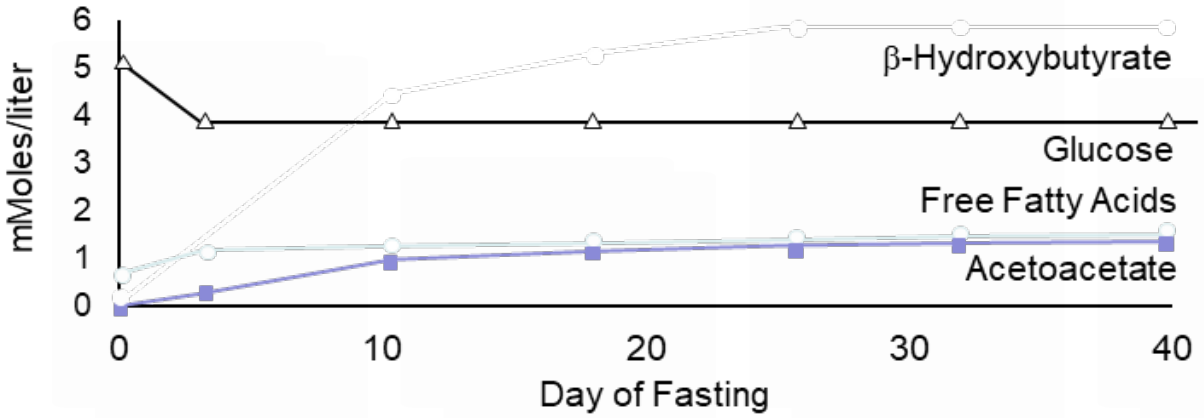
Dhatariya K et al Nat Rev Dis Primers 2020;6:40

Ketones – Why Are They Important?

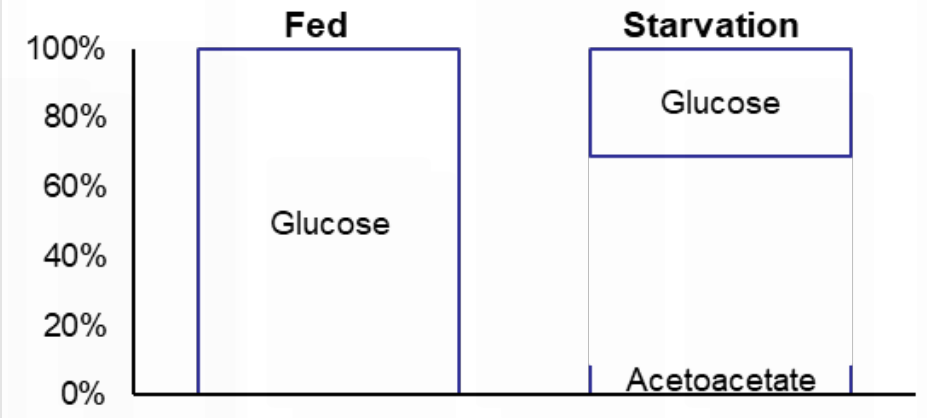
Levels of Circulating Substrates

Period of observation	Glucose mg/100 ml	Free fatty acids	Acetoacetate	β-Hydroxybutyrate mM	Glycerol	Amino acids	Lactate	Pyruvate
Post-absorptive	80	0.5	0.01	0.01	0.06	4.5	0.6	0.1
After 1 wk fast	65	1.5	1.0	4.0	0.1	4.5	0.6	0.1
After 4–5 wks fast	65	1.5	1.5	6.0	0.1	3.5	0.6	0.1

Blood Glucose, Free Fatty Acids and Ketone Body Levels During Fast



Brain Fuel



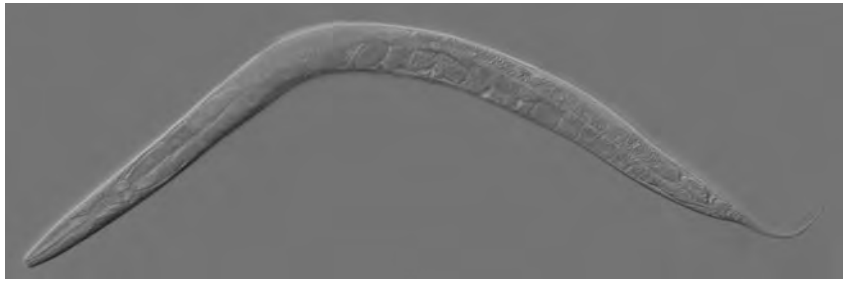
Cahill GF NEJM 1970;282(12):668-675
Cahill GF Diabetes 1971;20(12):785-799
Cahill GF Ann Rev Nutr 2006;26(1):1-22

Living Longer on Starvation Diets

Dietary deprivation extends lifespan in *Caenorhabditis elegans*

Garrick D. Lee,[1] Mark A. Wilson,[2] Min Zhu,[1] Catherine A. Wolkow,[2] Rafael de Cabo,[1] Donald K. Ingram[1,3] and Sige Zou[1]

dietary restriction (DR) (Masoro, 2005). DR has been shown to extend lifespan in many species, ranging from invertebrates to mammals. In addition, DR enhances resistance to a variety of



A Ketogenic Diet Extends Longevity and Healthspan in Adult Mice

Megan N. Roberts,[1] Marita A. Wallace,[2] Alexey A. Tomilov,[1] Zeyu Zhou,[1] George R. Marcotte,[2] Dianna Tran,[1] Gabriella Perez,[1] Elena Gutierrez-Casado,[7] Shinichiro Koike,[3] Trina A. Knotts,[1] Denise M. Imai,[4] Stephen M. Griffey, Kyoungmi Kim,[5] Kevork Hagopian,[1] Marissa Z. McMackin,[1] Fawaz G. Haj,[3] Keith Baar,[2,6] Gino A. Cortopassi,[1] Jon J. Ramsey,[1,9,*] and Jose Alberto Lopez-Dominguez[1,8,*]
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LETTER

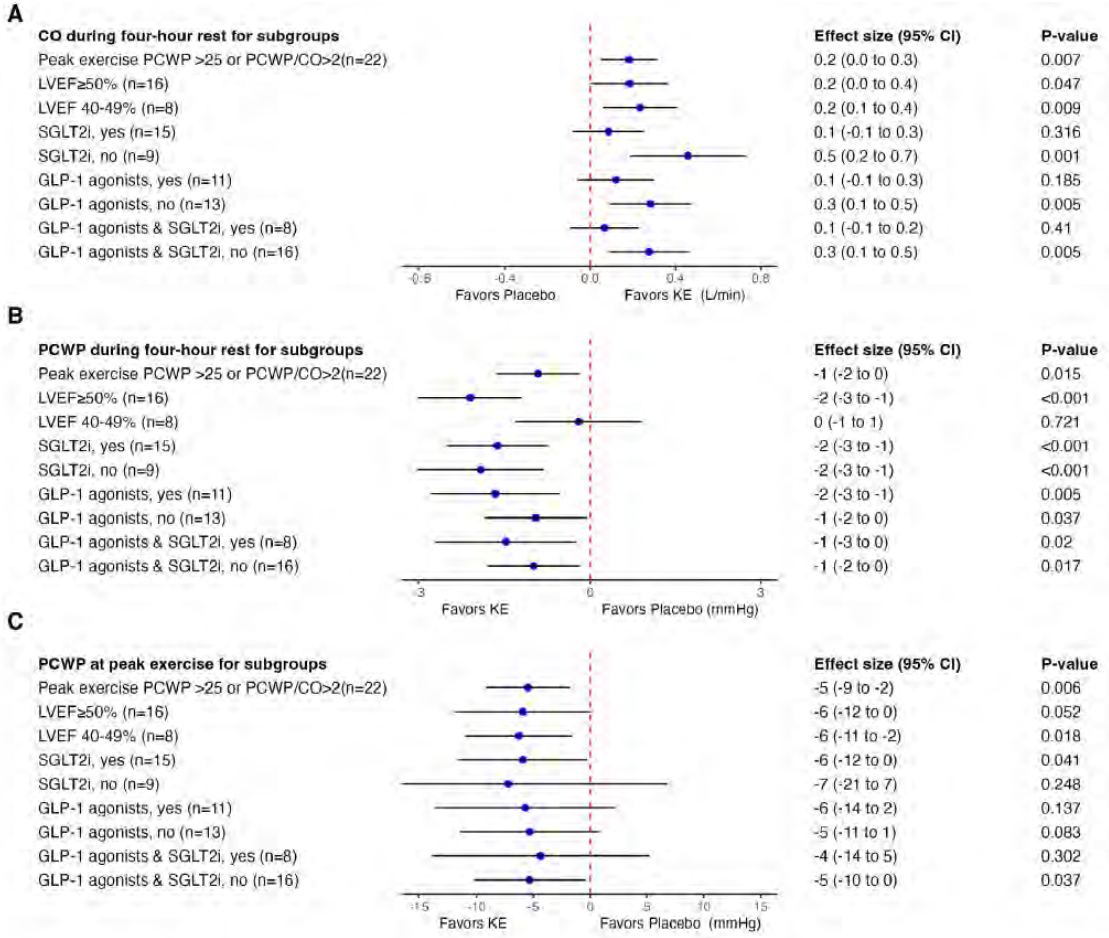
doi:10.1038/nature11432

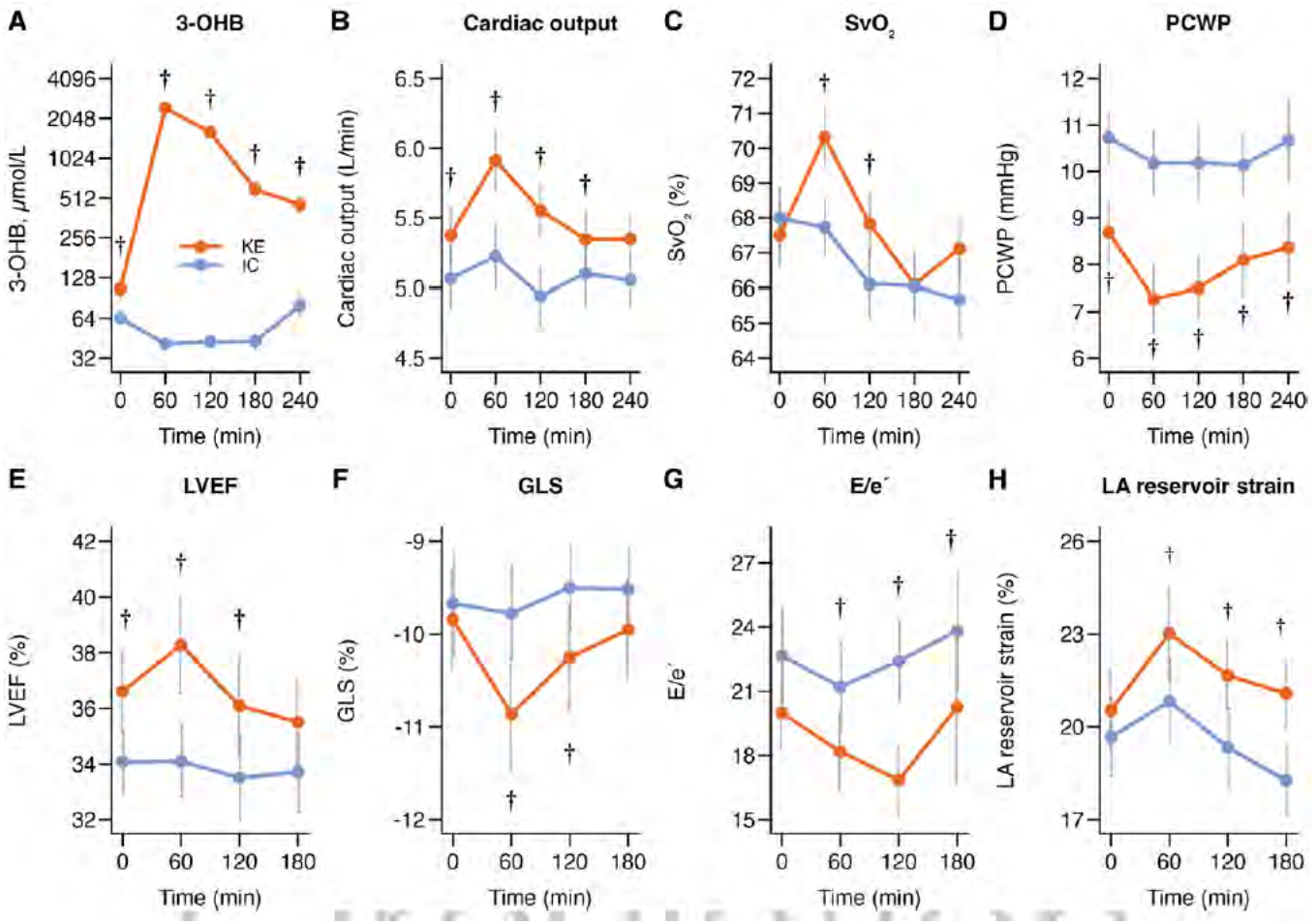
Impact of caloric restriction on health and survival in rhesus monkeys from the NIA study

Julie A. Mattison[1], George S. Roth[2], T. Mark Beasley[3], Edward M. Tilmont[1], April M. Handy[1,4], Richard L. Herbert[5], Dan L. Longo[6], David B. Allison[7], Jennifer E. Young[1], Mark Bryant[8], Dennis Barnard[9], Walter F. Ward[10], Wenbo Qi[11], Donald K. Ingram[12] & Rafael de Cabo[13]

Lee GD et al Ageing Cell 2006;5(6):515-524
Roberts MN et al Cell Metabol 2017;26(3):P539-546.E5
Mattison JA et al Nature 2012;489(7415):318-321

Failing Hearts Prefers Ketones





Gopalasingham N et al Circulation 2024;150(20):1570-1583
Berg-Hansen K et al Circulation 2024;149(19):1474-1489

Published in August 2024

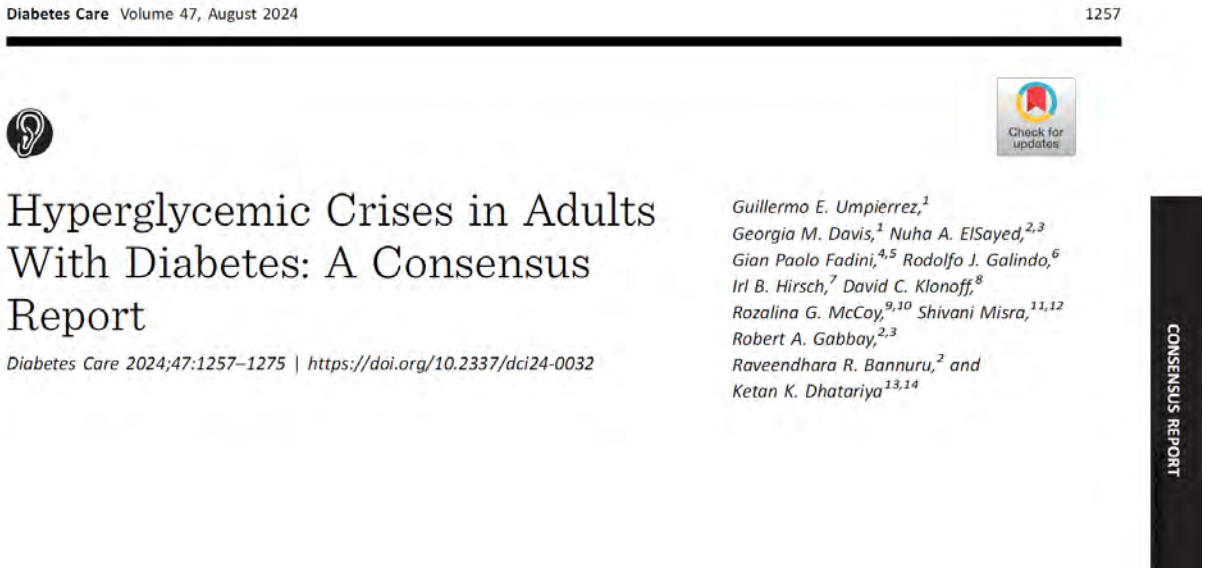
Diabetologia (2024) 67:1455–1479
https://doi.org/10.1007/s00125-024-06183-8

CONSENSUS REPORT

Check for updates

Hyperglycaemic crises in adults with diabetes: a consensus report

Guillermo E. Umpierrez[1] · Georgia M. Davis[1] · Nuha A. ElSayed[2,3] · Gian Paolo Fadini[4,5] · Rodolfo J. Galindo[6] · Irl B. Hirsch[7] · David C. Klonoff[8] · Rozalina G. McCoy[9,10] · Shivani Misra[11,12] · Robert A. Gabbay[2,3] · Raveendhara R. Bannuru[2] · Ketan K. Dhatariya[13,14]



Umpierrez GE et al Diabetes Care 2024;47(8):1257-1275
Umpierrez GE et al Diabeteologia 2024;67(8):1455-1479

New DKA Diagnostic Criteria

DKA	**Diabetes/hyperglycaemia**	Glucose ≥200 mg/dl (11.1 mmol/l) or prior history of diabetes
	Ketosis	β-hydroxybutyrate ≥3.0 mmol/l or urine ketone strip 2+ or greater
	Metabolic **A**cidosis	pH <7.3 and/or bicarbonate concentration <18 mmol/l

Umpierrez GE et al Diabetes Care 2024;47(8):1257-1275
Umpierrez GE et al Diabeteologia 2024;67(8):1455-1479

Why 3.0mmol/l?

DM

The hospital and home use of a 30-second hand-held blood ketone meter: guidelines for clinical practice

T. M. Wallace, N. M. Meston*, S. G. Gardner† and D. R. Matthews

Conclusion Near patient blood ketone testing is a useful adjunct to blood glucose monitoring in distinguishing between ketosis and simple hyperglycaemia. The data suggest that β-OHB levels ⩾1 mmol/l require further action and levels >3 mmol/l necessitate medical review. In addition, the rate of fall of β-OHB in DKA can be used as an indicator of the adequacy of treatment.

Wallace TM et al Diab Med 2001;18(8):640-645

Physiological vs Pathological

- It’s the rate of appearance and the ability for renal and respiratory compensation for the drop in pH
- A rise of β hydroxybutyrate of ≥0.2mmol/l/hr might be considered ‘pathological’
- But there are currently no technologies available to allow prediction or prevention other than glucose meters that say ‘Hi’ and ‘Check ketones’ or point of care capillary ketone meters

Any Age and Any Kind of Diabetes

Most common **hyperglycemic emergency** in persons living with diabetes

DKA is a **leading cause of death** among children and adults (< 58) with diabetes

1%–13% annual prevalence of DKA in adults with T1D across countries

DKA and T2D

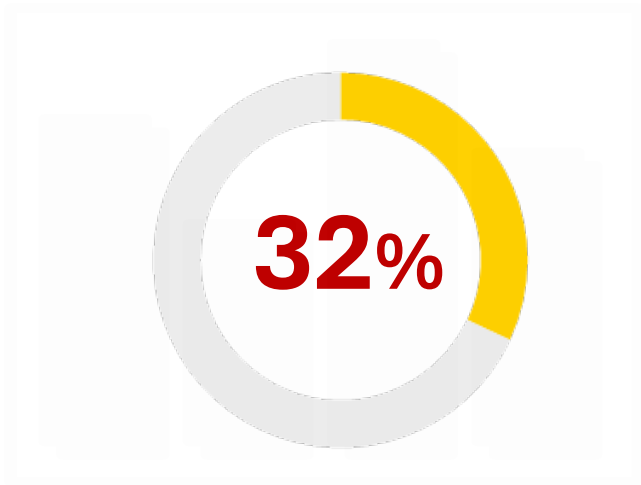
Hospitalization for DKA: 1 in 5 cases attributed to T2D

Higher mortality for T2D (0.85%) with DKA than T1D (0.2%)

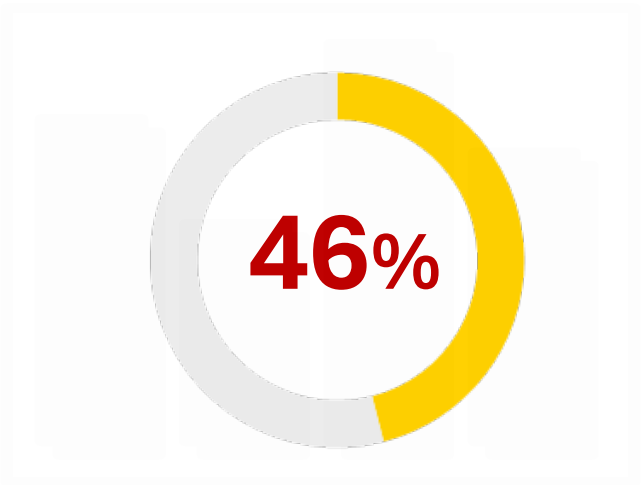
Umpierrez GE et al Diabetes Care 2024;47(8):1257-1275
Nguyen KT et al JDST 2022;16(3):689-715
Zhong VW et al Diabetes Care 2018;41(9):1870-1877
Canales SP et al Endocrine Pract 2024;20(5 Suppl):S24

DKA Unawareness

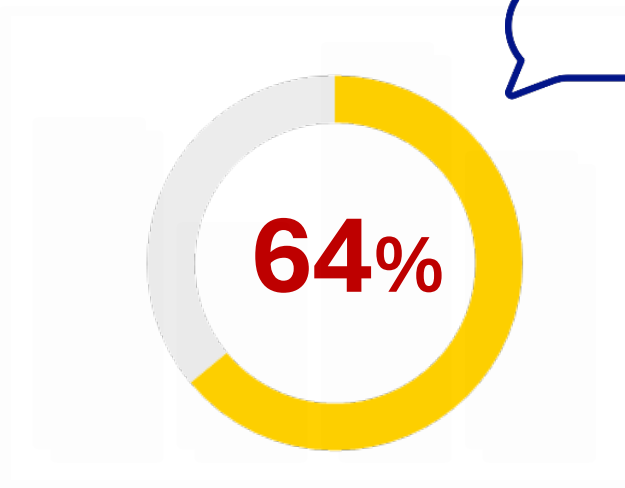
MULTINATIONAL, MULTICENTER SURVEY OF ENDOCRINE OUTPATIENT CLINIC PATIENTS WITH AVERAGE DURATION OF T1D OF 22 YEARS (N=333)



Were not familiar with the term DKA



Were unable to name a single symptom of DKA



Did not test for ketones at all

Hepprich M et al BMJ Open DRC 2023;11(6):e003662

No Self-Monitoring

< 20%

Test ketone levels, even when glucose is > 16.7 mmol/L for 1 hour or more

38%

Never test ketones when nauseated and/or vomiting

45%

Never test ketone levels when they detect a fever

Albanese-O'Neil A et al Diabetes Care 2017;40(4):e38-e39
Viridi N et al Diabetes Technology & Therapeutics 2023;25:S3

Barriers to DKA Prevention

- Lack of knowledge of what ketones are, what DKA is, when to check ketone levels, how to interpret ketone level results, and when to seek emergency medical care
- Some individuals with T1D experience feelings of responsibility for their disease and its management and are consequently less likely to seek help from healthcare providers
- Individuals with T1D do not expect that they could get DKA and that it could be life-threatening, or that it truly would require emergency medical care

