ABCD DTN-UK Educators Day, London 2025

The Growing Use of Technology Among Older Adults with Diabetes: Benefits, Challenges and Future Directions

Dr Giuseppe Maltese MRCP(D&E), PhD, FRCP, FHEA
Consultant in Diabetes and Endocrinology (and Specialist in Geriatrics)
Epsom and St Helier University Hospitals

Honorary Clinical Lecturer, King's College London

Diabetes UK Clinical Champion

Epsom and St Helier University Hospitals NHS Trust

DIABETES UK
KNOW DIABETES. FIGHT DIABETES.

KING'S College LONDON

Outline of this talk

- Increasing life expectancy of people with type 1 diabetes
- Hypoglycaemia and glucose variability in older people
- Available diabetes technologies and emerging evidence on their benefits for older people
- Assessing older people for diabetes technology
- Barriers to adopting diabetes technology
- Future research directions
- Conclusions

Type 1 Diabetes in Older People Has Nearly Tripled Globally Since the '90s

— But the increase marks good news for survival, study suggests

by Kristen Monaco, Senior Staff Writer, MedPage Today
June 13, 2024

Global burden of type 1 diabetes in adults aged 65 years and older, 1990-2019: population based study

Kaijie Yang,[1] Xue Yang,[1] Chenye Jin,[2] Shuangning Ding,[1] Tingting Liu,[1] Bing Ma,[3] Hao Sun,[3] Jing Zhang,[4] Yongze Li[1]

- **Objectives -** To estimate the burden, trends, and inequalities of type 1 diabetes mellitus (T1DM) among older adults at global, regional, and national level from 1990 to 2019.
- **Design** - Population based study
- **Population**- adults aged ≥65 years from 21 regions and 204 countries and territories (Global Burden of Disease and Risk Factors Study 2019) from 1990 to 2019.
- **Primary outcomes** were T1DM related age standardised prevalence, mortality, disability adjusted life years (DALYs), and average annual percentage change.

Key findings

- Globally, between 1990 and 2019, the number of people with T1D aged ≥65 years increased from 1.3 million to 3.7 million
- The age standardised prevalence rate of T1D among this age group increased by 28%, with an average annual trend of 0.86%
- The age standardised mortality from T1D among this age group significantly decreased by 25% with an average annual trend of −1.00%
- The age standardised DALYs decreased by 8.8%, with an average annual trend of −0.33%
- Mortality fell 13 times faster in countries with a high sociodemographic index versus countries with a low-middle sociodemographic index

HbA1c targets in older adults according to current international guidelines

International guidelines (year)	Good health/Non frail/Functionally independent	Complex-intermediate health/Moderately frail/Functionally dependent	Poor Health/Severely frail/End of life
ADA (2024)	<7.0-7.5% (<53-58 mmol/mol)	<8% (<64 mmol/mol)	Avoid hypoglycaemia
Endocrine Society (2019)	<7.5% ≥7.0% and <7.5%	<8% ≥7.5% and <8.0%	<8.5% ≥8.0% and <8.5%
IDF (2013)	7.0-7.5% (53-58 mmol/mol)	7.0-8.0% (53-64 mmol/mol) Frail Up to 8.5% (69 mmol/mol) Dementia Up to 8.5% (69 mmol/mol)	Avoid hypoglycaemia

Healthy (few coexisting chronic illnesses, intact cognitive and functional status)

Complex/intermediate (multiple coexisting chronic illnesses or two or more instrumental ADL impairments or mild to moderate cognitive impairment)

Very complex/poor health (LTC or end-stage chronic illnesses‡ or moderate to severe cognitive impairment or two or more ADL impairments)