Verhoeff NJ et al Can J Diab 2026;50:DOI10.1016/j.jcjd.2025.11.002

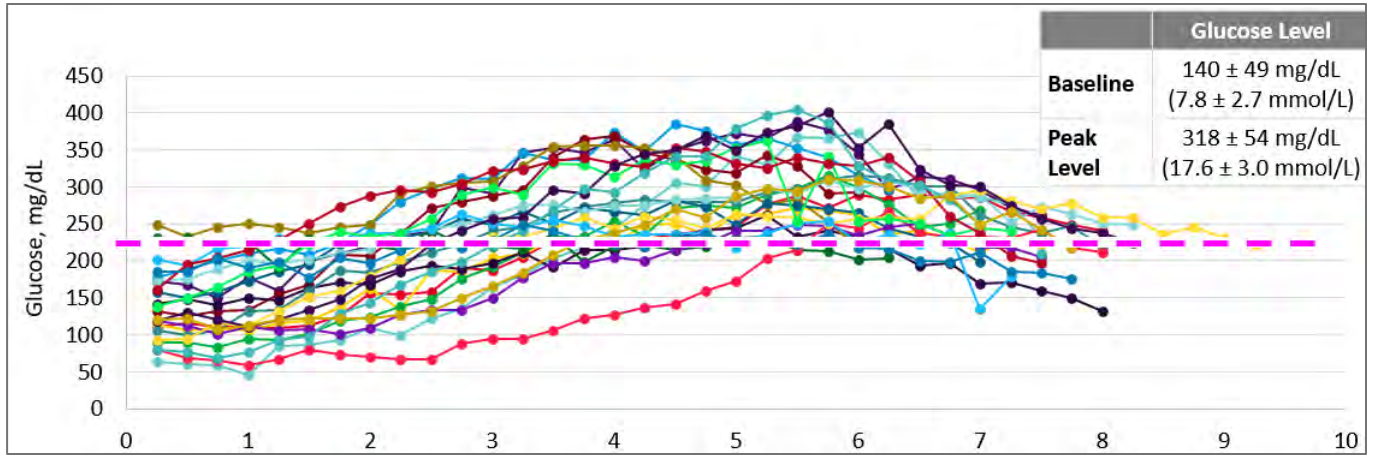
Barriers to DKA Prevention

- Individuals with T1D could benefit from frequent reinforcement regarding preparing for sick days and healthcare providers could benefit from frequent reinforcement to counsel on DKA
- It is difficult for individuals with T1D to remember information that will help them recognize and prevent DKA given all the other self-management burdens
- Support from loved ones and others with T1D improves ability to engage in DKA prevention
- There is financial inaccessibility to resources and outdated existing DKA preventative guidelines

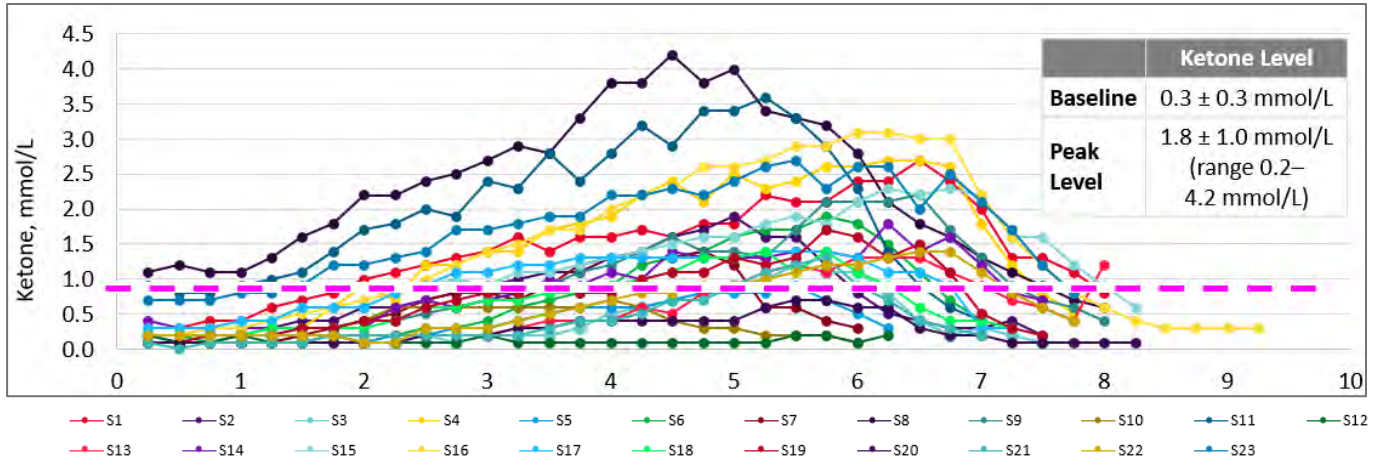
Verhoeff NJ et al Can J Diab 2026;50:DOI10.1016/j.jcjd.2025.11.002

Glucose and Ketone Variability

Glucose Profiles During Pump Suspension

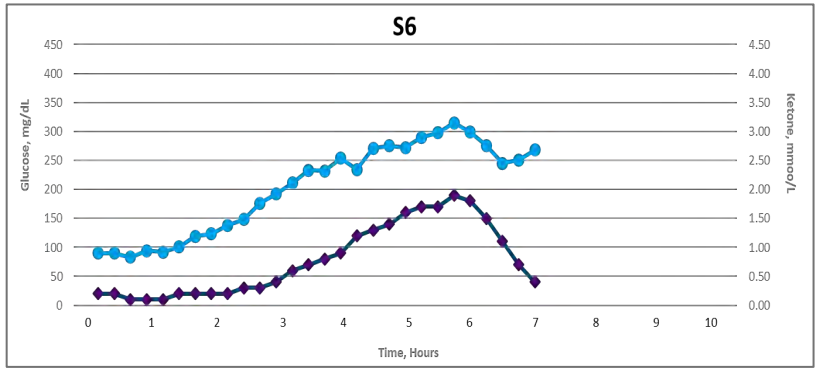


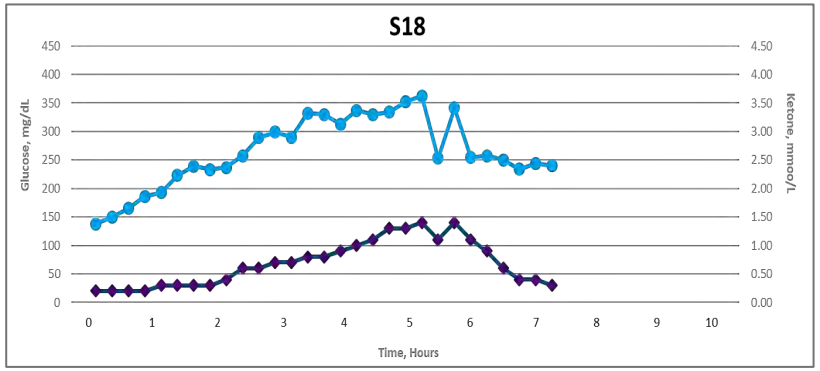
Ketone Profiles During Pump Suspension

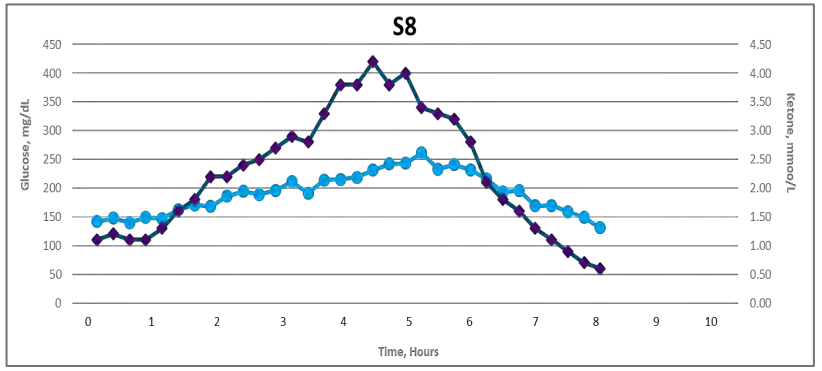


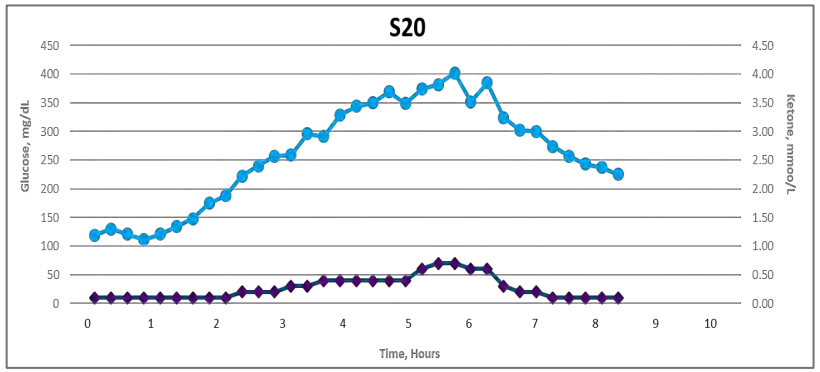
Data on file. Abbott Diabetes Care

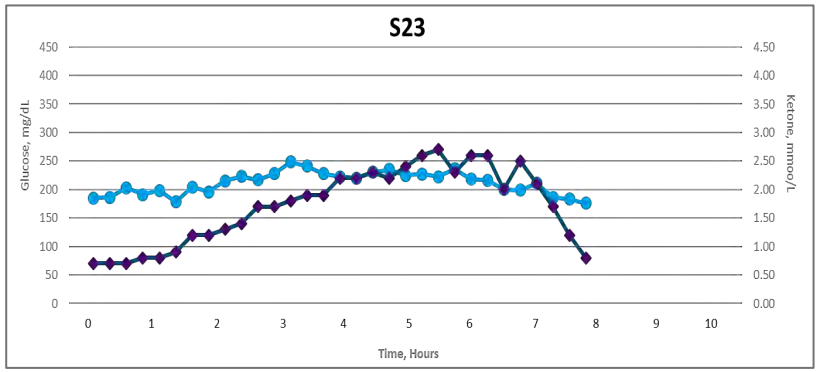
Glucose and Ketone Variability











Glucose Ketone

Notes:

(S6)	G and K rise together at about same rate
(S18)	G rises faster than K
(S8)	K rises faster than G
(S20)	G rises, K stays flat
(S23)	G stays flat, K rises

Data on file. Abbott Diabetes Care

On the Horizon – CKM and AID

SENSOR

- Continuously monitors glucose and ketone levels every minute without user calibration
- 10-14 days of data storage

MOBILE APP

- Automatically displays glucose result (value, trend arrow and graph)
- Optional, customizable glucose and ketone alarms

CLOUD SOFTWARE

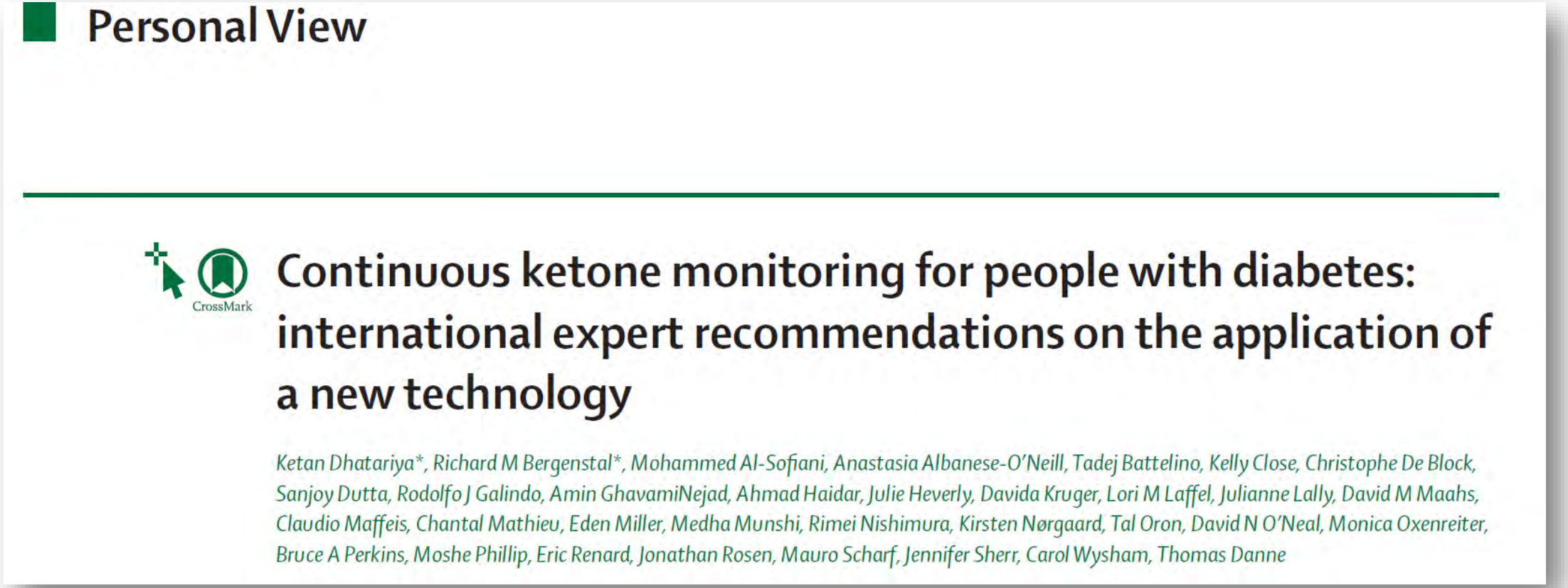
- Cloud-based software
- Glucose and ketone reports

MOBILE DEVICE APP

- Shared glucose and ketone alarms

AID SYSTEM

Suggested Use



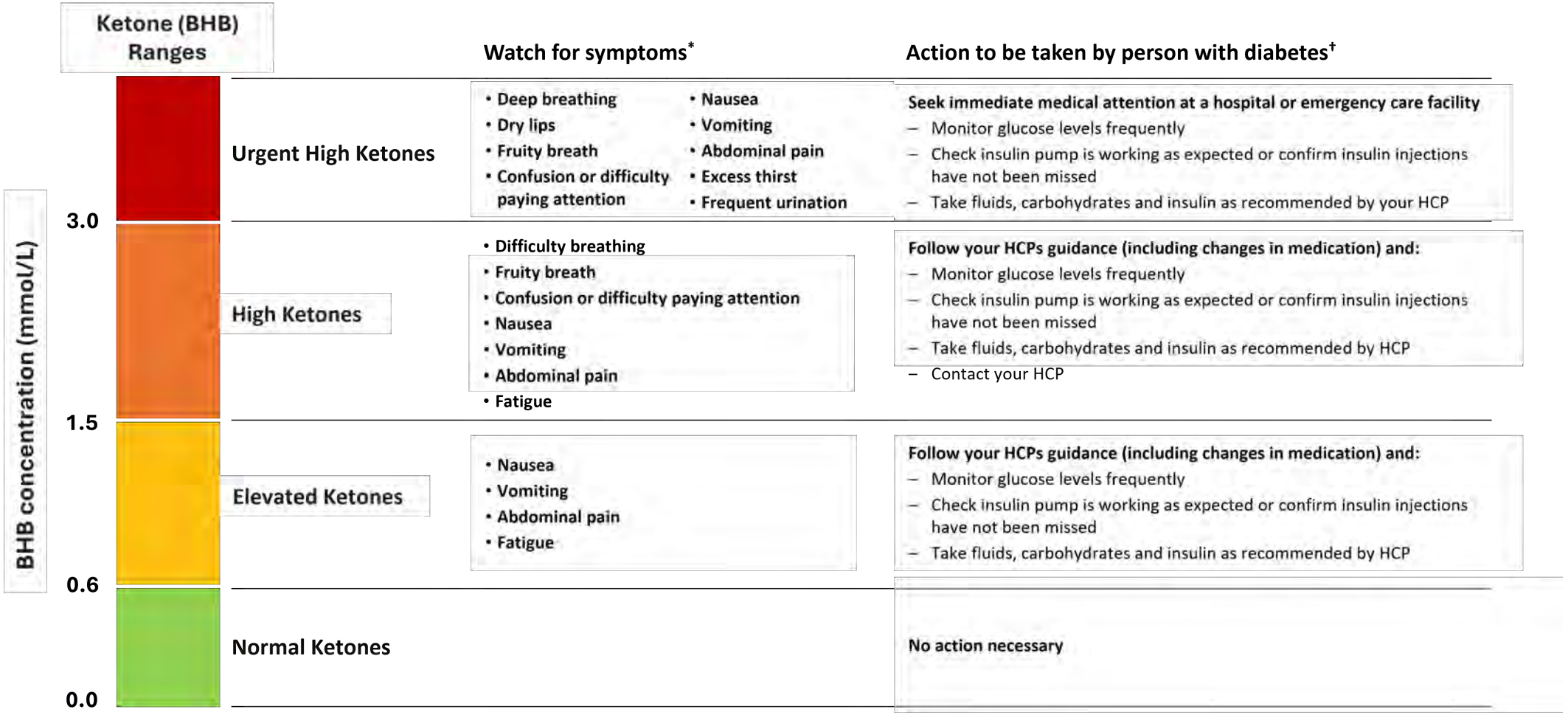
Personal View

Continuous ketone monitoring for people with diabetes: international expert recommendations on the application of a new technology

Ketan Dhatariya*, Richard M Bergenstal*, Mohammed Al-Sofiani, Anastasia Albanese-O'Neill, Tadej Battelino, Kelly Close, Christophe De Block, Sanjoy Dutta, Rodolfo J Galindo, Amin GhavamiNejad, Ahmad Haidar, Julie Heverly, Davida Kruger, Lori M Laffel, Julianne Lally, David M Maahs, Claudio Maffeis, Chantal Mathieu, Eden Miller, Medha Munshi, Rimei Nishimura, Kirsten Nørgaard, Tal Oron, David N O'Neal, Monica Oxenreiter, Bruce A Perkins, Moshe Phillip, Eric Renard, Jonathan Rosen, Mauro Scharf, Jennifer Sherr, Carol Wysham, Thomas Danne

Dhatariya K et al Lancet Diab Endocrinol 2026;14(1):82-92

Suggested Thresholds



Dhatariya K et al Lancet Diab Endocrinol 2026;14(1):82-92

Suggested Graphics

Orientation	Interpretation
	Ketones are **rising faster** than **0.4 mmol/L/h**
	Ketones are **changing slowly**, less than or equal to **0.4 mmol/L/h**
	Ketones are **falling faster** than **0.4 mmol/L/h**

Dhatariya K et al Lancet Diab Endocrinol 2026;14(1):82-92

Suggested Actions

STOP DKA considerations for bolus insulin and CHO			
Continuous ketone concentration (mmol/L)	**Blood glucose meter / CGM value (check every hour)***		
	4.0-8.0 mmol/L (70-150 mg/dL)	**8.1-14.0 mmol/L (151-250 mg/dL)**	**>14 mmol/L (>250 mg/dL)**
<0.6 Normal	• No extra insulin • Usual bolus to cover CHO + usual correction		• 5-10% TDD supplemental insulin or usual correction bolus • Usual bolus to cover CHO
0.6–1.5 Elevated Ketonemia ***Consider rate of change arrow***	• 5% TDD supplemental insulin + usual bolus to cover CHO • 30 - 45 g CHO every 2-4 hours	• 10% TDD supplemental insulin or 1.5x correction bolus • Usual bolus to cover CHO • 30 g CHO every 2-4 hours	• 10%TDD supplemental insulin or 1.5x correction bolus • Usual bolus to cover CHO every 2-4 hours
1.6–2.9 High Impending DKA ***Consider rate of change arrow***	• 10% TDD supplemental insulin + usual bolus to cover CHO • 30 - 45 g CHO every 2-4 hours	• 20% TDD supplemental insulin or 2x correction bolus • Usual bolus to cover CHO • 30 - 45 g CHO every 2-4 hours	• 20% TDD supplemental insulin or 2x correction bolus • Usual bolus to cover CHO every 2-4 hours
≥3.0 Urgent High Probable DKA	• 10% TDD supplemental insulin + usual bolus to cover CHO • 30 - 45 g CHO every 2-4 hours	• 20% TDD supplemental insulin or 2x correction bolus • Usual bolus to cover CHO • 30 - 45 g CHO every 2-4 hours	• 20% TDD supplemental insulin or 2x correction bolus • Usual bolus to cover CHO every 2-4 hours
DKA is likely if ketones remain ≥3 mmol/L (**Continuous Ketone System Alarm**) despite supplemental insulin			

Dhatariya K et al Lancet Diab Endocrinol 2026;14(1):82-92

Potentials

There are several!

- Helping to identify a rise in ketones allowing the implementation of ‘Sick Day Rules’
- Early warning of pump / infusion set failure
- Preventing acute illness / hospital admission
- Fewer pieces of ‘kit’ to carry about
- Developing an AID algorithm that incorporates ketones / sick day rules

The 'At Risk' Population

Adolescents and young adults
- Potential causes may include hormonal changes in puberty, transition from pediatric to adult care
- Psychosocial aspects can increase risks for DKA, e.g., eating disorders

Pregnancy
- Most common with pregestational T1D
- Associated with significant adverse fetal outcomes
- Risks for DKA heightened by 'morning sickness' in 2nd and 3rd trimester
- Pregnancy-specific symptoms include vaginal bleeding, uterine contractions
- Higher rates of euglycemic DKA

Older and frail individuals
- Symptoms may differ, with higher rates of respiratory distress, cognitive impairment, fever
- Recurrent DKA more common
- Greater risk of in-hospital mortality
- Care-home staff require education

SGLT2 inhibitors
- Used for glucose-lowering and cardiorenal protection
- DKA risk doubled in T1D compared to other glucose-lowering agents
- Higher rates of euglycemic DKA
- Associated with delayed DKA diagnosis

Insulin pump users
- Associated with catheter occlusion and other infusion-site issues
- Risks for DKA increased compared to daily insulin injection regimens
- DKA due to infusion-site failure is a real-world clinical management concern

Chronic kidney disease (CKD)
- Chronic metabolic acidosis in CKD can mask symptoms of DKA
- Euglycemic DKA more common with CKD than without, especially ESRD
- Treatment of DKA in CKD requires specific fluid and electrolyte management

Mental health & psychiatric disorders
- Three-fold increased risk of DKA compared to individuals without mental or psychiatric illness
- Comorbid psychiatric illness can impact insulin adherence, increasing DKA risk
- Atypical antipsychotic drugs associated with DKA

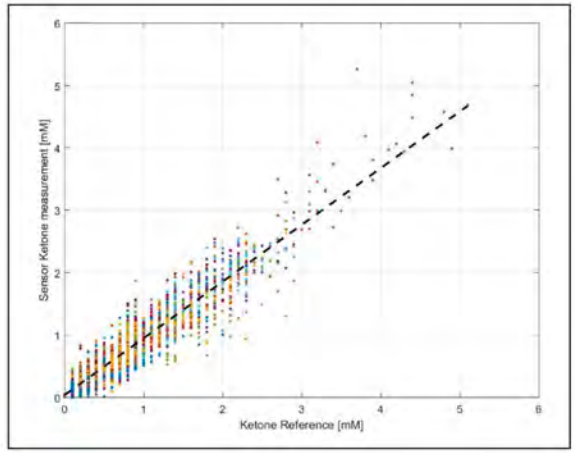
Rural populations
- Up to 68% additional risks for DKA compared to urban locations
- Association between DKA risk and indices of socio-economic deprivation

Low carbohydrate & ketogenic diets
- Increased risk for DKA in T2D during weight-loss therapies
- Exacerbated with SGLT2 inhibitors
- Guidelines discourage low carbohydrate/ ketogenic dieting in T1D or in T2D using SGLT2 inhibitors

Challenges & Unknowns

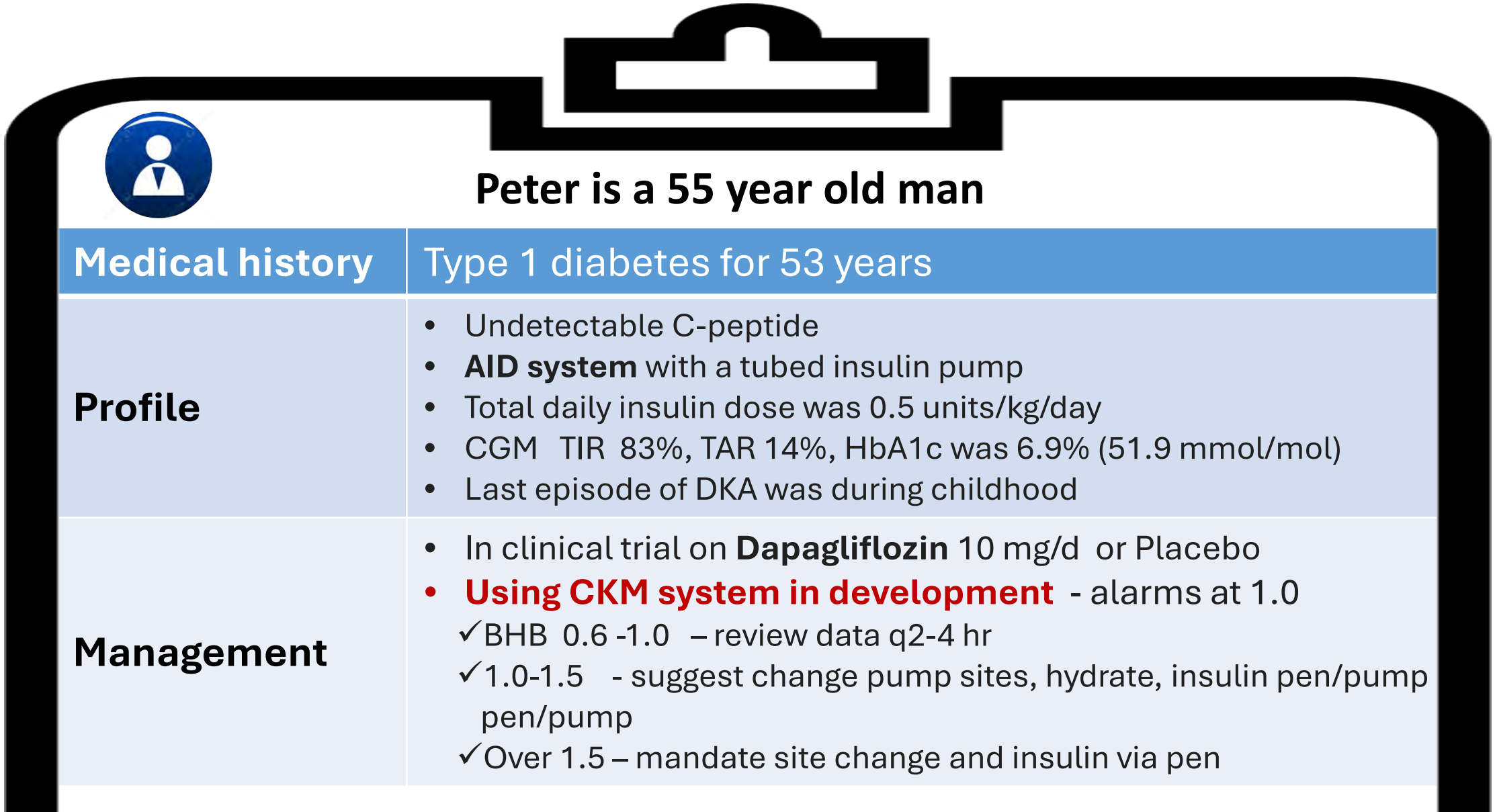
There are several!

- Education of people with diabetes – what do the numbers mean?
- Education of health care professionals – what do the numbers mean?
- When does physiological become pathological?
- Are there significant differences between blood / capillary and interstitial fluid?
- T1DM vs T2DM
- How to manage euglycaemic ketonaemia/DKA
- Reimbursement?



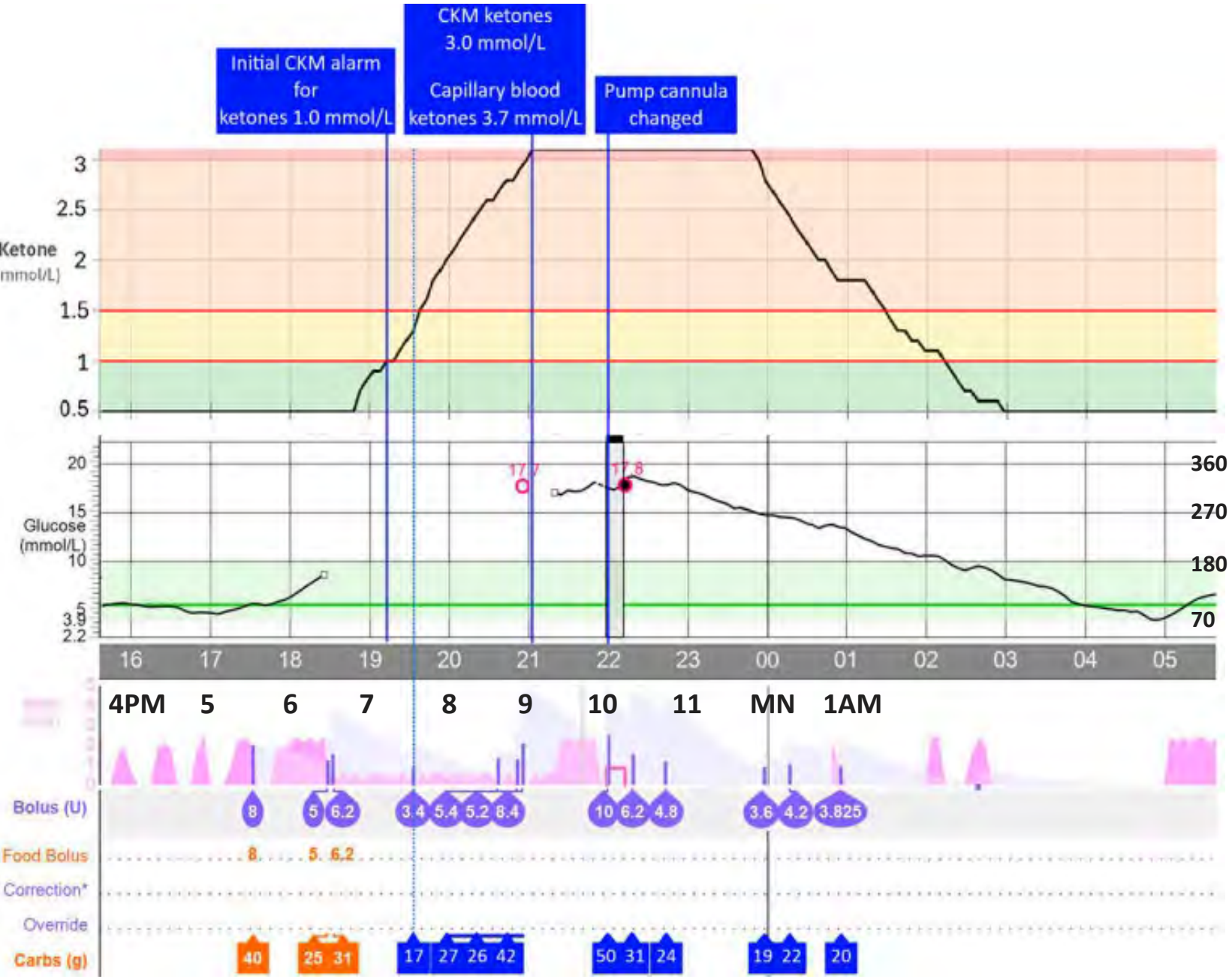
Alva et al Journal of Diabetes Sci Technol 2021;15(4):768-774

Preventing Diabetic Ketoacidosis with Continuous Ketone Monitoring: Insights from a Clinical Case



Peter is a 55 year old man

Medical history	Type 1 diabetes for 53 years
Profile	• Undetectable C-peptide • **AID system** with a tubed insulin pump • Total daily insulin dose was 0.5 units/kg/day • CGM TIR 83%, TAR 14%, HbA1c was 6.9% (51.9 mmol/mol) • Last episode of DKA was during childhood
Management	• In clinical trial on **Dapagliflozin** 10 mg/d or Placebo • **Using CKM system in development** - alarms at 1.0 ✓BHB 0.6 -1.0 – review data q2-4 hr ✓1.0-1.5 - suggest change pump sites, hydrate, insulin pen/pump pen/pump ✓Over 1.5 – mandate site change and insulin via pen



- Worked in the garden in the afternoon
- Premeal pump boluses 5:30 and 6:30 PM ---- glucose started up post-meal

6:30 PM CGM expired and was changed and 2hr warm up and one more hr charge transmitter (3hr no sensor)

7:15 PM CKM 1.0 ketone alarm
7:30 PM Alarm still >1 approaching 1.5 – gave insulin bolus via pump
8:00 PM Ketones 2.0
9:00 PM >3.1 CKM **alarm** (capillary glucose 319 mg/dL (17.7 mmol/L)

CGM started to work

9:30 PM Noted pump cannula site noted to be dislodged
By 10PM Replaced cannula and gave insulin via pump
By MN – **Ketones falling. Glucose and ketones normalized over 4-5 hrs.**

In Summary

- Ketones are an evolutionary adaptation to prolonged starvation
- Their presence can be beneficial or harmful – depending on the rate of appearance in the circulation
- Continuous ketone measurement seems to be the next logical step in the management of type 1 diabetes, and incorporation into an AID system seems likely
- Challenges remain but the potential for benefit is huge

Beyond CGM: Dual Sensing Technology as a Cornerstone of DKA Prevention

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- @ketandhatariya.bsky.social
- @JBDSIP
- @ABCDiab

CGM for Transforming Clinical Outcomes in Non-Intensive T2D Therapy

Dr Emma Wilmot

Associate Professor University of Nottingham

Honorary Consultant, University Hospitals of Derby & Burton NHS FT

Founder, ABCD Diabetes Technology Network UK

Disclosures

- **Emma Wilmot** has received personal fees from Abbott, AstraZeneca, Dexcom, Eli Lilly, Embecta, Insulet, Medtronic, Novo Nordisk, Roche, Sanofi, Sinocare, Ypsomed and research support from Abbott, Embecta, Insulet, Novo Nordisk, Sanofi.

Overview

Evidence base for continuous glucose monitoring

- Insulin treated
- Non insulin treated

Interactive case study

What next?

- Consider emerging research

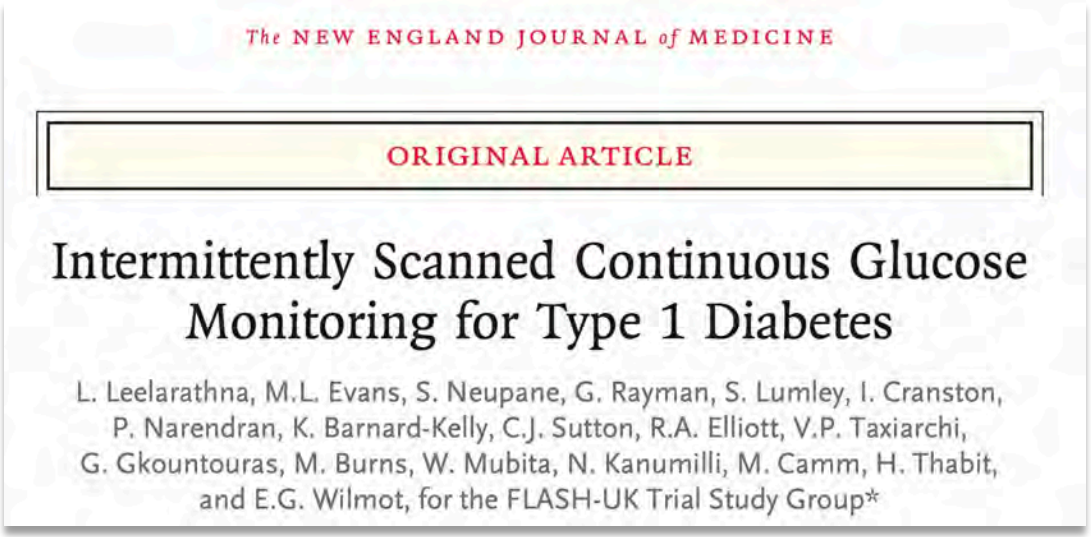
Flash UK Summary

isCGM in T1 diabetes

- Significant improvement in HbA1c
- Less hypoglycaemia
- Improved treatment satisfaction

Cost Effectiveness

- Incremental cost-per-QALY of £4477
- For people with HbA1c >75 mmol/mol (9.0%), cost-saving

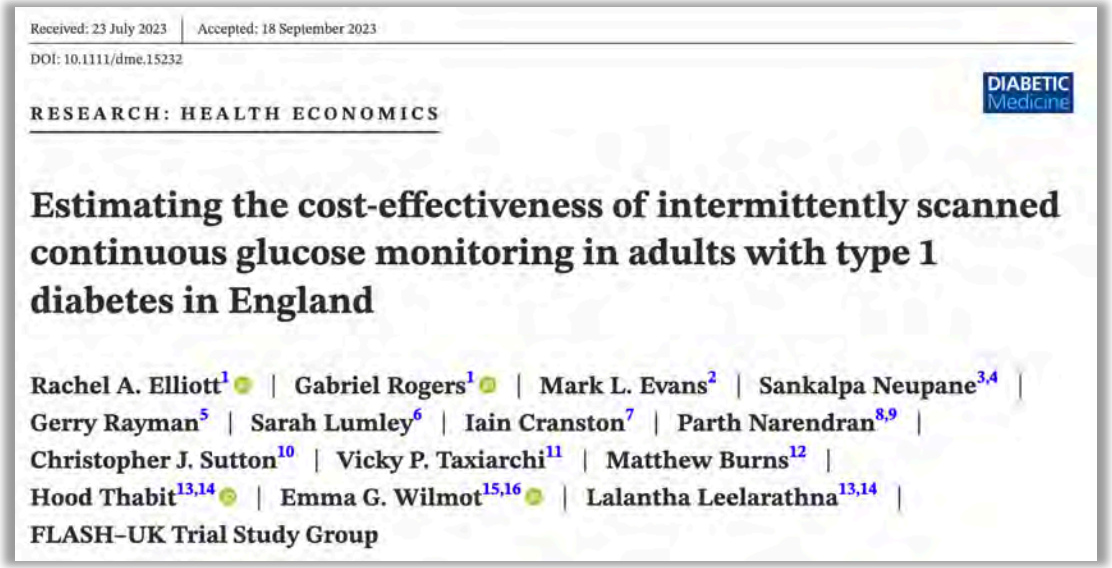


The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Intermittently Scanned Continuous Glucose Monitoring for Type 1 Diabetes

L. Leelarathna, M.L. Evans, S. Neupane, G. Rayman, S. Lumley, I. Cranston, P. Narendran, K. Barnard-Kelly, C.J. Sutton, R.A. Elliott, V.P. Taxiarchi, G. Gkountouras, M. Burns, W. Mubita, N. Kanumilli, M. Camm, H. Thabit, and E.G. Wilmot, for the FLASH-UK Trial Study Group*



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DOI: 10.1111/dme.15232

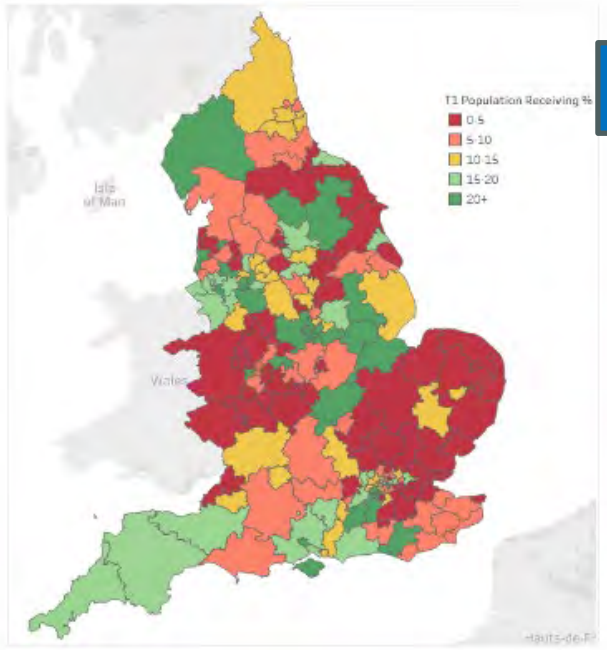
DIABETIC Medicine

RESEARCH: HEALTH ECONOMICS

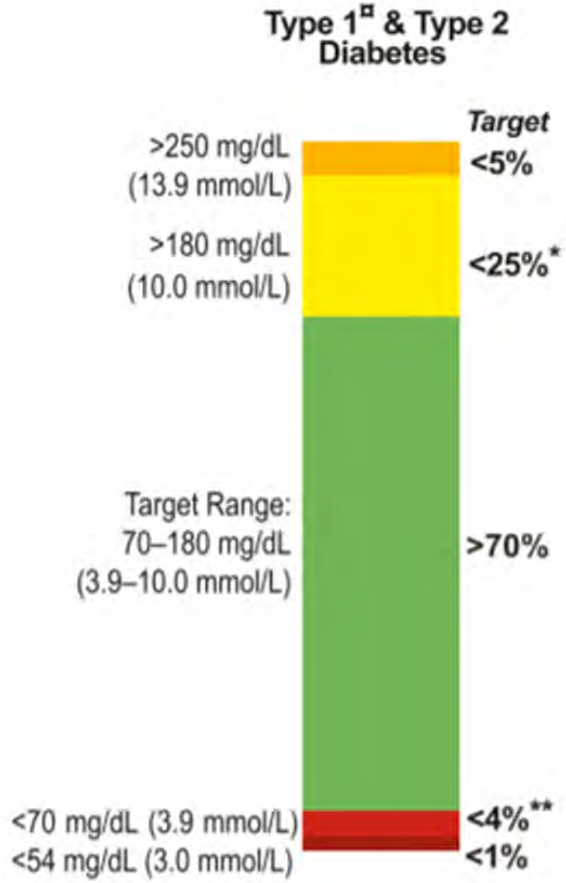
Estimating the cost-effectiveness of intermittently scanned continuous glucose monitoring in adults with type 1 diabetes in England

Rachel A. Elliott[1] | Gabriel Rogers[1] | Mark L. Evans[2] | Sankalpa Neupane[3,4] | Gerry Rayman[5] | Sarah Lumley[6] | Iain Cranston[7] | Parth Narendran[8,9] | Christopher J. Sutton[10] | Vicky P. Taxiarchi[11] | Matthew Burns[12] | Hood Thabit[13,14] | Emma G. Wilmot[15,16] | Lalantha Leelarathna[13,14] | FLASH–UK Trial Study Group

Impact of CGM in T1DM in England



>95% of people living with T1DM in the UK now have access to NHS funded CGM



Battelino et al. International Consensus on Time in Range. Diabetes Care 2019; 42: 1593-1603

UK NICE Recommendations (2022)

Continuous glucose monitoring

1.6.17 Offer intermittently scanned continuous glucose monitoring (isCGM, commonly referred to as 'flash') to adults with type 2 diabetes on multiple daily insulin injections if any of the following apply:

- they have recurrent hypoglycaemia or severe hypoglycaemia
- they have impaired hypoglycaemia awareness
- they have a condition or disability (including a learning disability or cognitive impairment) that means they cannot self-monitor their blood glucose by capillary blood glucose monitoring but could use an isCGM device (or have it scanned for them)
- they would otherwise be advised to self-measure at least 8 times a day.