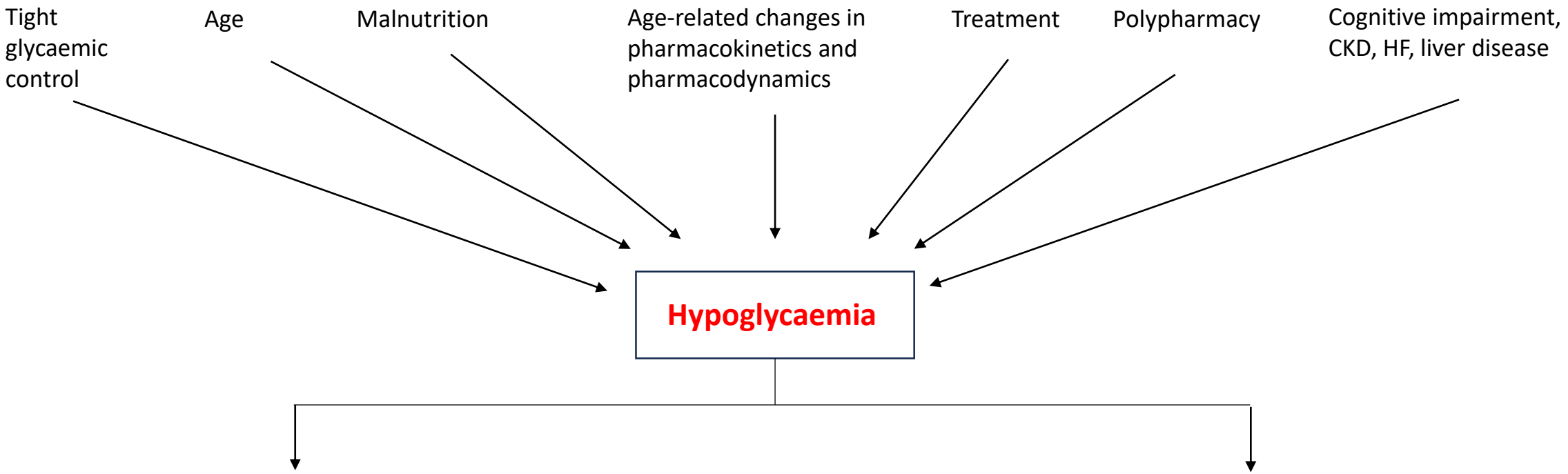
Arch Intern Med. 2011 February 28; 171(4): 362–364. doi:10.1001/archinternmed.2010.539.

Frequent hypoglycemia among elderly with poor glycemic control

Medha N. Munshi, MD[1,2,3], Alissa R. Segal, PharmD[1,4], Emmy Suhl, RD[1], Elizabeth Staum, RD[1], Laura Desrochers, BS[5], Adrianne Sternthal, BS[1], Judy Giusti, RD[1], Richard McCartney, BA[1], Yishan Lee, MS[1], Patricia Bonsignore, MS[6], and Katie Weinger, EdD[1,3]

- Forty adults aged ≥69 years with HbA1c>64 (8%) mmol/mol were evaluated with blinded CGM. Sixty-five percent (26/40 patients) had at least one episode of hypoglycaemia over the 3-day period.
- Among the 26 patients with hypoglycemia, 12 (46%) had an episode with glucose levels <2.8 mmol/L, and 19 (73%) had an episode with levels <3.3 mmol/L.
- The authors evaluated CGM results by levels of glycemic control (by A1C) and type of diabetes in 26 patients with hypoglycemia. Fourteen patients had HbA1c levels between 64-76 mmol/mol (8–9%) and 12 had HbA1c>75 mmol/mol (9%)

Hypoglycaemia in older people with diabetes



Short-term consequences

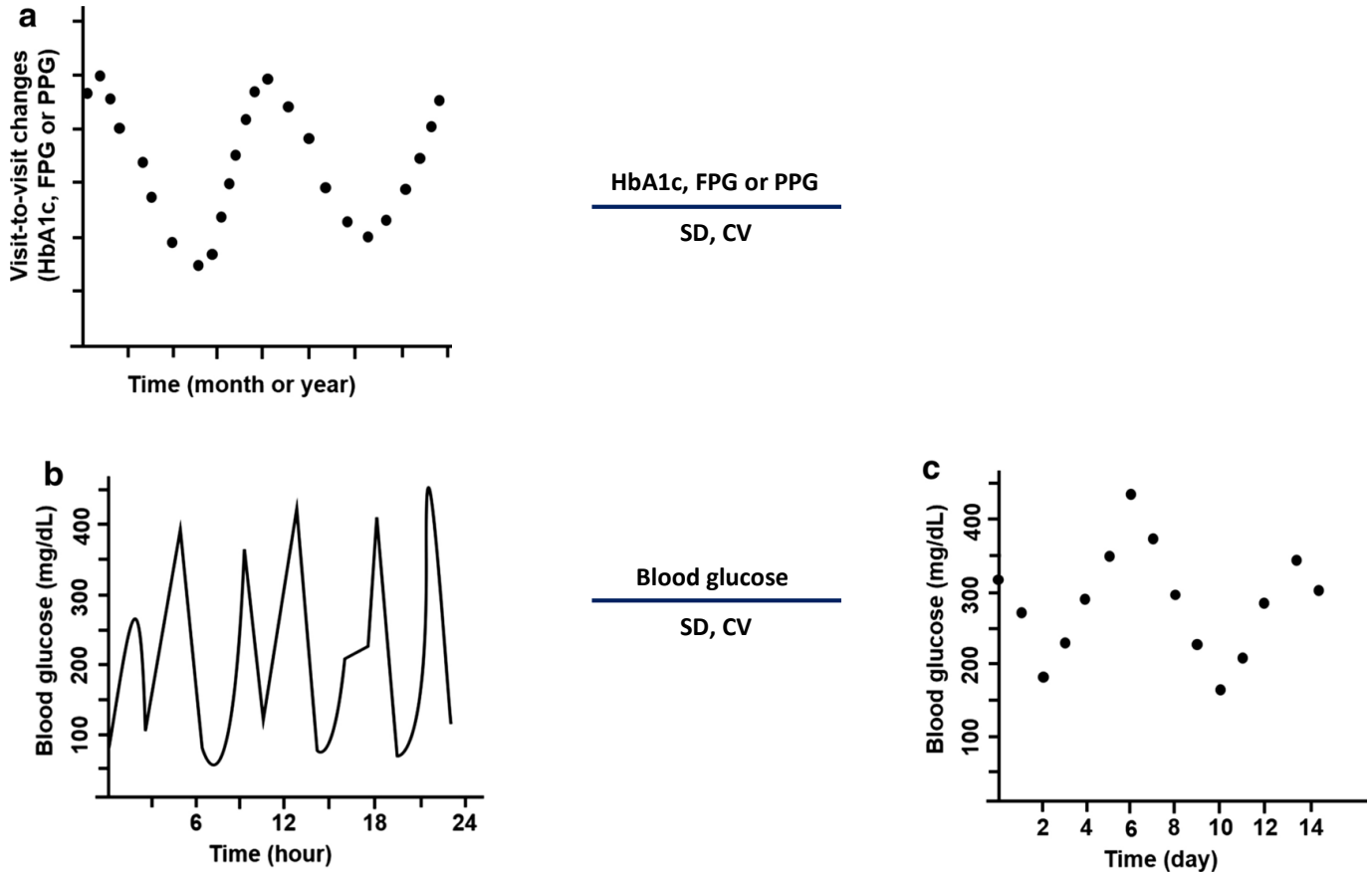
- Hyperglycaemia
- Fear of hypoglycaemia
- Falls and fractures
- Cardiac arrythmias
- ED attendance and hospital admission

Long-term consequences

- Social marginalisation
- Functional decline
- Cognitive decline
- Frailty
- Disability
- Institutionalisation

What's the glucose variability and how is it measured?