For guidance on continuous glucose monitoring (CGM) for pregnant women, see the NICE guideline on diabetes in pregnancy. **[2022]**

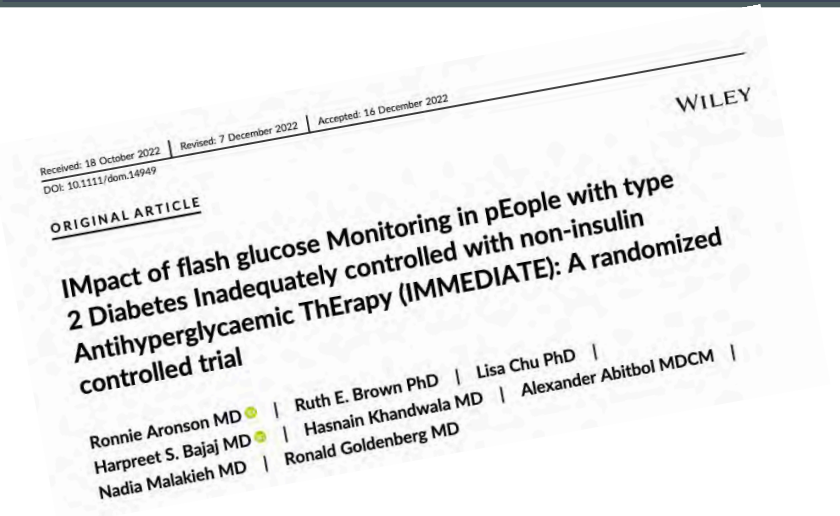
1.6.18 Offer isCGM to adults with insulin-treated type 2 diabetes who would otherwise need help from a care worker or healthcare professional to monitor their blood glucose. **[2022]**

NICE define MDI as two or more daily insulin injections

Type 2 diabetes in adults: management

NICE guideline [NG28] Published: 02 December 2015 Last updated: 29 June 2022

RCTs of CGM



Received: 18 October 2022 | Revised: 7 December 2022 | Accepted: 16 December 2022

DOI: 10.1111/dom.14949

WILEY

ORIGINAL ARTICLE

IMpact of flash glucose Monitoring in pEople with type 2 Diabetes Inadequately controlled with non-insulin Antihyperglycaemic ThErapy (IMMEDIATE): A randomized controlled trial

Ronnie Aronson MD | Ruth E. Brown PhD | Lisa Chu PhD | Harpreet S. Bajaj MD | Hasnain Khandwala MD | Alexander Abitbol MDCM | Nadia Malakieh MD | Ronald Goldenberg MD

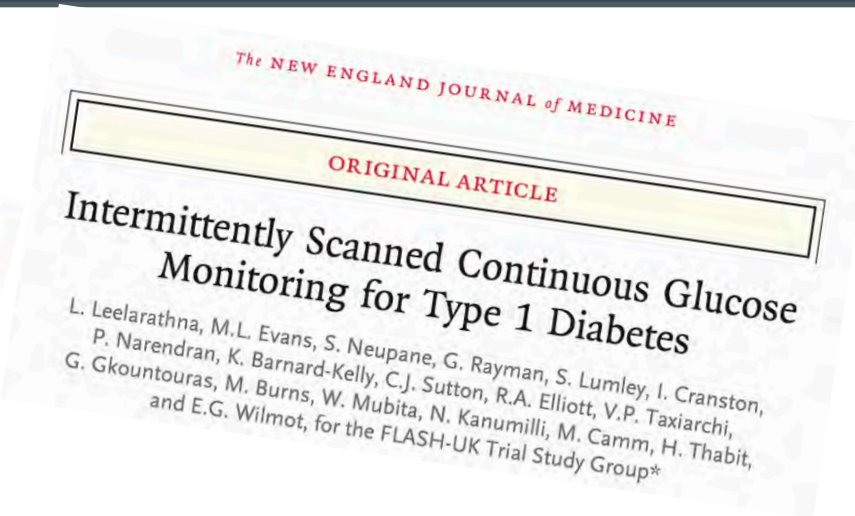
Research

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

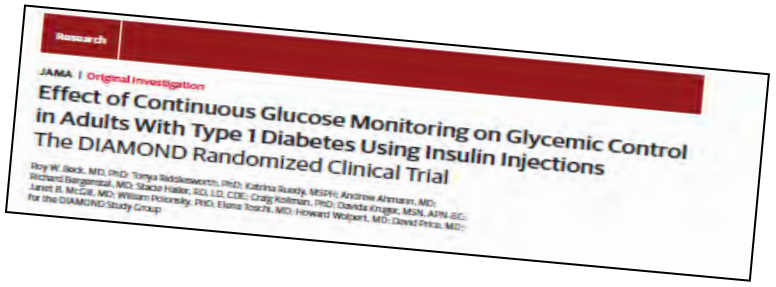


The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Intermittently Scanned Continuous Glucose Monitoring for Type 1 Diabetes

L. Leelarathna, M.L. Evans, S. Neupane, G. Rayman, S. Lumley, I. Cranston, P. Narendran, K. Barnard-Kelly, C.J. Sutton, R.A. Elliott, V.P. Taxiarchi, G. Gkountouras, M. Burns, W. Mubita, N. Kanumilli, M. Camm, H. Thabit, and E.G. Wilmot, for the FLASH-UK Trial Study Group*



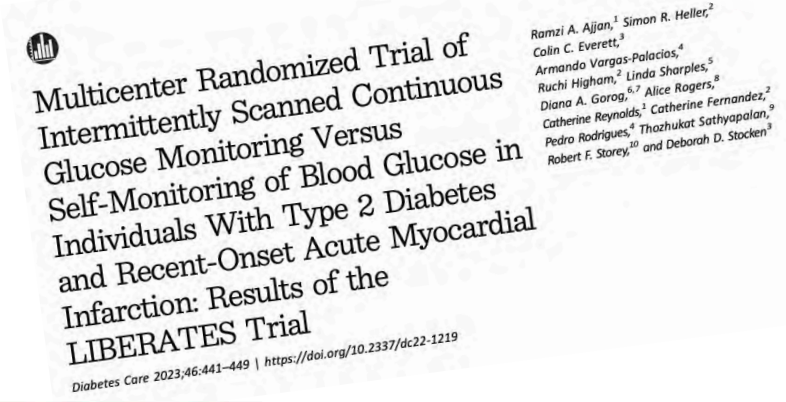
Research

JAMA | Original Investigation

Effect of Continuous Glucose Monitoring on Glycemic Control in Adults With Type 1 Diabetes Using Insulin Injections

The DIAMOND Randomized Clinical Trial

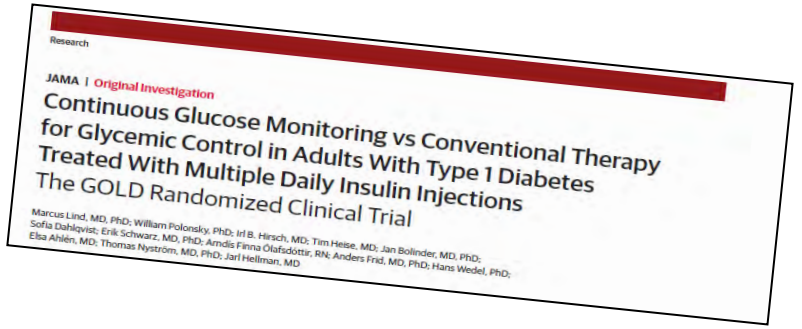
Roy W. Beck, MD, PhD; Tonya Riddlesworth, PhD; Katrina Ruedy, MSPH; Andrew Ahmann, MD; Richard Bergenstal, MD; Stacie Haller, RD, LD, CDE; Craig Kollman, PhD; Davida Kruger, MSN, APN-BC; Janet B. McGill, MD; William Polonsky, PhD; Elena Toschi, MD; Howard Wolpert, MD; David Price, MD; for the DIAMOND Study Group



Multicenter Randomized Trial of Intermittently Scanned Continuous Glucose Monitoring Versus Self-Monitoring of Blood Glucose in Individuals With Type 2 Diabetes and Recent-Onset Acute Myocardial Infarction: Results of the LIBERATES Trial

Ramzi A. Ajjan,[1] Simon R. Heller,[2] Colin C. Everett,[3] Armando Vargas-Palacios,[4] Ruchi Higham,[2] Linda Sharples,[5] Diana A. Gorog,[6,7] Alice Rogers,[8] Catherine Reynolds,[1] Catherine Fernandez,[2] Pedro Rodrigues,[4] Thozhukat Sathyapalan,[9] Robert F. Storey,[10] and Deborah D. Stocken[3]

Diabetes Care 2023;46:441–449 | https://doi.org/10.2337/dc22-1219



Research

JAMA | Original Investigation

Continuous Glucose Monitoring vs Conventional Therapy for Glycemic Control in Adults With Type 1 Diabetes Treated With Multiple Daily Insulin Injections

The GOLD Randomized Clinical Trial

Marcus Lind, MD, PhD; William Polonsky, PhD; Irl B. Hirsch, MD; Tim Heise, MD; Jan Bolinder, MD, PhD; Sofia Dahlqvist; Erik Schwarz, MD, PhD; Arndís Finna Ólafsdóttir, RN; Anders Frid, MD, PhD; Hans Wedel, PhD; Elsa Ahlén, MD; Thomas Nyström, MD, PhD; Jarl Hellman, MD

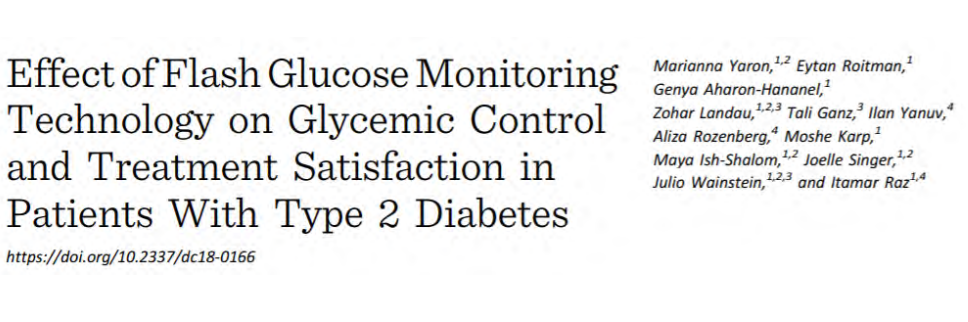
Annals of Internal Medicine

ORIGINAL RESEARCH

Continuous Glucose Monitoring Versus Usual Care in Patients With Type 2 Diabetes Receiving Multiple Daily Insulin Injections

A Randomized Trial

Roy W. Beck, MD, PhD; Tonya D. Riddlesworth, PhD; Katrina Ruedy, MSPH; Andrew Ahmann, MD; Stacie Haller, RD, LD, CDE; Davida Kruger, MSN, APN-BC; Janet B. McGill, MD; William Polonsky, PhD; David Price, MD; Stephen Aronoff, MD; Ronnie Aronson, MD; Elena Toschi, MD; Craig Kollman, PhD; and Richard Bergenstal, MD; for the DIAMOND Study Group*



Effect of Flash Glucose Monitoring Technology on Glycemic Control and Treatment Satisfaction in Patients With Type 2 Diabetes

Marianna Yaron,[1,2] Eytan Roitman,[1] Genya Aharon-Hananel,[1] Zohar Landau,[1,2,3] Tali Ganz,[3] Ilan Yanuv,[4] Aliza Rozenberg,[4] Moshe Karp,[1] Maya Ish-Shalom,[1,2] Joelle Singer,[1,2] Julio Wainstein,[1,2,3] and Itamar Raz[1,4]

https://doi.org/10.2337/dc18-0166

CGM in Type 2 Diabetes

Randomised Controlled Trials:
Intensive Insulin Tx

DIAMOND T2 Study

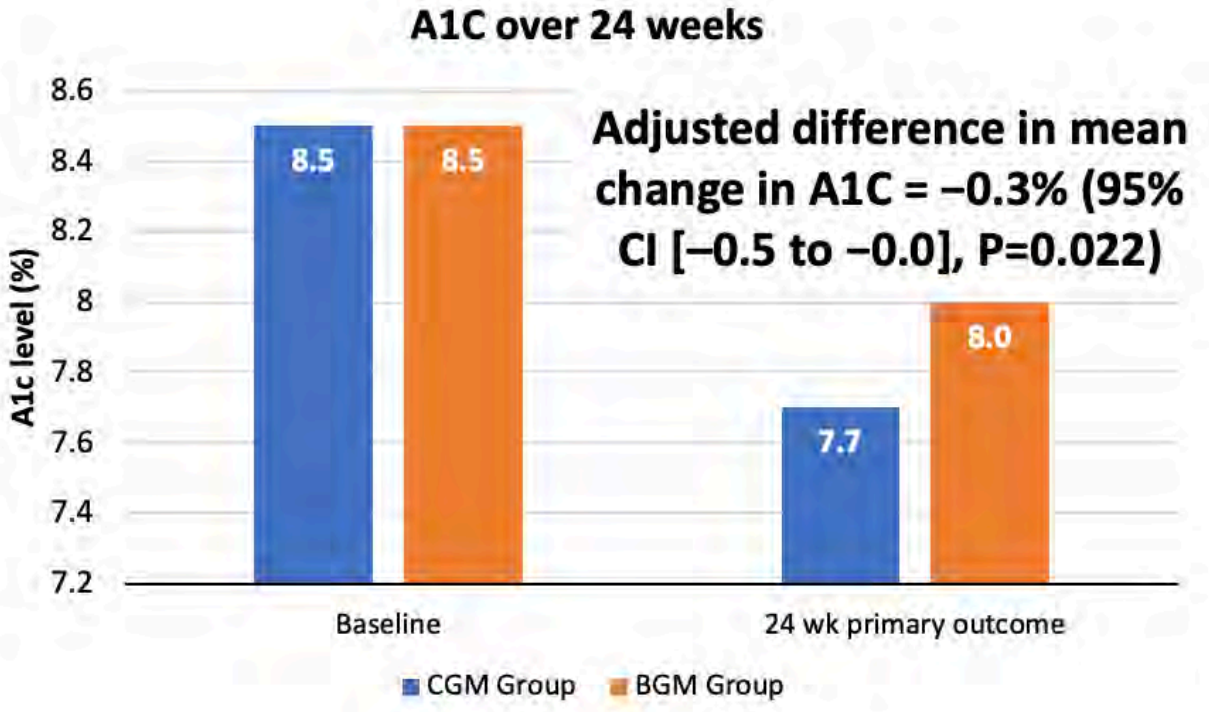
Annals of Internal Medicine ORIGINAL RESEARCH

Continuous Glucose Monitoring Versus Usual Care in Patients With Type 2 Diabetes Receiving Multiple Daily Insulin Injections

A Randomized Trial

Roy W. Beck, MD, PhD; Tonya D. Riddlesworth, PhD; Katrina Ruedy, MSPH; Andrew Ahmann, MD; Stacie Haller, RD, LD, CDE; Davida Kruger, MSN, APN-BC; Janet B. McGill, MD; William Polonsky, PhD; David Price, MD; Stephen Aronoff, MD; Ronnie Aronson, MD; Elena Toschi, MD; Craig Kollman, PhD; and Richard Bergenstal, MD; for the DIAMOND Study Group*

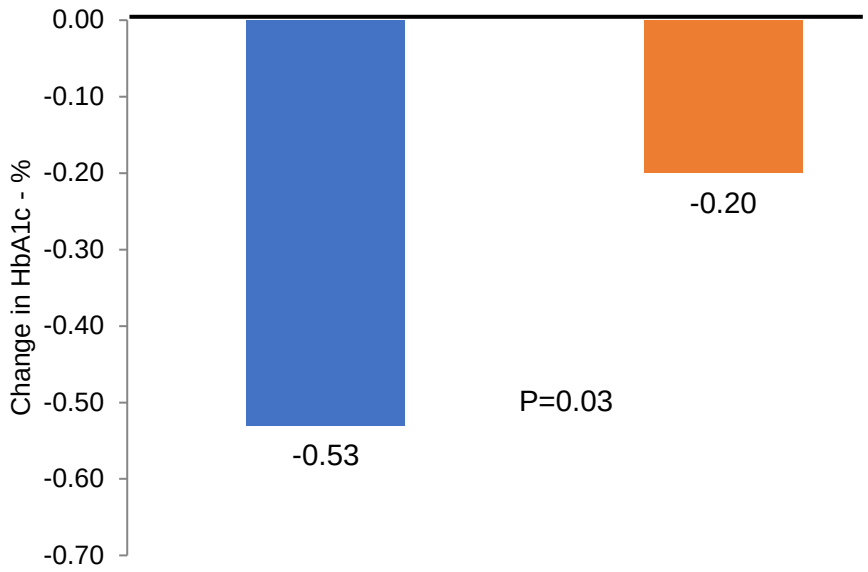
- To determine the effectiveness of rtCGM in adults with **T2DM on MDI**
- Age >25 years old attending endocrinology practices in N. America
- HbA1c 7.5 %-10.0 %
- Mean SMBG frequency ≥ 2/day



Beck RW et al. Ann Intern Med. 2017;167:365-374.

Flash Glucose-Sensing Technology as a Replacement for Blood Glucose Monitoring for the Management of Insulin-Treated Type 2 Diabetes: a Multicenter, Open-Label Randomized Controlled Trial

Thomas Haak · Hélène Hanaire · Ramzi Ajjan · Norbert Hermanns · Jean-Pierre Riveline · Gerry Rayman



- RCT with T2DM adults on **intensive insulin therapy,** 26 European diabetes centers
- Randomised to isCGM or SMBG
- Primary outcome: difference in HbA1c at 6 months

Results:

- No difference in HbA1c overall
- <65 years subgroup mean change HbA1c -0.33%, p = 0.03 favouring isCGM (blue intervention, orange control)

Glucose Level	Difference (vs control)	P value	Reduction vs control
<3.9mmol/l	-0.47h (-28 min)	P<0.001	**43%**
<3.1 mmol/l	-0.22h (-13 min)	P=0.0014	**53%**
<2.5mmol/l	-0.14h (-8 min)	P=0.0013	**64%**

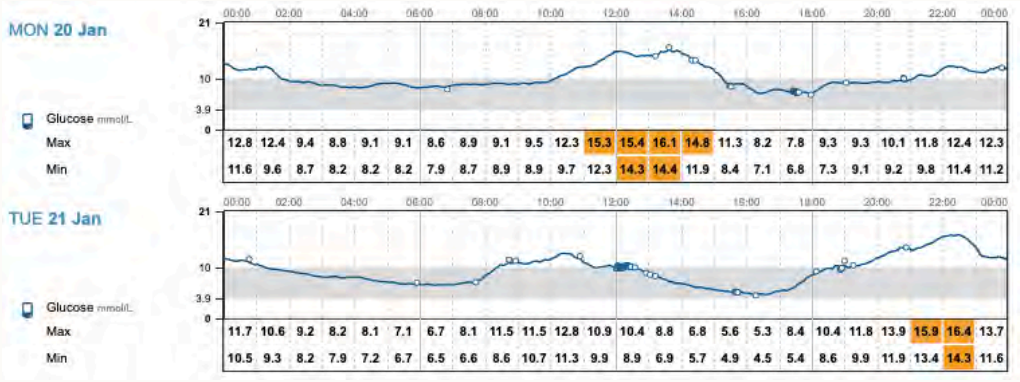
Haak et al, Diabetes Ther. 2017 Feb;8(1):55

Home > Diabetologia > Article

Continuous glucose monitoring with structured education in adults with type 2 diabetes managed by multiple daily insulin injections: a multicentre randomised controlled trial

Article | Published: 19 April 2024

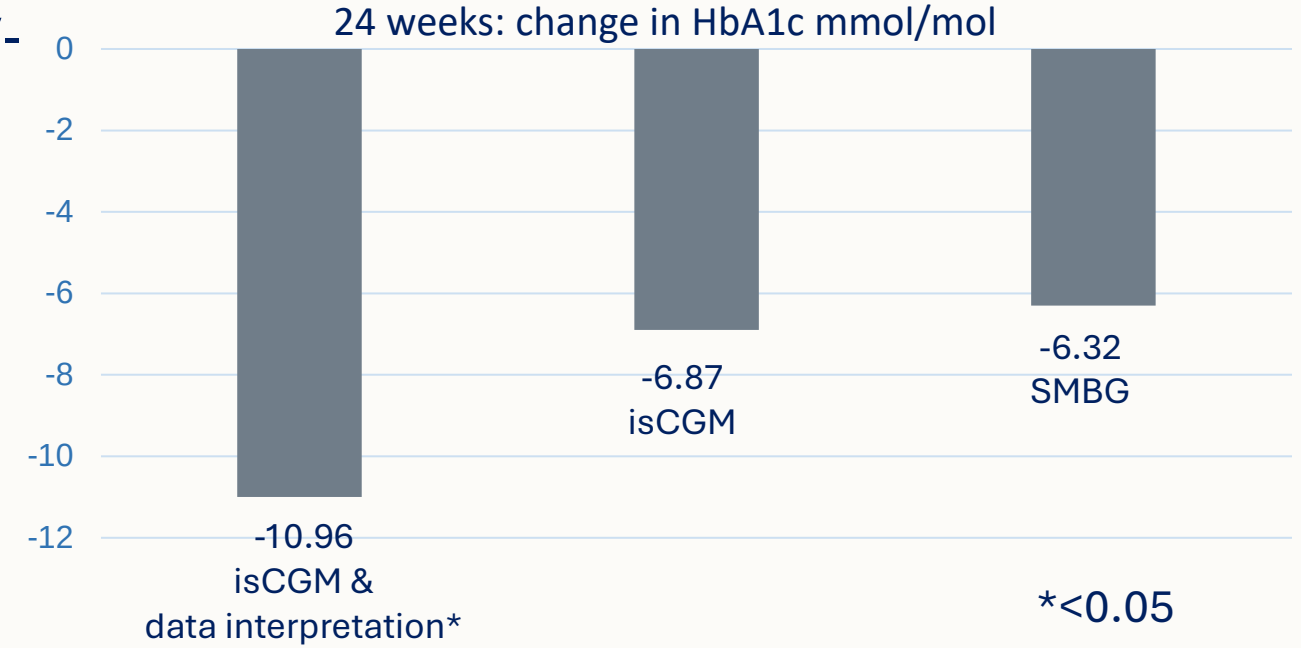
Volume 67, pages 1223–1234, (2024) Cite this article



Aimed to compare the effectiveness of isCGM +/- structured education programme vs. SMBG in adults T2DM MDI.

24 week RCT, randomly assigned:

- **isCGM with a structured education on adjusting insulin dose/timing according to CGM patterns**
- isCGM with education
- SMBG with education



Take home: Education on CGM data matters!

Kim JY, Diabetologia 2024

CGM in Type 2 Diabetes

Basal Insulin

MOBILE Study

Research

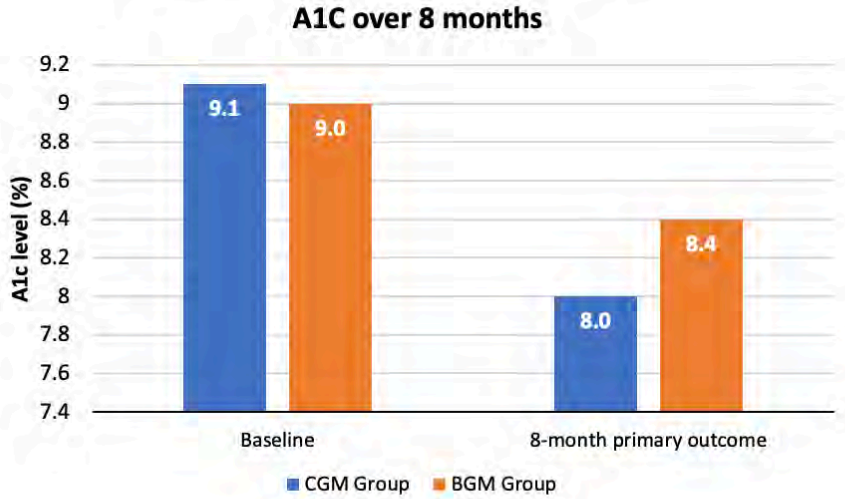
JAMA | Original Investigation

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

- To determine the effectiveness of Dexcom G6 CGM in adults with T2DM treated with **basal insulin (no prandial)**
- HbA1c 7.8 % to 11.5% (62 to 102 mmol/mol)
- 22 Endocrinology practices in USA, participant under primary care physician for diabetes care

Adjusted difference in mean change in HbA1C –0.4%
(95% CI [–0.8% to –0.1%], P=0.02)



No difference of basal / total daily insulin between groups

% TIR 3.9 to 10 mmol/L

- **59% CGM vs. 43% BGM** (adjusted difference, 15%, P<0.001)

% TBR <3.9 mmol/L

- **0.2% CGM vs. 0.5% BGM** (adjusted difference, -0.24%, P=0.02)