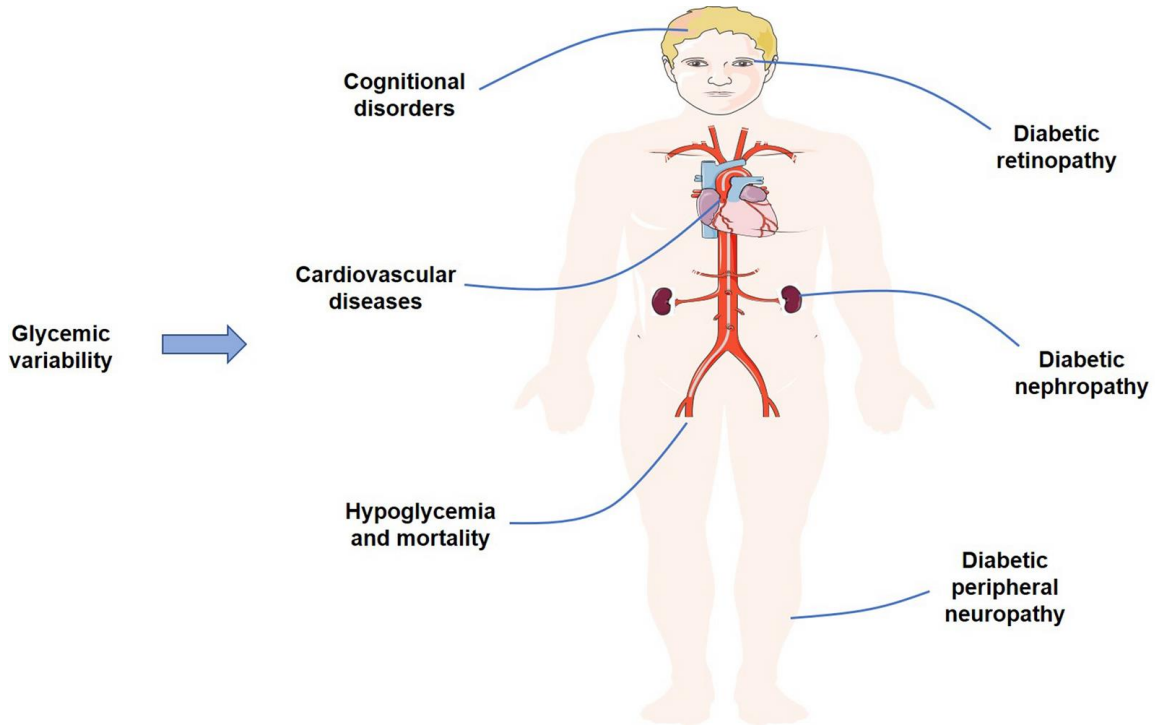
"Glucose variability, referring to oscillations in blood glucose levels, is usually defined by the measurement of fluctuations of glucose or other related parameters of glucose homoeostasis over a given interval of time"



a Long-term GV based on visit-to-visit changes of HbA1c, FPG or PPG. **b**, **c** Short-term GV represented by within-day and between-day GV

Glucose variability: why is it important?

- Fasting plasma glucose variability independently associated with all-cause mortality in older patients with type 2 diabetes (Xu et al. *Sci Rep* 2016)
- Visit-to-visit glucose variability in HbA1c and fasting glucose levels associated with an increased risk of CV events and mortality in type 2 diabetes (ADVANCE trial) (Hirakawa et al. *Diabetes Care* 2014)
- Glucose variability has been reported to be associated with poor functional outcome in patients with diabetes who have had an intracerebral haemorrhage (Wu et al. *J Neurosurg* 2017)
- Visit-to-visit variations in fasting plasma glucose concentration and HbA1c are associated with Alzheimer's disease (Taiwan Diabetes Study) (Li et al. *Diabetes Care* 2017)
- Older people, when compared to middle aged subjects, have a greater glucose variability which is associated with an increased risk of supraventricular and ventricular arrythmias (Zhang et al. *BMC Endocr Disord* 2021).



The effects of glycaemic variability on the adverse clinical outcomes

Cardiovascular Diabetology **volume 19**, Article number: 102 (2020)

13. Older Adults: Standards of Care in Diabetes—2025

*American Diabetes Association Professional Practice Committee**

Diabetes Care 2025;48(Suppl. 1):S266–S282 | https://doi.org/10.2337/dc25-S013

Hypoglycaemia - Recommendations

13.5 Recommend continuous glucose monitoring (CGM) for older adults with type 1 diabetes to improve glycemic outcomes, reduce hypoglycemia, and reduce treatment burden.

13.6 Offer CGM for older adults with type 2 diabetes on insulin therapy to improve glycemic outcomes and reduce hypoglycemia.

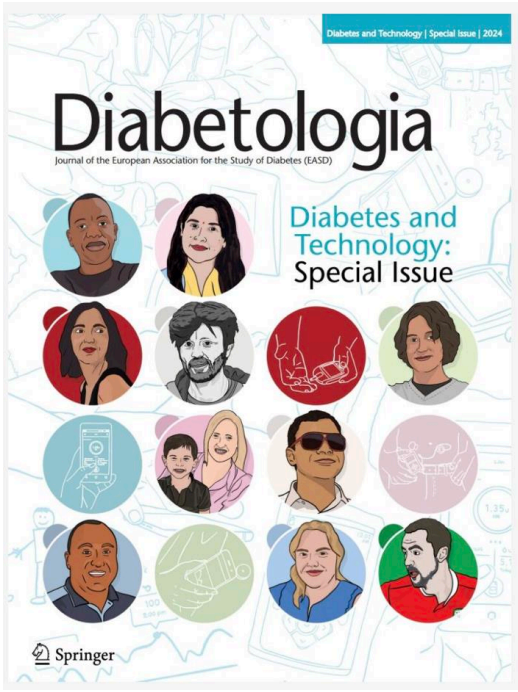
13.7 Consider the use of automated insulin delivery systems, mechanical insulin delivery systems, and other advanced insulin delivery devices such as connected pens to reduce risk of hypoglycemia for older adults, based on individual ability and support system.

Ageing well with diabetes: the role of technology

Review | Open access | Published: 13 August 2024

(2024) Cite this article

Giuseppe Maltese ✉, Sybil A. McAuley, Steven Trawley & Alan J. Sinclair

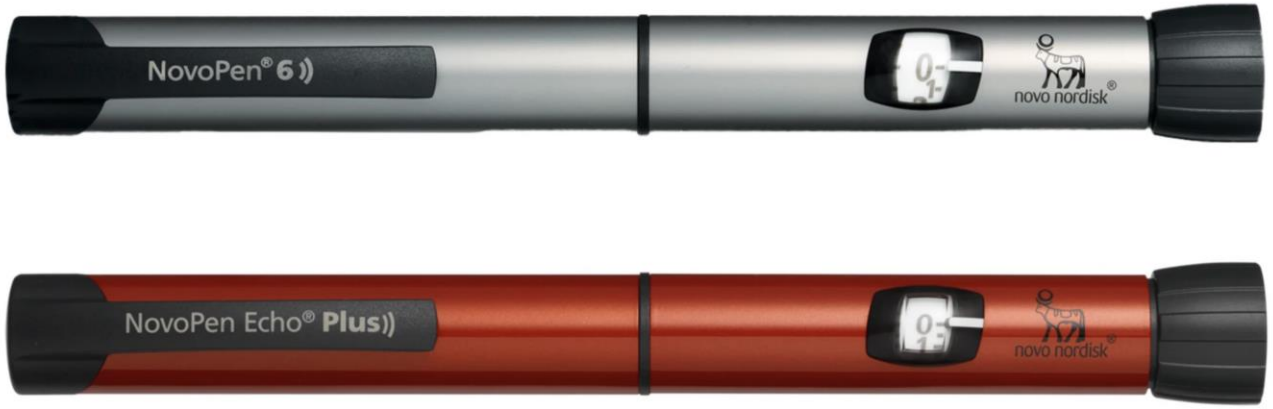


Bluetooth Connected Pens (Smart Pens)