Martens et. al. JAMA. 2021;325 (22): 2262-2272

MOBILE Study

Open access Original research

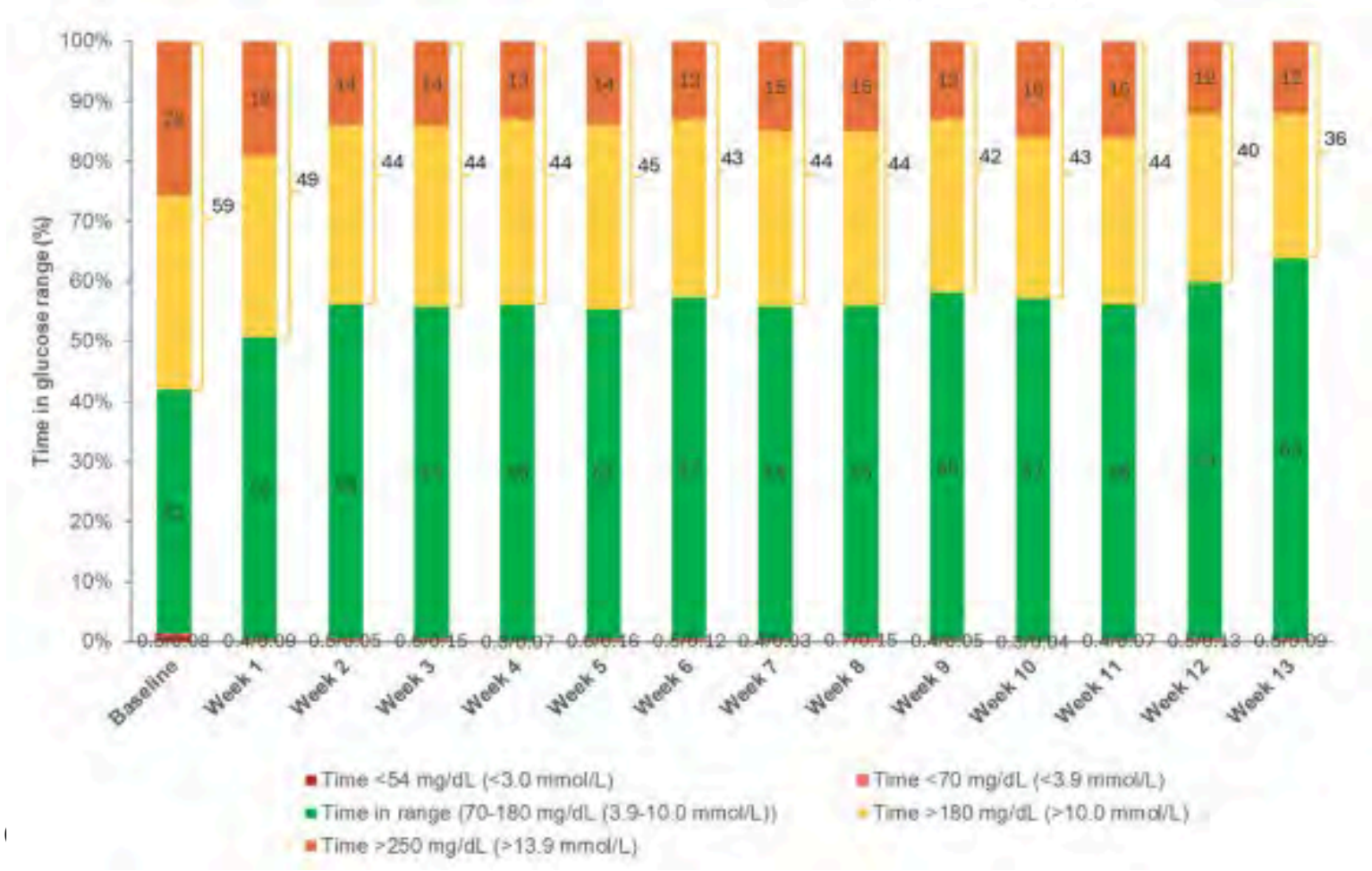
BMJ Open Diabetes Research & Care

Rapid improvements in glycemic management with use of continuous glucose monitoring in adults with type 2 diabetes treated with basal insulin: 3-month analysis of the MOBILE study

Thomas W Martens,[1,2] Roy W Beck,[3] Corbin Griffen,[4] Junrui Di,[4] Karen Elkind-Hirsch,[4] Matthew L Johnson,[4] Jessica R Castle,[4] Stayce E Beck,[4] Richard M Bergenstal[1]

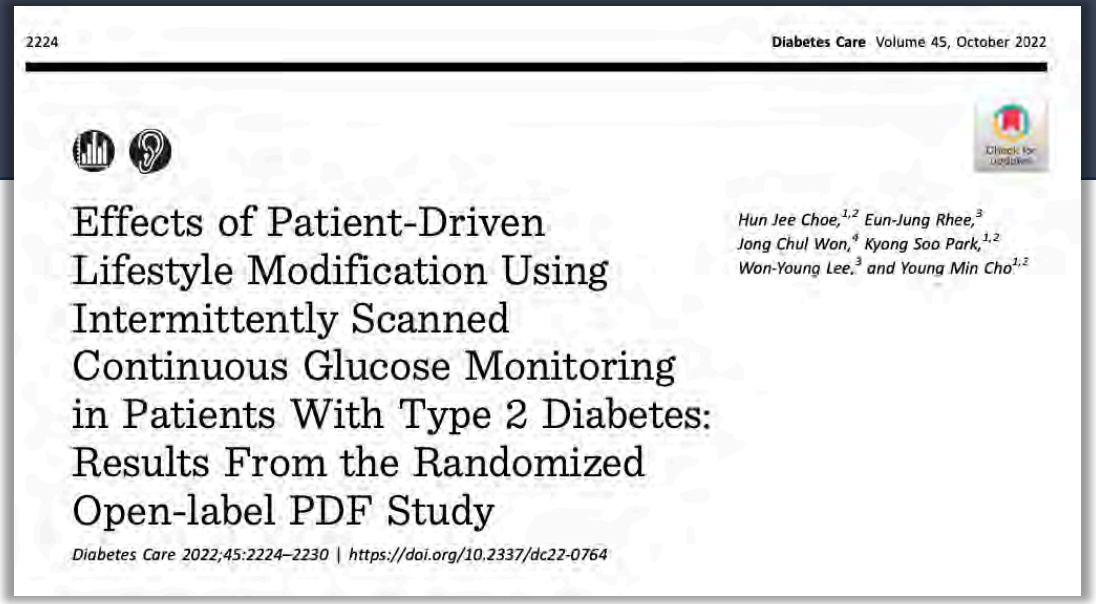
At 3 months:

- 9.1±1.0% to 8.0±1.2% CGM group
- 9.0±0.9% to 8.5±1.5% BGM group
- Adjusted difference, **−0.6%** (95% CI −0.9% to −0.3%); p<0.001)



Martens TW et al, BMJ Open Diab Res and

PDF Study



2224 Diabetes Care Volume 45, October 2022

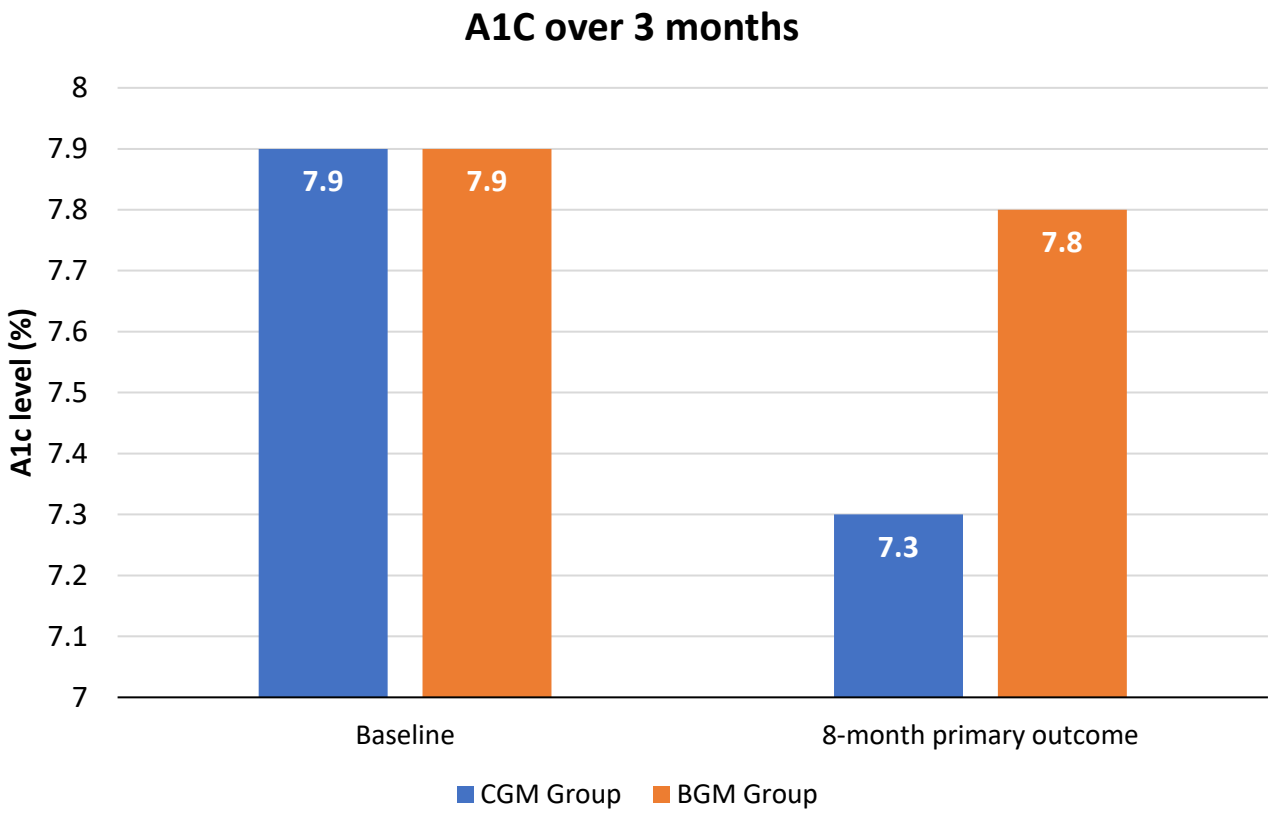
Effects of Patient-Driven Lifestyle Modification Using Intermittently Scanned Continuous Glucose Monitoring in Patients With Type 2 Diabetes: Results From the Randomized Open-label PDF Study

Hun Jee Choe,[1,2] Eun-Jung Rhee,[3] Jong Chul Won,[4] Kyong Soo Park,[1,2] Won-Young Lee,[3] and Young Min Cho[1,2]

Diabetes Care 2022;45:2224–2230 | https://doi.org/10.2337/dc22-0764

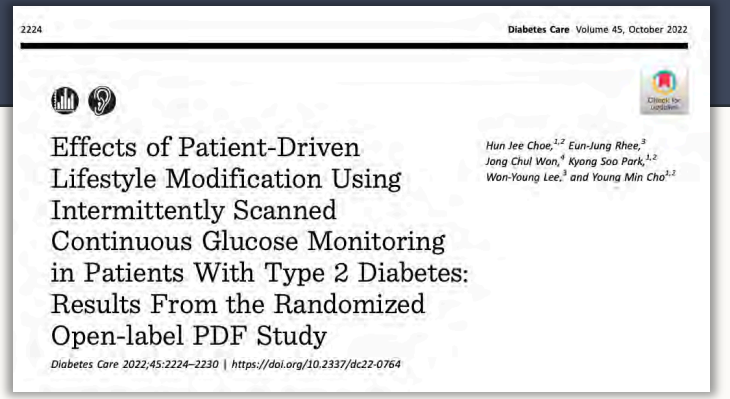
- 12 week RCT (n=126)
- HbA1c >7% on oral and/or basal insulin therapy
- Primary end point HbA1c
- isCGM + diabetes education vs SMBG

Risk-adjusted difference
-0.50% (0.74 to 0.26) <0.001



Choe et al. Diabetes Care 2022; 45:2224-2230

Keep It Simple



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Diabetes Care 2022;45:2224–2230 | https://doi.org/10.2337/dc22-0764

Healthy food?

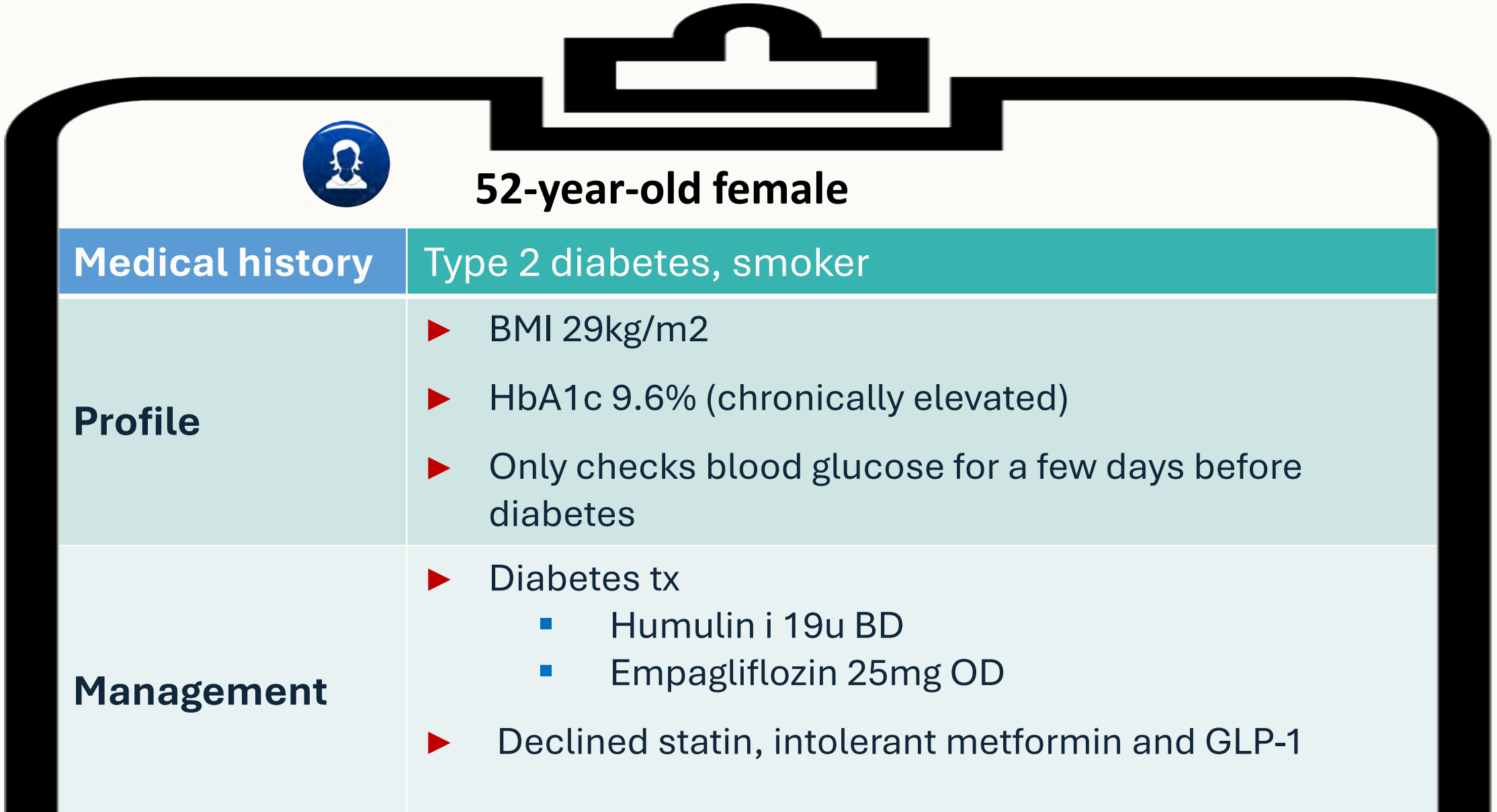
Post meal high glucose?	Yes	No
No	Stay on current eating pattern	Cut down the amount
Yes	Cut down the amount	Stay away

Choe et al. Diabetes Care 2022; 45:2224-2230

Clinical Case Discussion

Basal Insulin-Treated Type 2 Diabetes

Clinical Case Discussion



52-year-old female

Medical history	Type 2 diabetes, smoker
Profile	▶ BMI 29kg/m2 ▶ HbA1c 9.6% (chronically elevated) ▶ Only checks blood glucose for a few days before diabetes
Management	▶ Diabetes tx ▪ Humulin i 19u BD ▪ Empagliflozin 25mg OD ▶ Declined statin, intolerant metformin and GLP-1

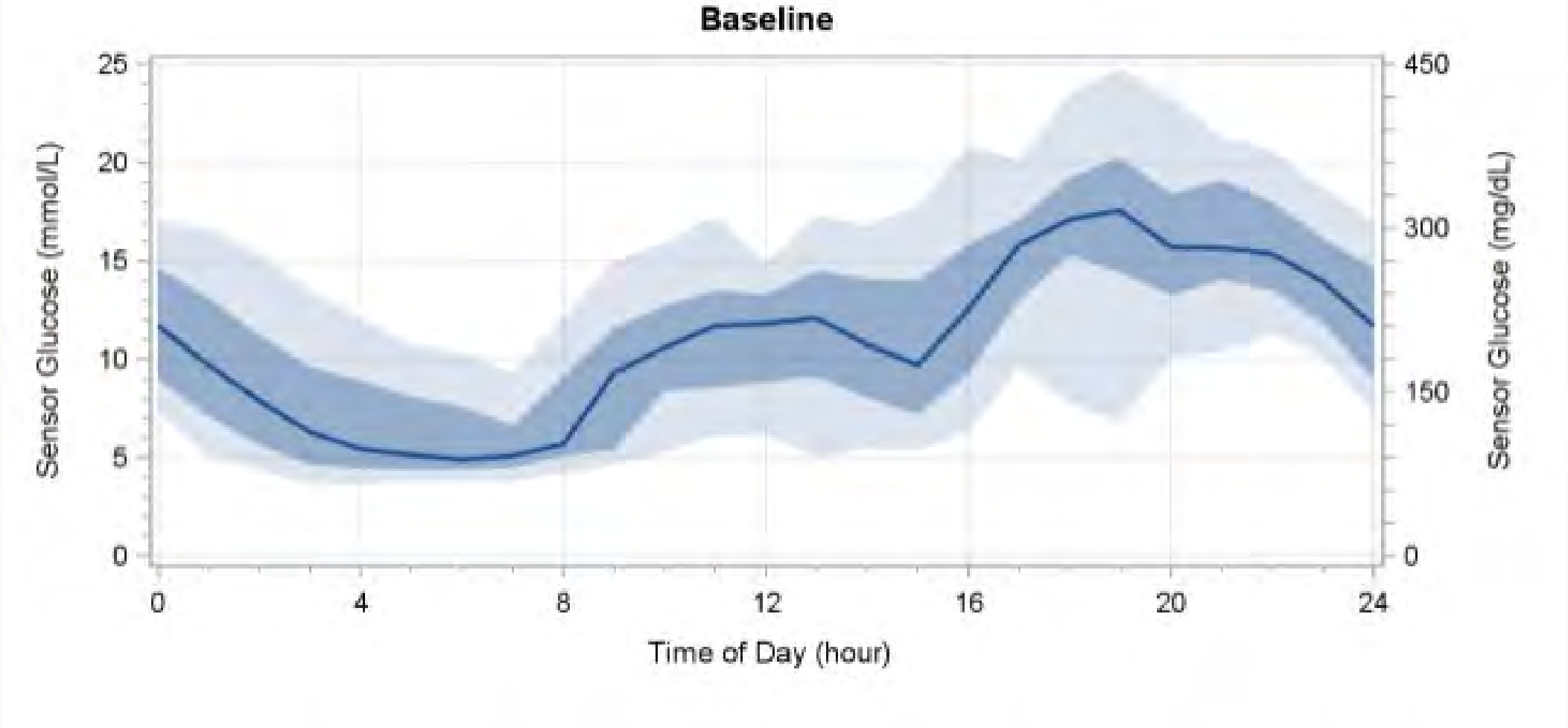
Glucose Data

	Pre-breakfast	Pre-lunch	Pre-dinner	Pre-bed
Sunday	4.9 mmol/L			
Monday	5.2 mmol/L			
Tuesday				
Wednesday	6.3 mmol/L			
Thursday	5.1 mmol/L			

Question: How will you alter the insulin dosing (Humulin i 19 units BD)?

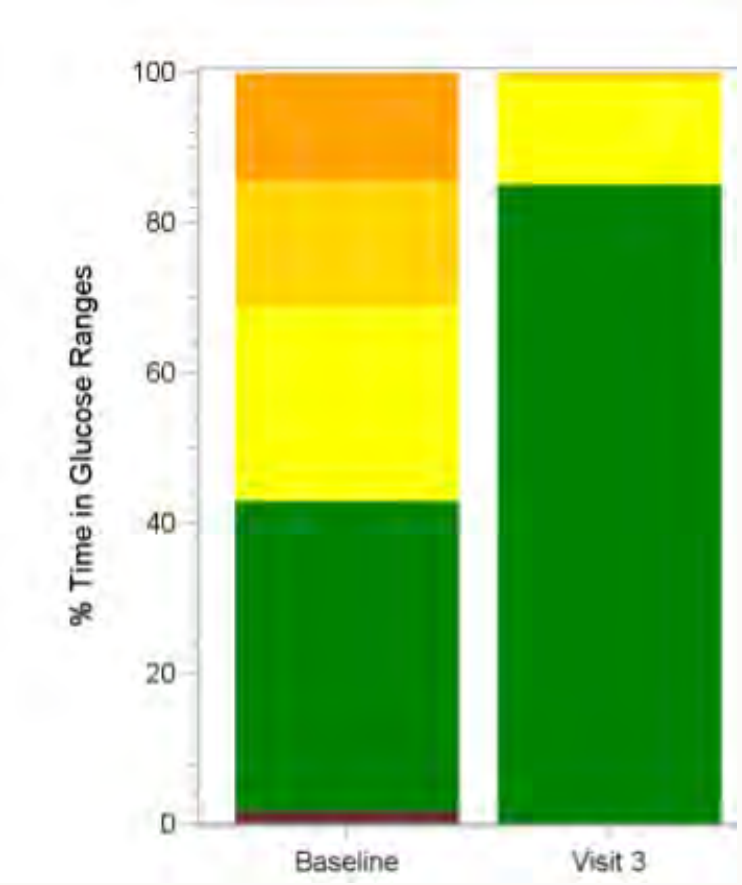
1) Increase the morning dose
2) Increase the evening dose
3) Add in prandial insulin
4) Wait for more blood glucose data first
5) Wait and give a trial of rtCGM first