CGM devices

Insulin pumps and automated insulin delivers systems (AID)

Bluetooth-enabled insulin pens



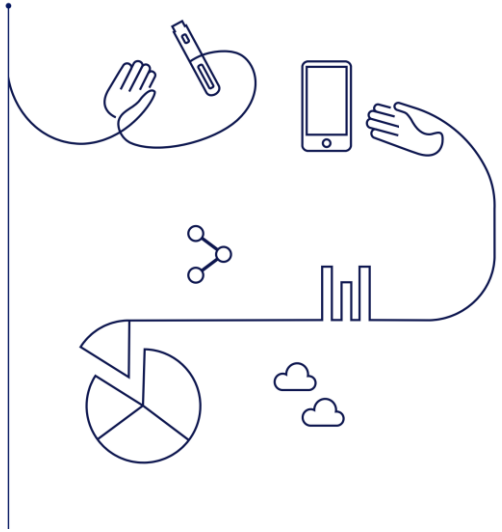


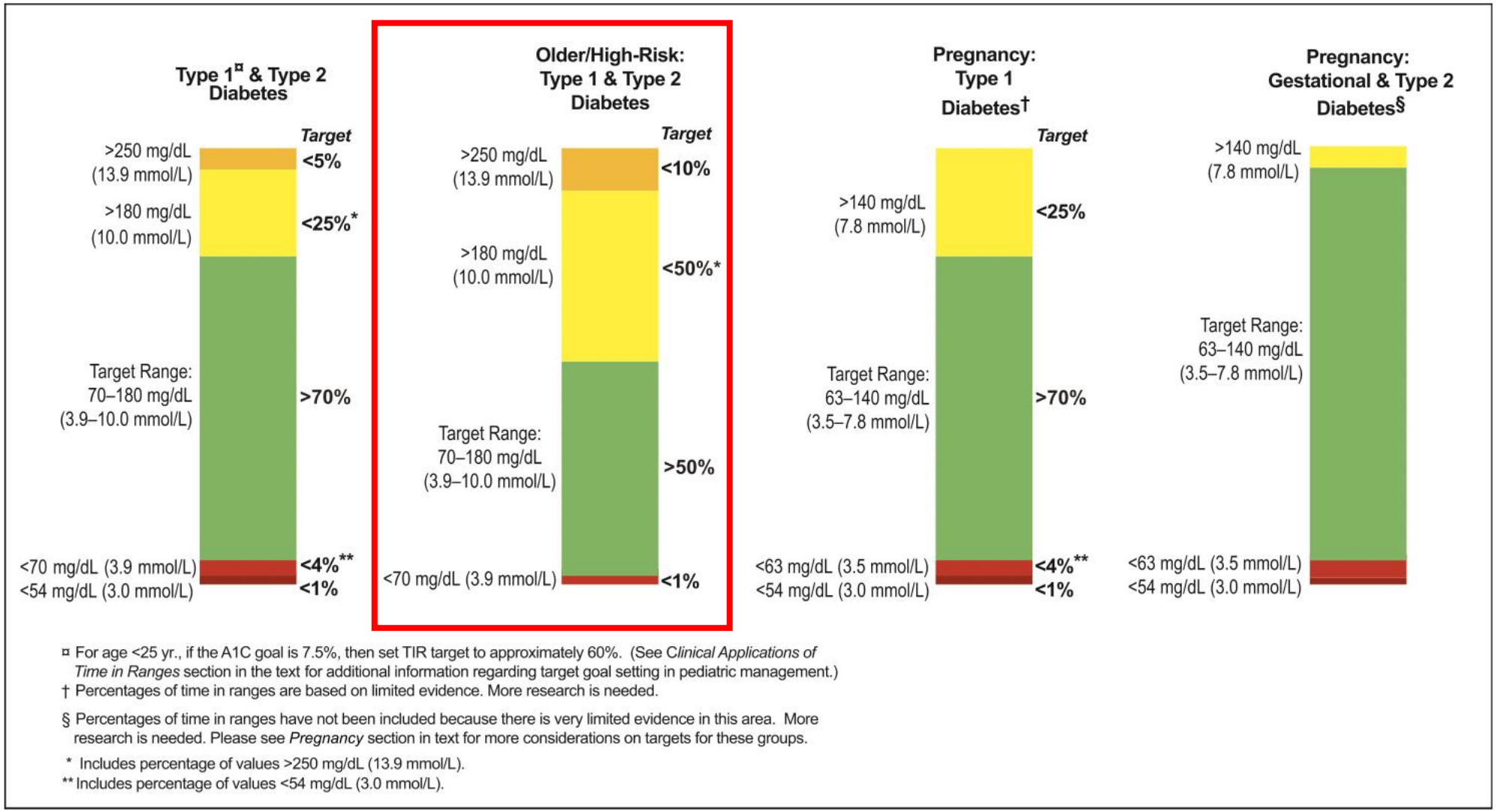
Table 2 Key studies investigating CGM in older people with diabetes

Study	Type of diabetes	Sample size	Age (years)[a]	Comparison	Follow-up (weeks)	Main outcomes
Subanalysis of DIAMOND, Ruedy et al 2017 [41]	T1D and T2D	116	67 ± 5	CGM vs BGM	24	Greater reductions in HbA_{1c} (−9.8 ± 7.7 mmol/mol [−0.9 ± 0.7%] vs −5.5 ± 7.7 mmol/mol [−0.5 ± 0.7%], respectively [adjusted difference in mean change −4.4 ± 1.1 mmol/mol [−0.4 ± 0.1%], $p<0.001$]) and TAR ($p=0.006$) and lower GV ($p=0.02$) in the CGM group vs BGM group
WISDM, Pratley et al 2020 [42]	T1D	203	Median (IQR) 68 (65–71)	CGM vs BGM	24	Lower TBR in the CGM group vs BGM group (2.7% vs 4.9%; adjusted treatment difference −1.9%)
Subanalysis of MOBILE, Bao et al 2022 [43]	T2D	175	≥65 (range 65–79)	CGM vs BGM	32	Greater reduction in HbA_{1c} in the CGM group vs BGM group (mean change −11.8 mmol/mol [−1.08%] vs −4.2 mmol/mol [−0.38%] [adjusted mean difference −0.65%, 95% CI −1.49, 0.19]). For TIR, mean adjusted treatment group difference was 19% (95% CI 4, 35, $p=0.01$)
Retrospective study, Guerci et al 2023 [44]	T2D	38,312	≥65	FM	96	Reduction in adverse diabetes events (−34% and −40% after 12 and 24 months' use of FM, respectively). For those aged 70–79 and ≥80 years, significant reductions in SH 24 months following FM initiation (–30% and –46%, respectively)
Retrospective observational cohort study, Reaven et al 2023 [45]	T1D and T2D	20,721	66.7 ± 9.8	CGM vs BGM	48	Significantly greater improvement in HbA_{1c} in both T1D (−2.8 mmol/mol [−0.26%], 95% CI −0.33, −0.19) and T2D (−3.8 mmol/mol [−0.35%], 95% CI −0.40, −0.31) in CGM group vs non-users. In those with T1D, significantly lower risk of hypoglycaemia (HR 0.69, 95% CI 0.48, 0.98) and all-cause hospitalisation (HR 0.89, 95% CI 0.83, 0.97) in CGM group vs non-users
Survey study, Polonsky et al 2016 [46]	T1D and T2D	285	70.7 ± 5.0	CGM vs BGM	24	Users reported fewer episodes of SH than non-users for the previous 6 months ($p<0.01$) and greater reductions in emergency department attendance and paramedic-led home visits ($p<0.01$), better general well-being ($p<0.001$) and less distress and hypoglycaemia fear ($p<0.05$)
Qualitative study, Litchman et al 2017 [47]	T1D	22	70 ± 4.7	CGM users vs CGM non-users	–	CGM users less likely than non-users to experience SH ($p=0.02$) or hypoglycaemia resulting in a fall or the inability to drive a motor vehicle ($p=0.01$)