Blind CGM Data

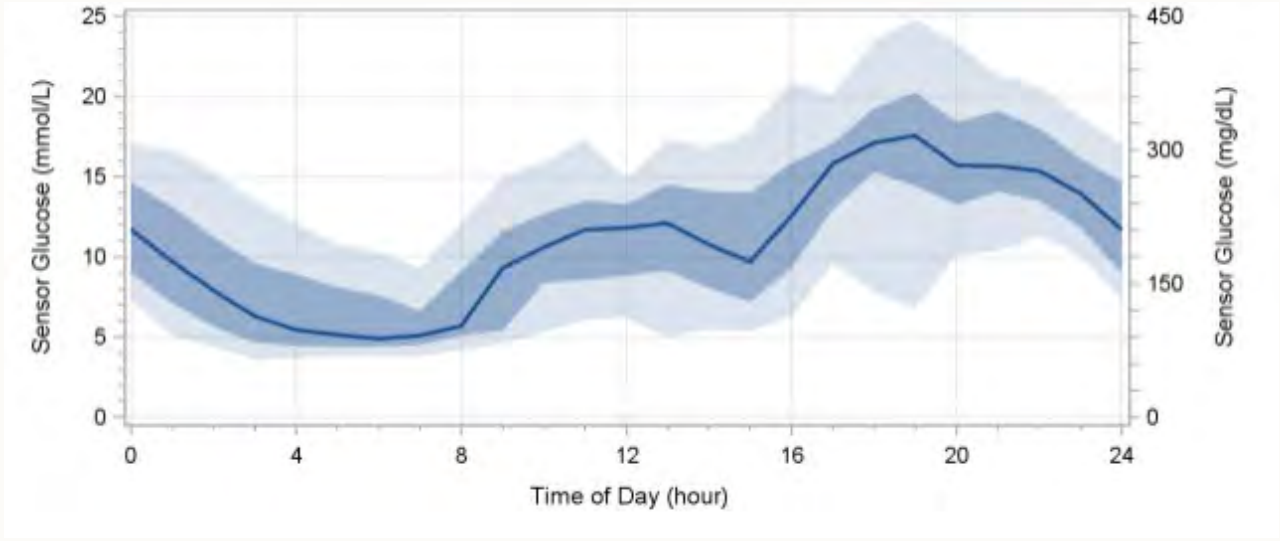


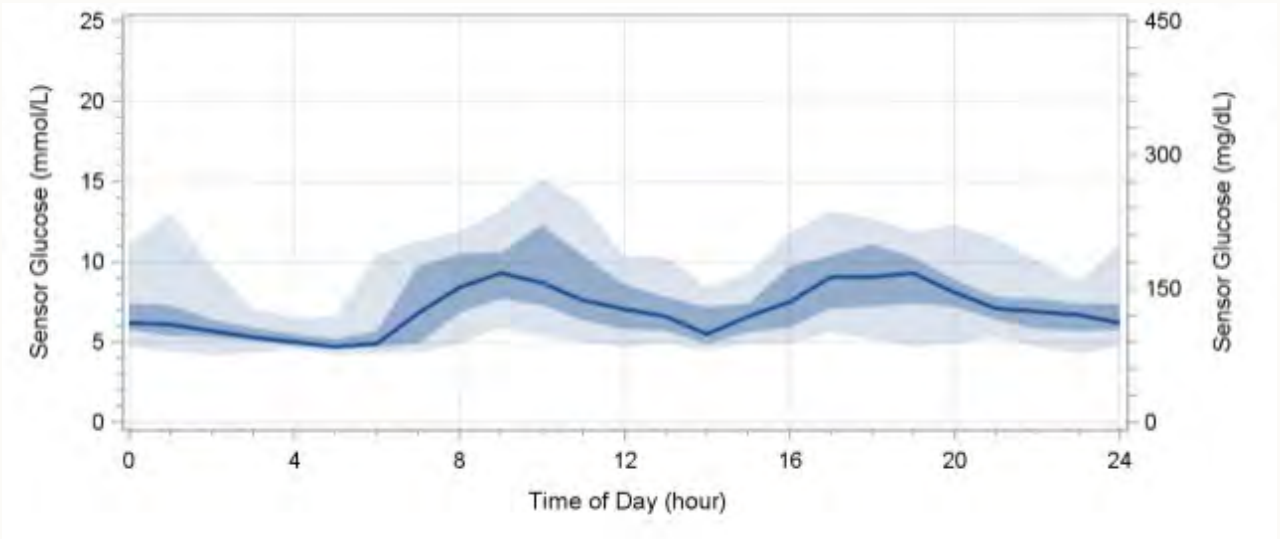
By Four Months

- Patient used rtCGM for four months
- Gained insight into the impact of foods on her glucose levels
- Made changes to her diet: avoiding chocolates, sweets and eating less bread
- By 4 months she had reduced her insulin dose from 19u BD to 14u BD
- Time in Range improved from **41 to 85%**
- HbA1c improved from **9.6% to 6.9%**



Before and Four Months Later



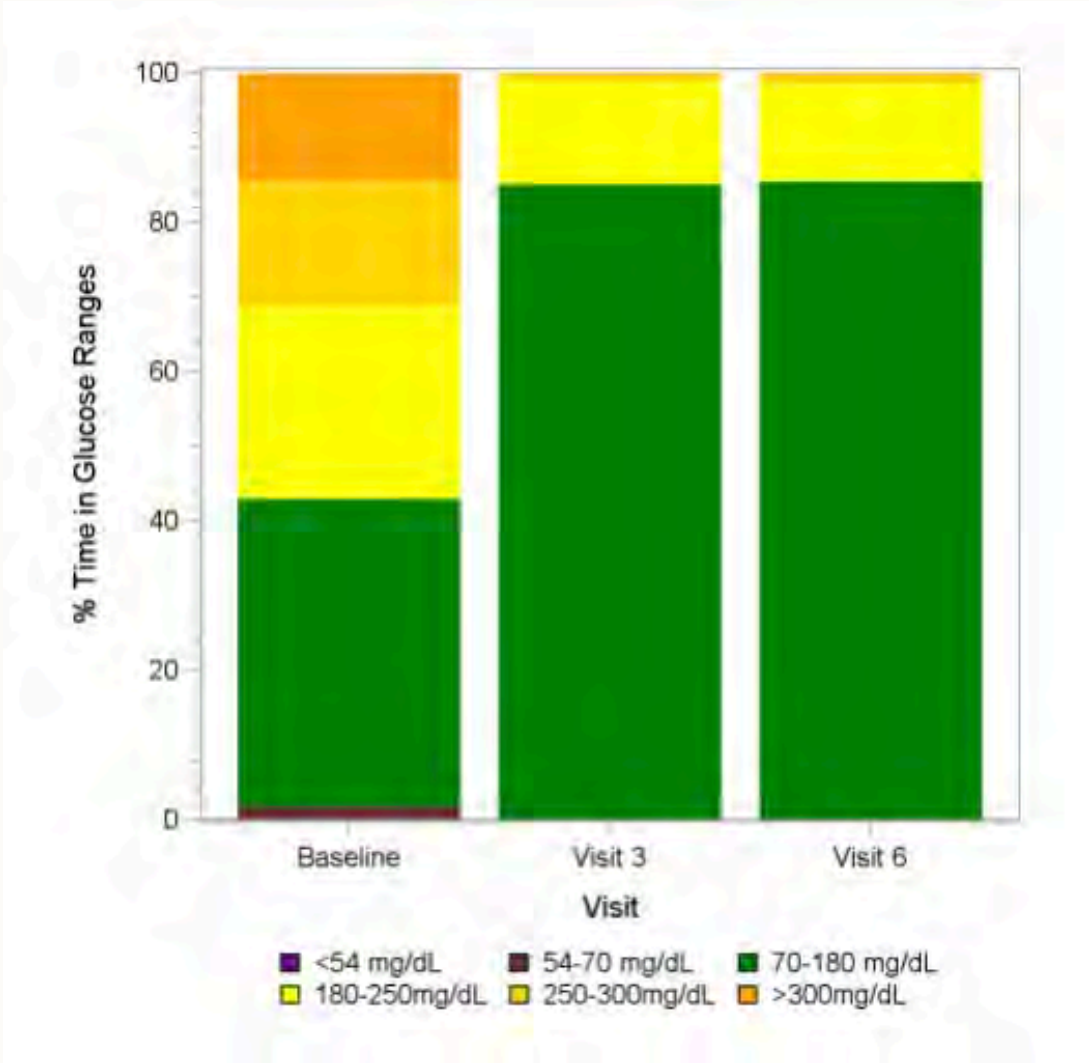


HbA1c 9.6%
TIR 41%

HbA1c 6.9%
TIR 85%

After Eight Months of rtCGM

- By eight months she had further reduced her insulin dose to 10 units morning, 12 units at night
- Sustained improvements in dietary intake
- Time in Range 85%
- HbA1c improved
  - 9.6% at start
  - 6.9% at 4 months
  - 6.5% at 8 months
  - 6.6% at 12 months
- Weight reduced 96 to 87kg



Access to Technology

Non-Intensive Insulin Therapy

Access to Technology

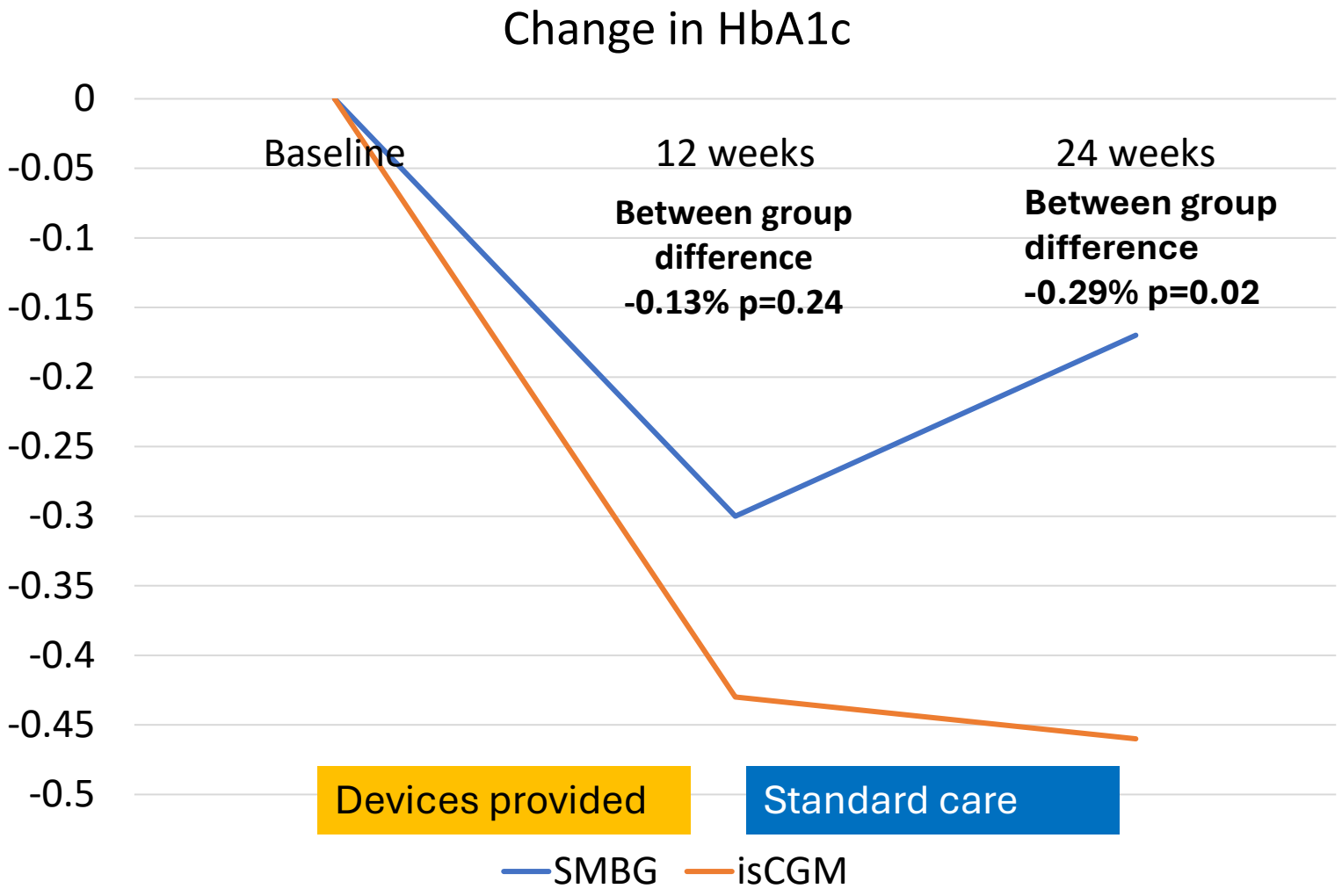
Can you currently access funding for rtCGM for all your patients with T2DM who are on non intensive insulin therapy (basal only)?

1) Yes
2) Yes, but only if they have insurance
3) No

CGM in Type 2 Diabetes

Non-Insulin Therapy

Wada et al




Open access Original research

BMJ Open Diabetes Research & Care

Flash glucose monitoring helps achieve better glycemic control than conventional self-monitoring of blood glucose in non-insulin-treated type 2 diabetes: a randomized controlled trial

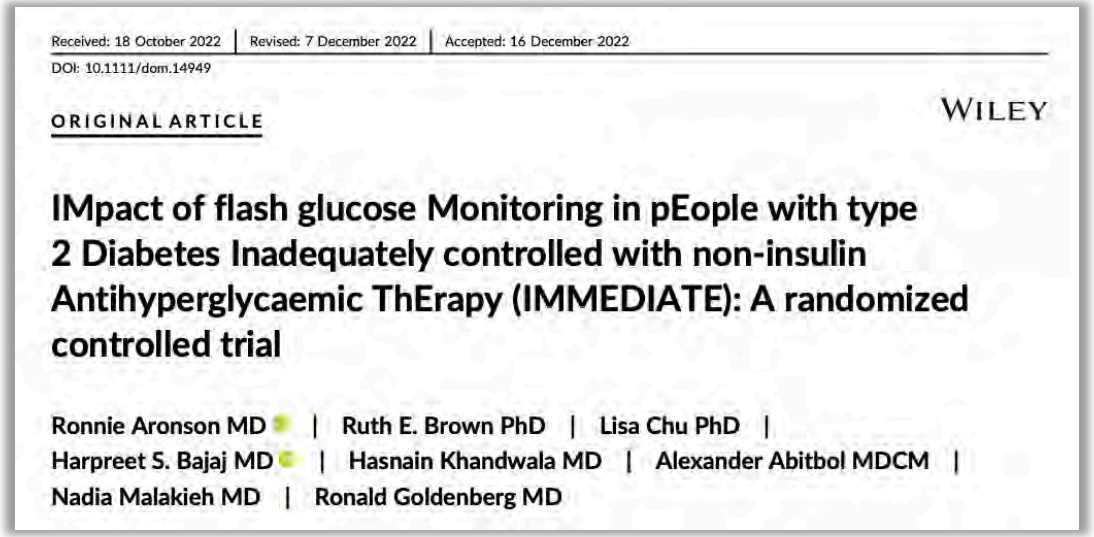
Eri Wada,[1] Takeshi Onoue ,[1] Tomoko Kobayashi,[1] Tomoko Handa,[1] Ayaka Hayase,[1] Masaaki Ito,[1] Mariko Furukawa,[1] Takayuki Okuji,[1] Norio Okada,[1] Shintaro Iwama,[1] Mariko Sugiyama,[1] Taku Tsunekawa,[1] Hiroshi Takagi,[1] Daisuke Hagiwara,[1] Yoshihiro Ito,[1,2] Hidetaka Suga,[1] Ryoichi Banno,[1,3] Yachiyo Kuwatsuka,[4] Masahiko Ando,[4] Motomitsu Goto,[1] Hiroshi Arima[1]

- RCT **non-insulin- treated** T2DM
- HbA1c 7.5-8.5% in Japan
- Randomised to isCGM or SMBG for 12 weeks
- Primary outcome HbA1c
- Significant improvements with isCGM:
  - ↑ Diabetes Treatment Satisfaction
  - ↓ Mean glucose
- No difference in hypoglycaemia

Wada et al, BMJ Diab Res Care 2020; 8:e001115

IMMEDIATE Study

- Multi-site RCT (n=116)
- HbA1c of >7.5% on **non-insulin therapy**
- Follow-up 16 weeks, 1:1 Randomisation
- isCGM (Libre) + diabetes education vs diabetes education alone
- Primary outcome: Time in range



Received: 18 October 2022 | Revised: 7 December 2022 | Accepted: 16 December 2022
DOI: 10.1111/dom.14949

ORIGINAL ARTICLE

WILEY

IMpact of flash glucose Monitoring in pEople with type 2 Diabetes Inadequately controlled with non-insulin Antihyperglycaemic ThErapy (IMMEDIATE): A randomized controlled trial

Ronnie Aronson MD | Ruth E. Brown PhD | Lisa Chu PhD | Harpreet S. Bajaj MD | Hasnain Khandwala MD | Alexander Abitbol MDCM | Nadia Malakieh MD | Ronald Goldenberg MD

Aronson R et. al. Diabetes Obes Metab 2023 Apr;25(4):1024-1031

IMMEDIATE: Key Outcomes

TABLE 2 CGM metrics between the isCGM + DSME and the DSME arms at follow-up

	isCGM + DSME	DSME	Adjusted mean difference (95% CI)	Adjusted *P* value
n	51	48		
% TIR (3.9-10.0 mmol/L)	76.3 ± 17.4	65.6 ± 22.6	−9.9 (−17.3 to −2.5)	**.009**
% time in the tight glycaemic range (3.9-7.8 mmol/L)	50.3 ± 21.9	40.4 ± 23.1	−8.5 (−16.6 to −0.3)	**.042**
% TAR (> 10.0 mmol/L)	21.2 ± 18.1	30.7 ± 24.5	8.1 (0.5 to 15.7)	**.037**
% TBR (< 3.9 mmol/L)	1.9 ± 3.5	3.0 ± 6.5	1.3 (−0.8 to 3.3)	.218
% TBR level 2 (< 3.0 mmol/L)	0.6 ± 2.3	0.9 ± 3.1	0.3 (−0.8 to 1.4)	.553

- Adjusted mean difference for follow-up HbA1c -0.3% lower (P = 0.048) in isCGM
- Glucose monitoring satisfaction survey higher (P<0.01)

- Non-insulin antihyperglycaemic therapies were added among less than 10% of participants in each arm over the trial follow-up period
  - Improvement in glycaemia more to do with life-style change?

Aronson R et. al. Diabetes Obes Metab 2023 Apr;25(4):1024-103

CGM with Remote Support

Can CGM with **remote telemonitoring-enabled virtual diabetes educator** visits improve glycaemic management in adults with T2DM, not on insulin?

- 6-week RCT of CGM with telemonitoring vs. usual care
- Both groups received educator support

- **CGM 0.65 % greater HbA1c reduction at 12 weeks p = 0.008**

- CGM participants
  - Lost more weight (difference in weight reduction 2.17 kg p = 0.029)
  - More satisfied with their treatment

Take home: CGM with remote support is superior

Lau et al. DRCP 2024

Access to Technology

Non-Insulin Therapy

Access to Technology

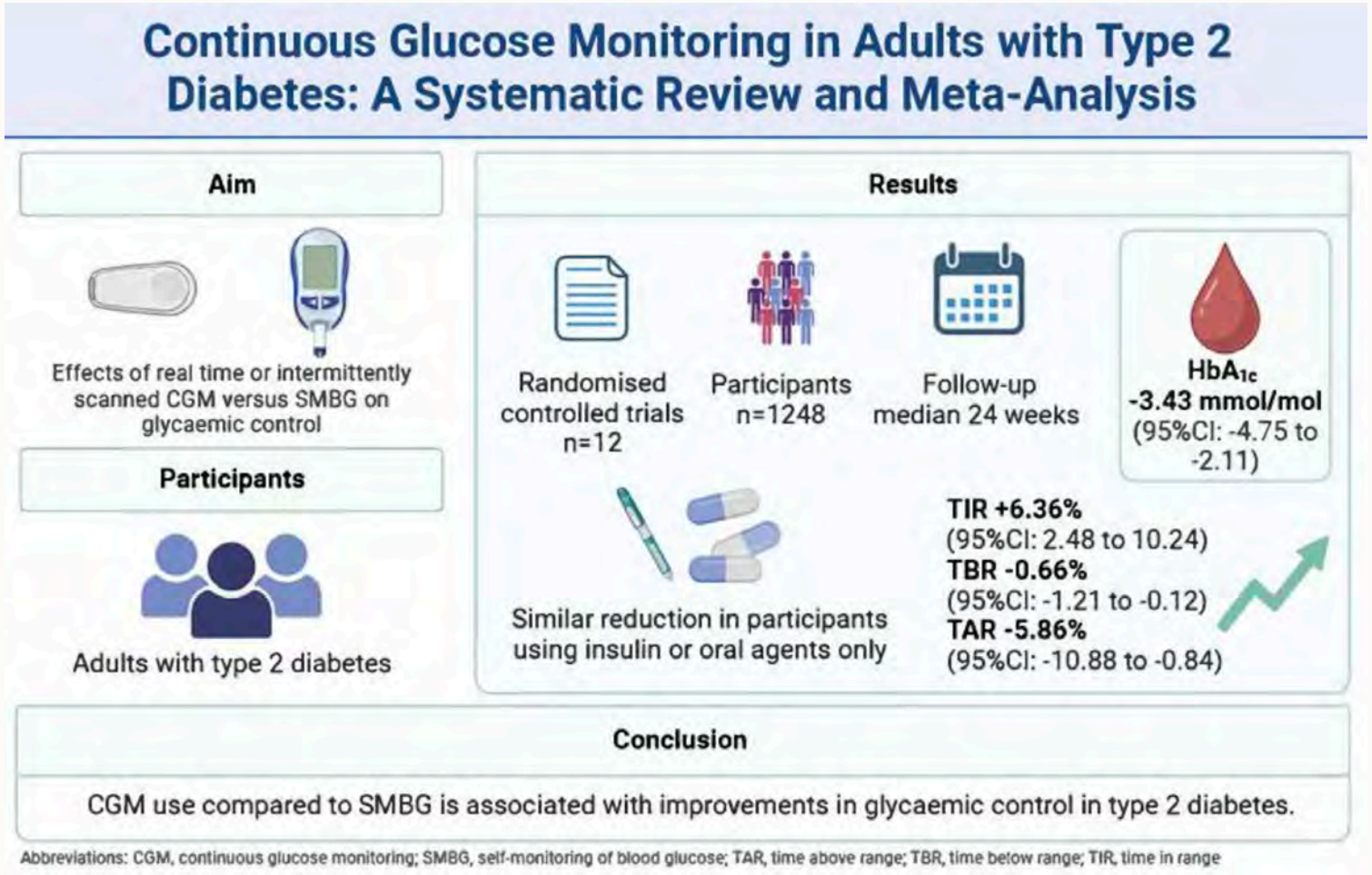
Can you currently access funding for rtCGM for all your patients with T2DM who are on non-insulin therapy?

1) Yes
2) Yes, but only if they have insurance
3) No

CGM in Type 2 Diabetes

In Summary

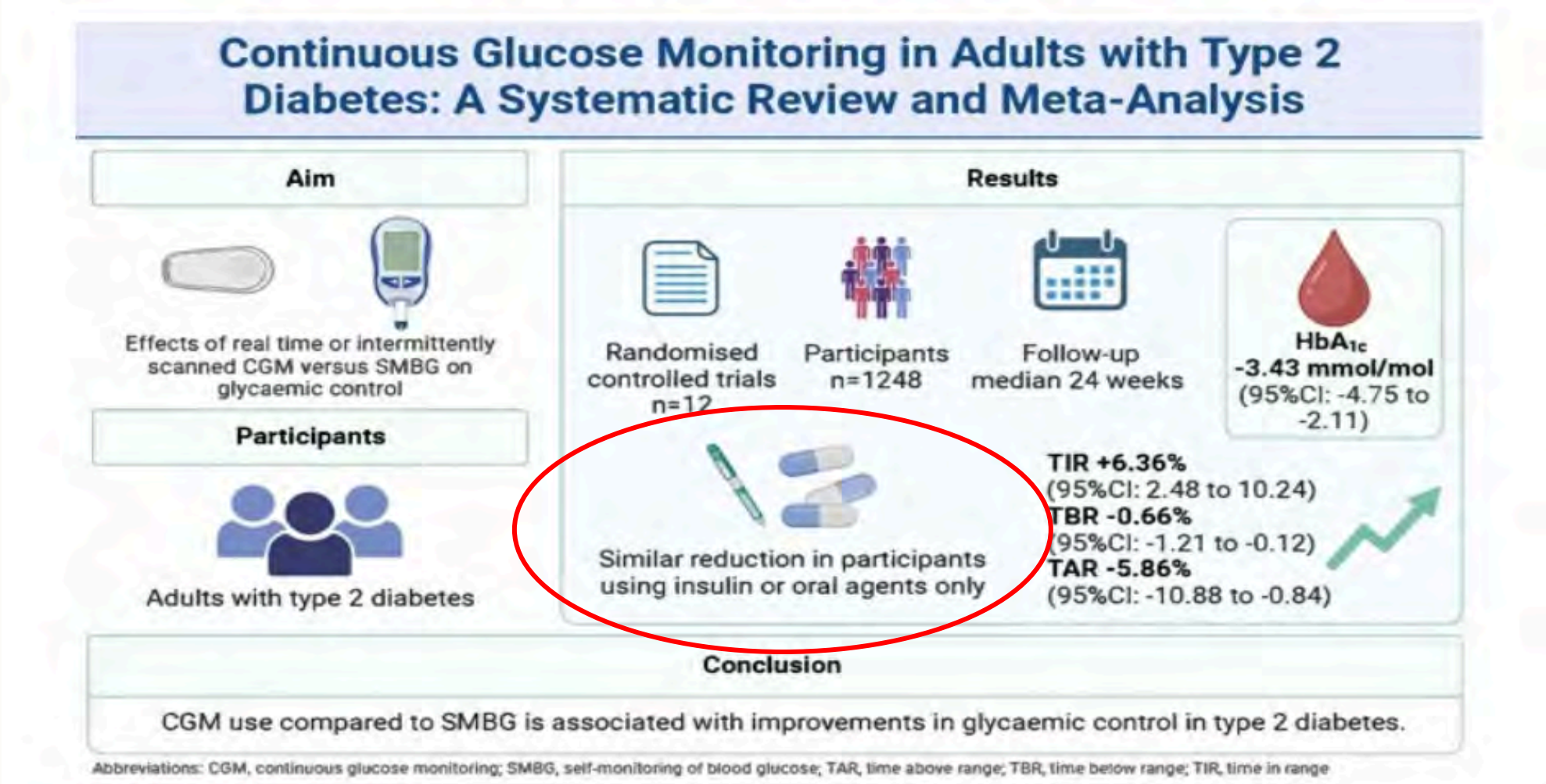
CGM Systematic Review



Excluded studies with pregnant women or individuals with type 1 diabetes, studies that investigated GlucoWatch or a professional CGM device or an intervention that consisted of CGM combined with an additional glucose-lowering treatment strategy

Jancev et al. Diabetologia 2024 Feb 16. doi: 10.1007/s00125-024-06107-6.

CGM Systematic Review



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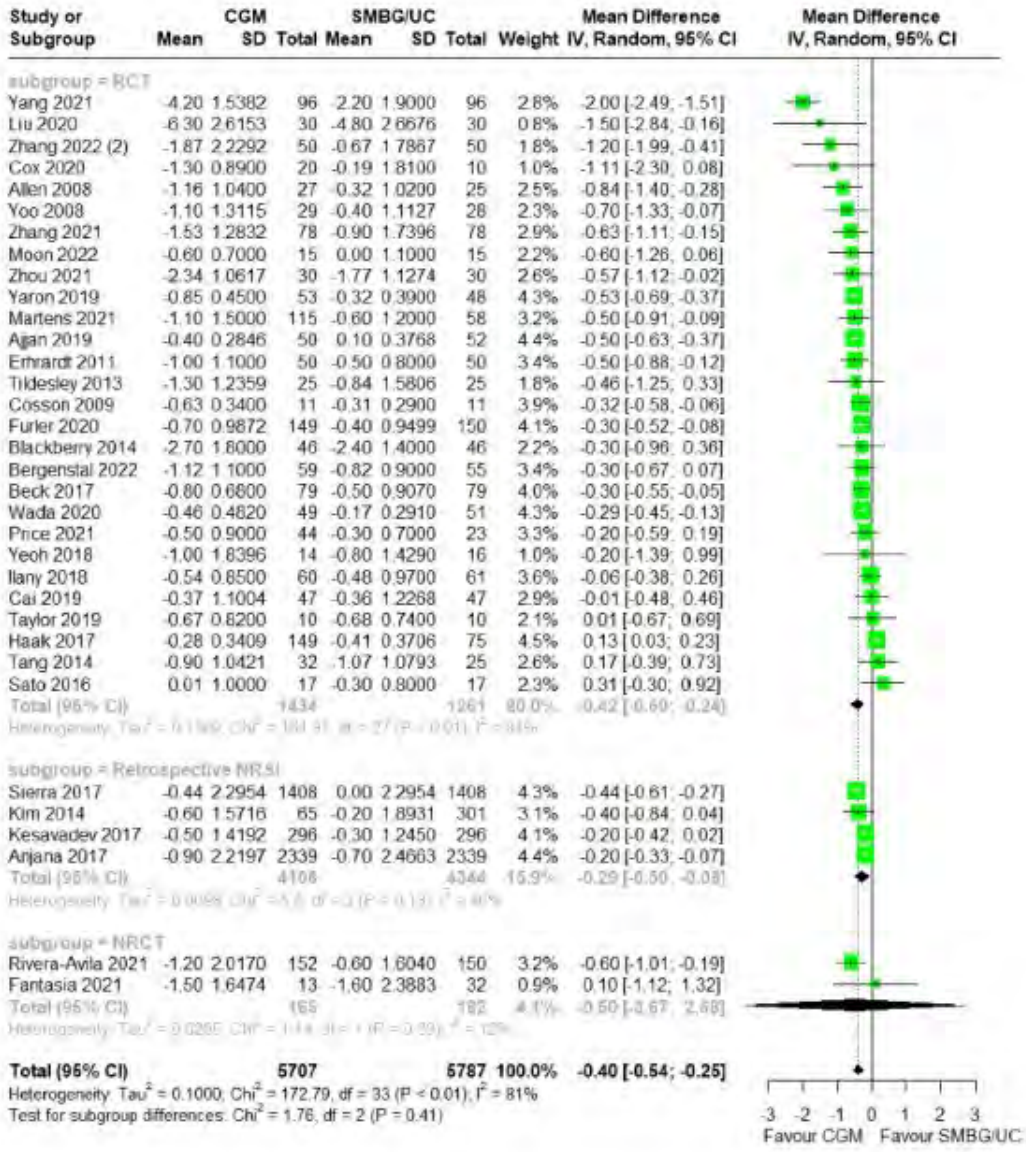
Jancev et al. Diabetologia 2024 Feb 16. doi: 10.1007/s00125-024-06107-6.

Umbrella Review

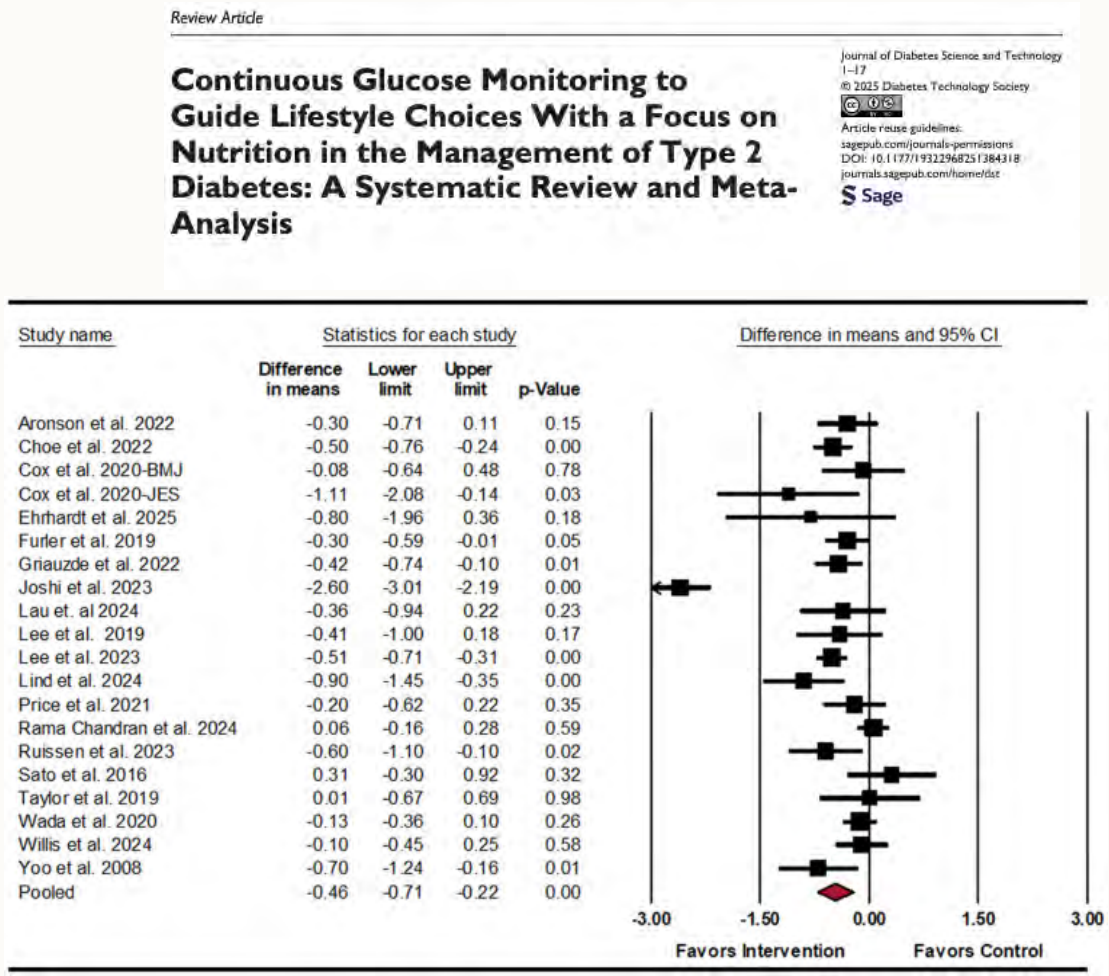
- CGM was associated with
  - **HbA1c decrease** (MD = -0.40% [95% CI: -0.54 to -0.25]),
  - **TIR increase** (MD = 6.00% [95%CI: 3.13 to 8.88])
  - **TAR decrease** (MD = -4.33% [95%CI: -8.37 to -0.28])
- Findings invariant with CGM modality, study funding, **pre-existing insulin treatment**, risk-of-bias.
- Conclusion: CGM could lead to better clinical outcomes than SMBG/UC and was of moderate evidence certainty (GRADE)
- "We recommend the introduction of CGM into standard care alongside SMBG for T2DM"



Tan YY, et al. Arch Public Health. 2024 Dec 2;82(1):231.

Focus on Nutrition

- Systematic review and meta-analysis examined the role of CGM in guiding lifestyle choices with a focus on nutrition in the management of T2D
- CGM intervention vs control:
  - 0.46% (95% CI: –0.71, –0.22) greater reduction in HbA1c
  - 2.06 kg (95% CI: –3.74, –0.38) greater reduction in body weight (or approximately 2.5% reduction)



Review Article

Continuous Glucose Monitoring to Guide Lifestyle Choices With a Focus on Nutrition in the Management of Type 2 Diabetes: A Systematic Review and Meta-Analysis

Journal of Diabetes Science and Technology
1–17

DOI: 10.1177/19322968251384318
journals.sagepub.com/home/dst
Sage

Study name	Difference in means	Lower limit	Upper limit	p-Value
Aronson et al. 2022	-0.30	-0.71	0.11	0.15
Choe et al. 2022	-0.50	-0.76	-0.24	0.00
Cox et al. 2020-BMJ	-0.08	-0.64	0.48	0.78
Cox et al. 2020-JES	-1.11	-2.08	-0.14	0.03
Ehrhardt et al. 2025	-0.80	-1.96	0.36	0.18
Furler et al. 2019	-0.30	-0.59	-0.01	0.05
Griauzde et al. 2022	-0.42	-0.74	-0.10	0.01
Joshi et al. 2023	-2.60	-3.01	-2.19	0.00
Lau et. al 2024	-0.36	-0.94	0.22	0.23
Lee et al. 2019	-0.41	-1.00	0.18	0.17
Lee et al. 2023	-0.51	-0.71	-0.31	0.00
Lind et al. 2024	-0.90	-1.45	-0.35	0.00
Price et al. 2021	-0.20	-0.62	0.22	0.35
Rama Chandran et al. 2024	0.06	-0.16	0.28	0.59
Ruissen et al. 2023	-0.60	-1.10	-0.10	0.02
Sato et al. 2016	0.31	-0.30	0.92	0.32
Taylor et al. 2019	0.01	-0.67	0.69	0.98
Wada et al. 2020	-0.13	-0.36	0.10	0.26
Willis et al. 2024	-0.10	-0.45	0.25	0.58
Yoo et al. 2008	-0.70	-1.24	-0.16	0.01
Pooled	-0.46	-0.71	-0.22	0.00

Bannuru RR, et al. J Diabetes Sci Technol. 2025 Oct 18:19322968251384318..

CGM in Type 2 Diabetes
What's Next?

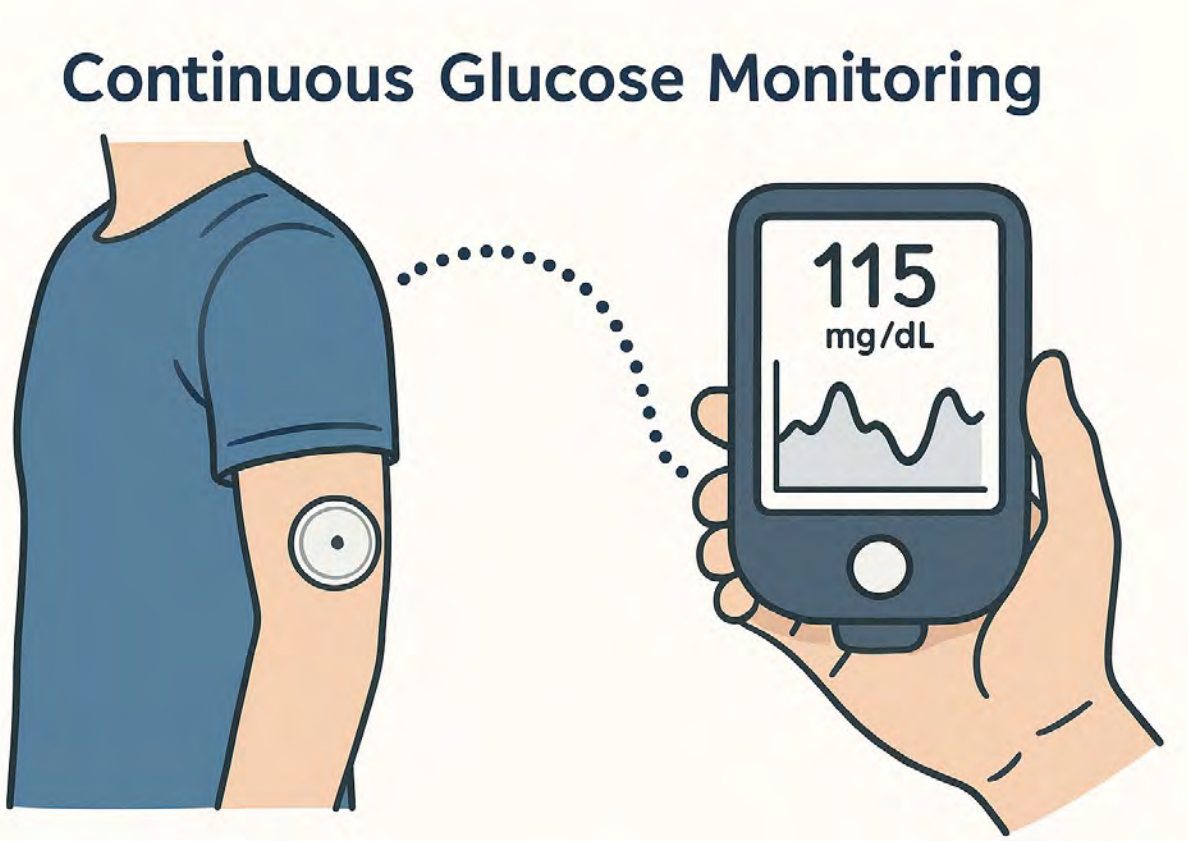
BMJ Open

Visit this Journal BMJ

BMJ Open. 2025 Apr 15;15(4):e090154. doi: 10.1136/bmjopen-2024-090154

Impact of real-time glucose monitoring using FreeStyle Libre 3 on glycaemia in type 2 diabetes managed with basal insulin plus SGLT2 inhibitor and/or GLP-1 agonist: the FreeDM2 randomised controlled trial protocol

Emma G Wilmot [1,2], Ramzi A Ajjan [3,4], Yee S Cheah [5], Pratik Choudhary [6], Iain Cranston [7], Rachel Ann Elliott [8], Mark Evans [9,10], Ahmed Iqbal [11,12], Shafie Kamaruddin [13], Katharine Barnard-Kelly [14], Alistair Lumb [15,16], Thinzar Min [17], Patrick Moore [18], Parth Narendran [19], Sankalpa Neupane [20,21], Gerry Rayman [22], Thozhukat Sathyapalan [23,24], Hood Thabit [25,26], Thomas Yates [27,28], Lalantha Leelarathna [26,29,✉]



Wilmot et al. BMJ Open 2025

FreeDM2 Study Aims

- Individuals treated with basal insulin, SGLT2i and GIP/GLP-1 therapy represent an **increasingly significant proportion** of those living with **T2DM.**
- Despite combination therapy, many **do not** achieve **glycaemic targets**.
- There is a **lack** of high quality RCT evidence supporting the use of **CGM** in people with T2DM treated with the combination of **basal insulin** with **GIP/GLP-1 or SGLT2i** therapy.
- Our **understanding** of **behavioral changes** associated with CGM use are limited

Aim:
To determine whether the FreeStyle Libre 3 CGM system improves HbA1c over 16-weeks compared to SMBG in adults with suboptimal glycaemia

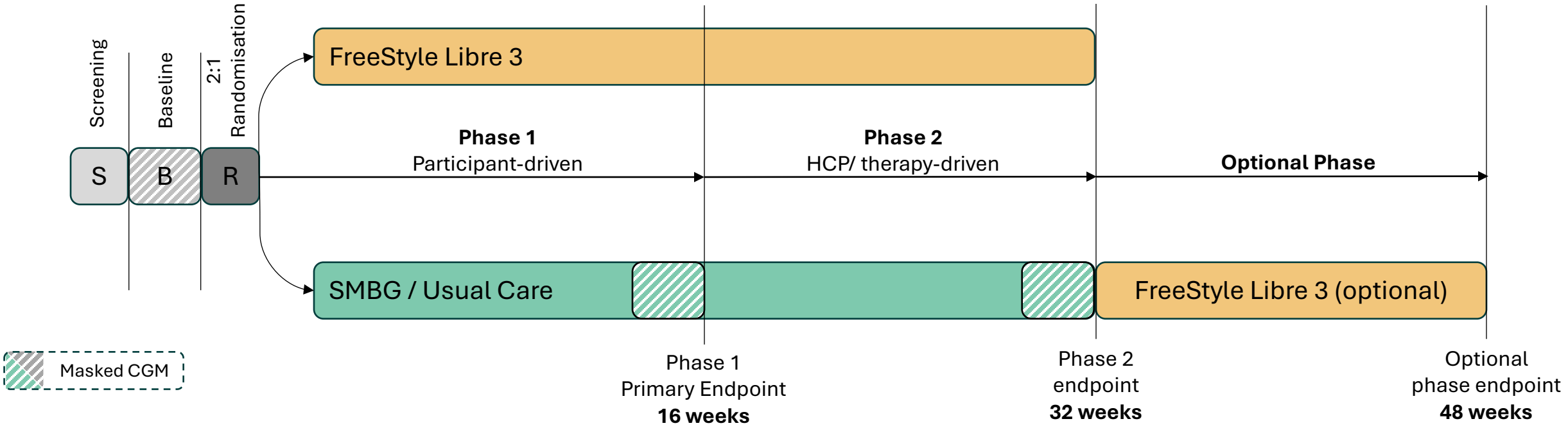
Wilmot et al. BMJ Open 2025

Study Design

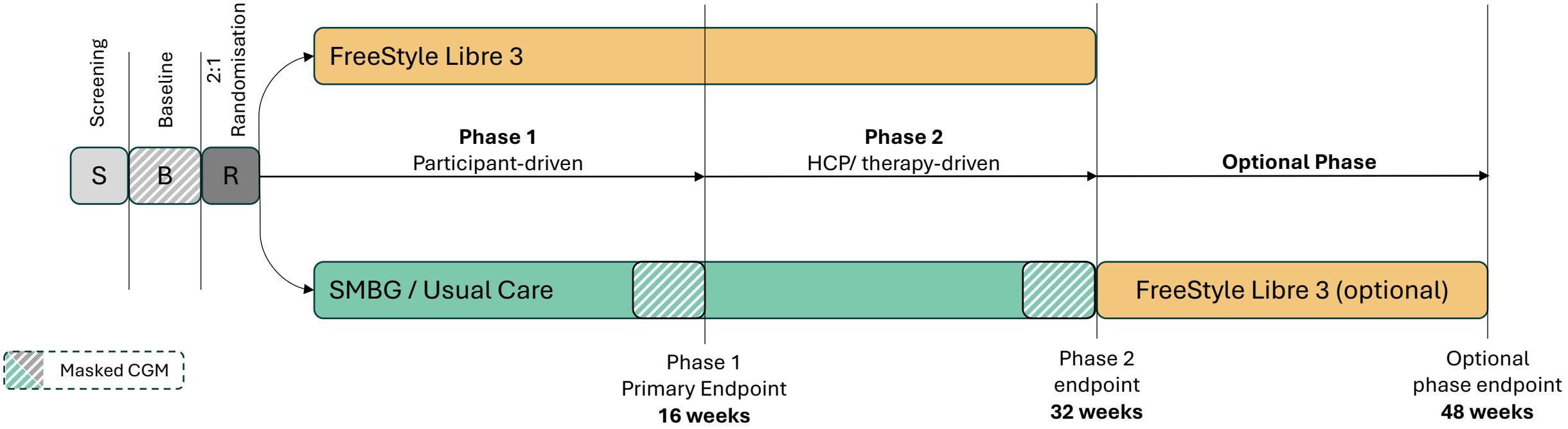
UK study: recruitment from 24 secondary & primary care centres & nationally via self-referral.

Key inclusion criteria

- Adults with T2DM
- Basal-only insulin plus SGLT2i and/or GLP-1 dual GIP/GLP-1-RA
- HbA1c ≥59 and ≤97 mmol/mol (≥7.5 and ≤11.0%)



Analysis Endpoints



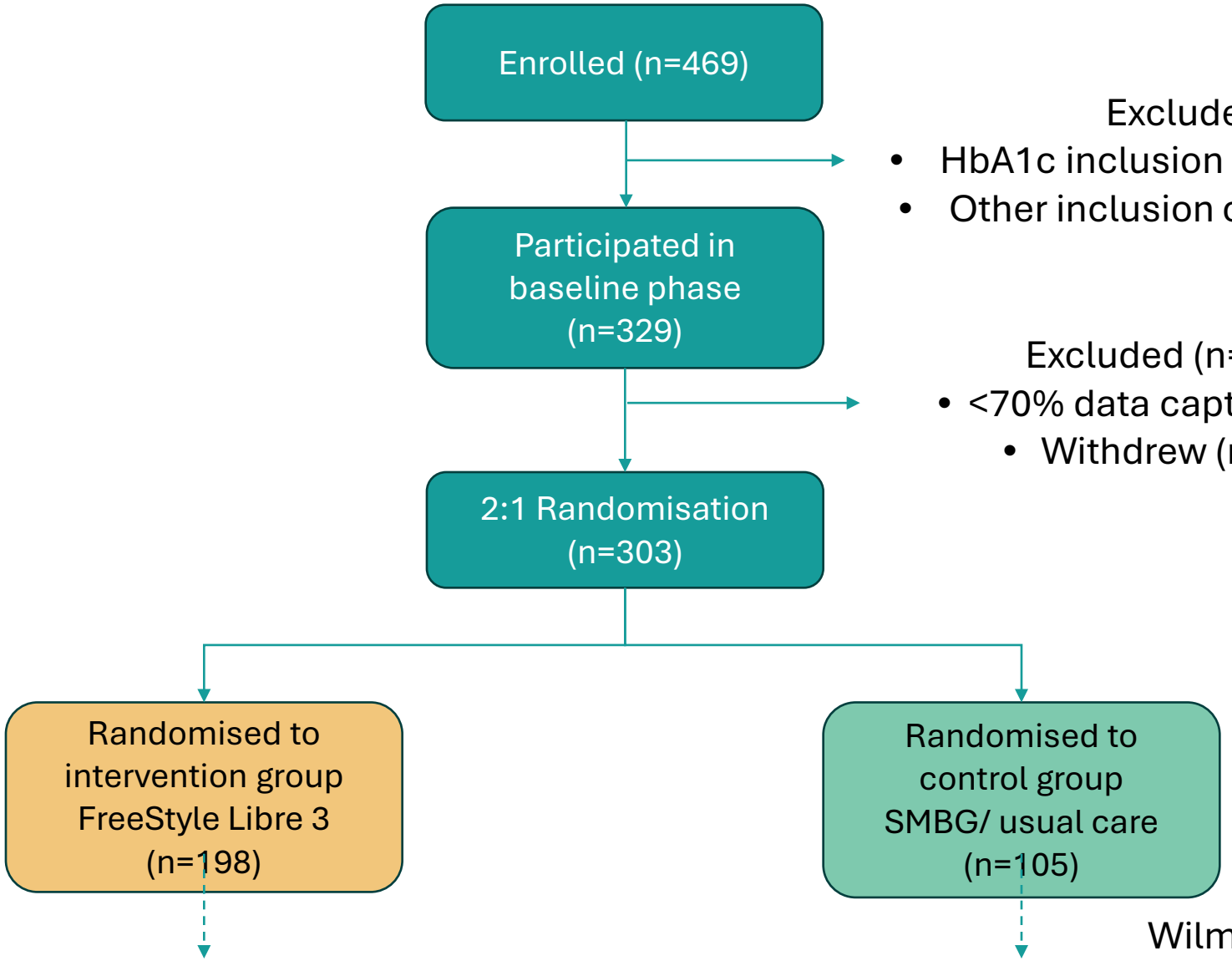
Primary endpoint

- Between group difference in HbA1c change at 16 weeks

Secondary endpoints

- Between group difference in HbA1c change at 32 weeks
- Weight and blood pressure
- Accelerometer data
- PROMs (including EQ-5D-5L, GMSS, UKDDQ, HCS, HFS-II) and qualitative interviews.
- CGM metrics
- Changes to insulin doses and non-insulin medications
- Safety

Participant Flow Diagram



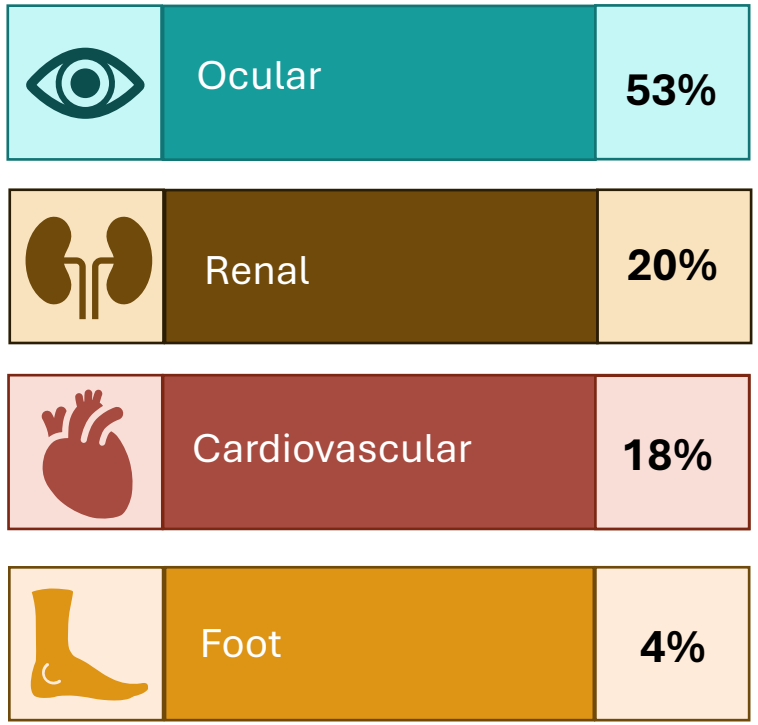
Wilmot et al. EASD 2025

Baseline Data
Demographics and Medical History

Demographic	All (n=303)	FSL3 Intervention (n=198)	SMBG/ Usual Care (n=105)
Age, years	60.7 ± 9.8	61.2 ± 10.2	59.8 ± 9.1
Male sex, %	67.3	66.7	68.6
BMI, kg/m^2	31.2 ± 5.6	31.1 ± 5.6	31.3 ± 5.7
Diabetes duration, years	16.7 ± 6.9	17.1 ± 6.6	15.9 ± 7.4

mean± SD unless stated otherwise

Diabetes related complications at baseline

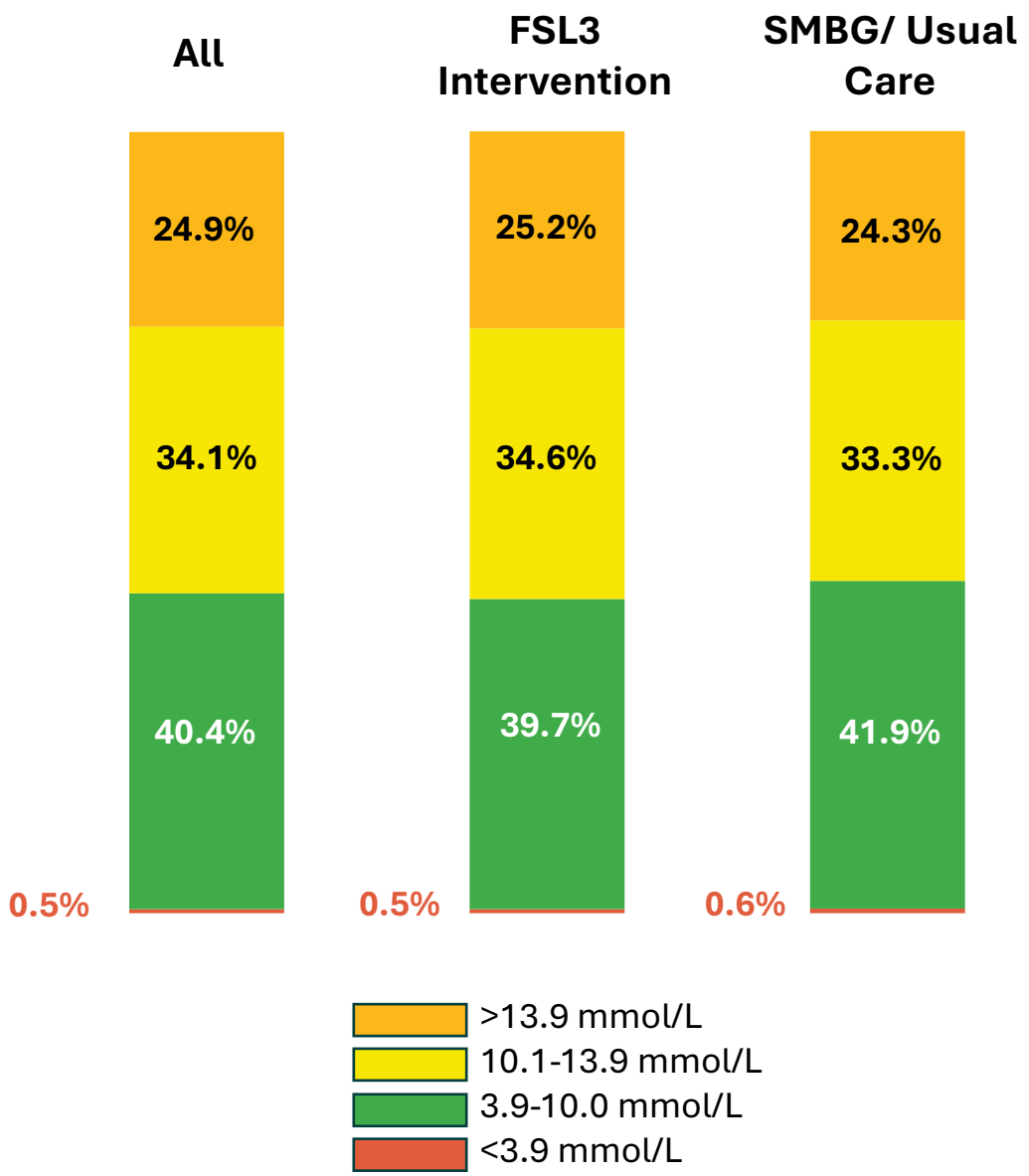


Wilmot et al. EASD 2025

Baseline Data
Glycaemia

Parameter	All (n=303)	FSL3 Intervention (n=198)	SMBG/ Usual Care (n=105)
HbA1c, mmol/mol	73 ± 11	73 ± 11	73 ± 11
HbA1c, %	8.8 ± 1.0	8.8 ± 1.0	8.8 ± 1.1
Mean daily fingerstick frequency	2.0 ± 1.9	1.9 ± 1.8	2.1 ± 2.0

mean± SD unless stated otherwise



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FreeDM2 RCT

- FreeDM2 will provide information on the **efficacy** of the FreeStyle Libre 3 system on glycaemic outcomes in adults with T2DM with suboptimal HbA1c levels despite basal insulin plus SGLT2i and/or incretin therapy.

- The **two-phase design** will provide insight into the impact of
  - **Patient-driven insulin titration**
  - **Therapy escalation**

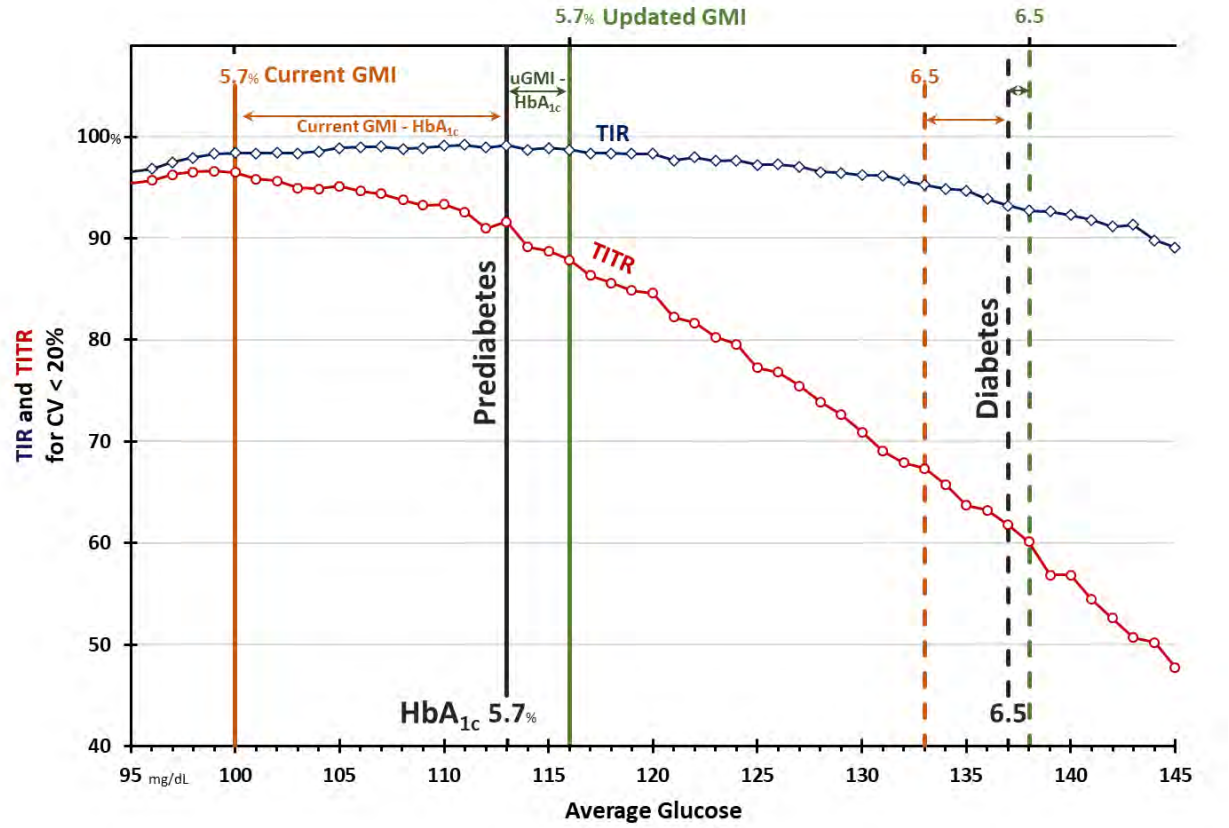
Wilmot et al. EASD 2025

ATTD 2026 Late-Breaking Abstracts

Screening for and Prevention of Type 2 Diabetes

CURRENT GMI CAN OVER DIAGNOSE PREDIABETES WITH UPDATED GMI AND TITR MITIGATTING THIS RISK

Session Name 0740 - ORAL PRESENTATIONS 04: SCREENING, PREVENTION AND CURE OF DIABETES (ID 37)
Session Type ORAL PRESENTATIONS SESSION
Date Fri, 13.03.2026
Session Time 09:30 - 10:30
Room Hall 212
Presenter Ramzi Ajjan (United Kingdom)
Lecture Time 10:00 - 10:10



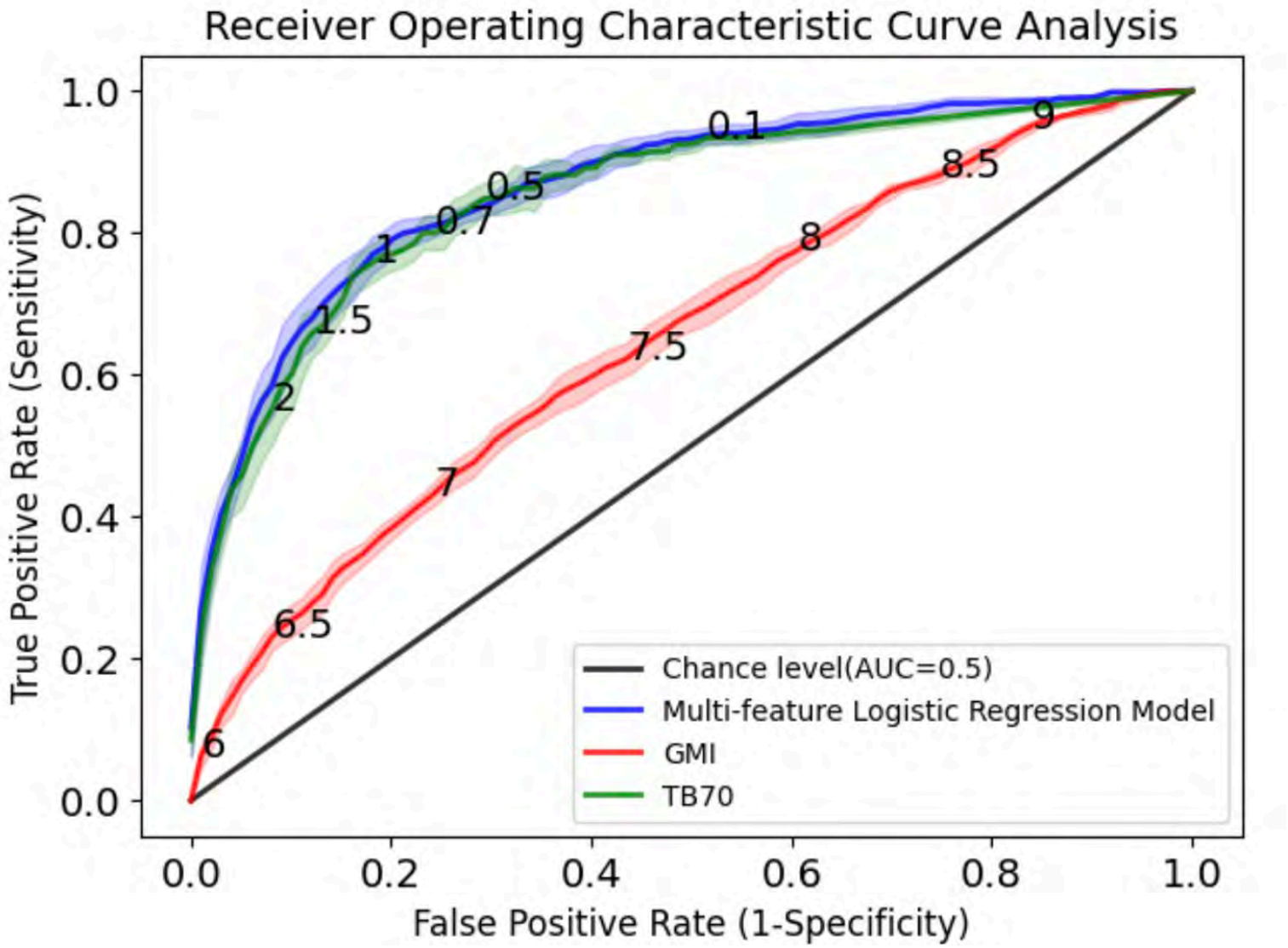
Updated GMI (uGMI) and time in tight range (TITR) are more sensitive to HbA1c cut off values for the diagnosis of prediabetes.

Current GMI can over diagnose prediabetes and should be replaced with **updated GMI, which aligns more closely with HbA1c**.

Similarly, TITR should replace TIR as a measure of normoglycaemia and prediabetes.

Ajjan R. ATTD 2026

Data-Driven Identification of Patients Requiring Insulin Reduction Using Continuous Glucose Monitoring Prior to GLP-1 RA Initiation



CGM data before GLP-RA initiation helps identify patients likely to experience hypoglycemia post-initiation, enabling preemptive insulin reduction.

Pai A, et al. ATTD 2026

Budget Impact Analysis of Freestyle Libre Systems for People with T2D on Basal Insulin

- Reimbursement of FSL in most European countries remains restricted to people T1D and T2D on intensively managed insulin regimens.
- This study estimated the budget impact of expanding FSL access to people with T2D on basal insulin only (T2B) from a European payer perspective.
- **Results:** Expanding reimbursement of FSL to the T2B population resulted in **a net cost savings of €444** per patient per year.
- At a cohort level, this translated to a **net annual cost savings of €443,803** for the payer. OWSA identified the baseline rate of hospitalization and cost of all-cause healthcare resource utilization as key model drivers.

Conclusion

This budget impact analysis showed **the acquisition cost of FSL is offset by HCRU reduction in the T2B population.**

As such, reimbursement expansion of FSL in this population can result in significant net cost savings to European health systems.

Jendle J, et al. ATTD 2026

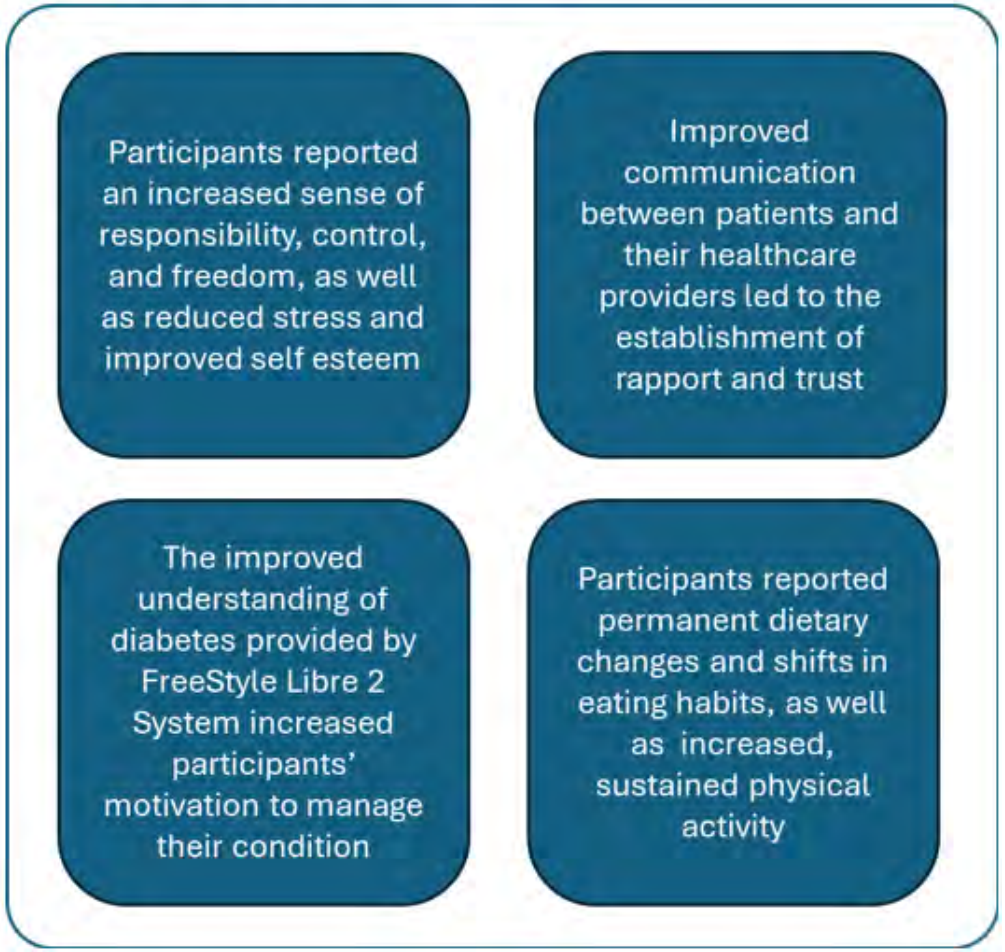
Experiences of Diabetes Management With Freestyle Libre 2

A Focus Group Study Among People Living With Type 2 Diabetes In Quebec

- A focus group of 16 adults with T2DM living in Quebec and using FSL2

- Focus group participants found that **FSL2 improved their diabetes self-management, communication with healthcare providers, stress levels, and facilitated short- and long-term lifestyle changes.**

Figure 2. Key insights



Yale JF, et al. ATTD 2026

Conclusion

- Undisputed benefits of CGM in people with T1DM
- Evidence so far suggest CGM is beneficial in Type 2 diabetes
- Benefits in some groups may be more to do with lifestyle modification?
- FreeDM2 RCT results will be presented on Thursday

CGM for Transforming Clinical Outcomes in Non-Intensive T2D Therapy

Thank You