[a]Data are mean ± SD unless indicated otherwise

BGM, blood glucose monitoring; FM, flash monitoring; SH, severe hypoglycaemia; T1D, type 1 diabetes; T2D, type 2 diabetes; TAR, time above range; TBR, time below range

CGM-based targets for different diabetes populations



¤ For age <25 yr., if the A1C goal is 7.5%, then set TIR target to approximately 60%. (See *Clinical Applications of Time in Ranges* section in the text for additional information regarding target goal setting in pediatric management.)

† Percentages of time in ranges are based on limited evidence. More research is needed.

§ Percentages of time in ranges have not been included because there is very limited evidence in this area. More research is needed. Please see *Pregnancy* section in text for more considerations on targets for these groups.

* Includes percentage of values >250 mg/dL (13.9 mmol/L).

** Includes percentage of values <54 mg/dL (3.0 mmol/L).

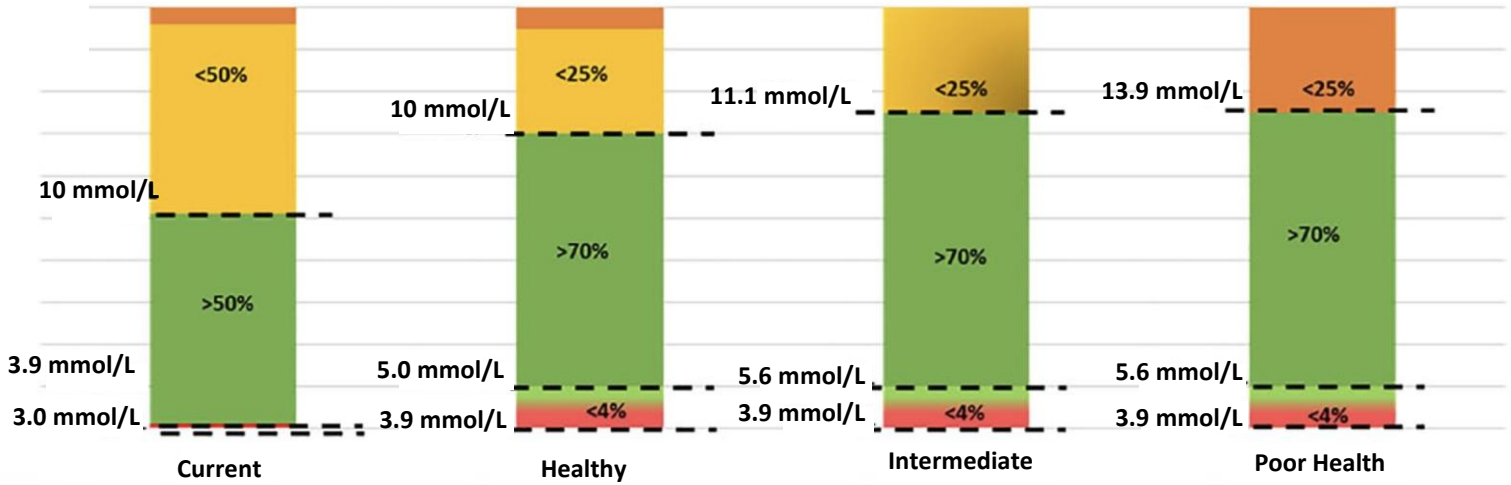
Adapted from Battelino et al. Diabetes Care 2019;42(8):1593–1603

Glucose Targets Using Continuous Glucose Monitoring Metrics in Older Adults With Diabetes: Are We There Yet?

Journal of Diabetes Science and Technology
2024, Vol. 18(4) 808–818

DOI: 10.1177/19322968241247568
journals.sagepub.com/home/dst
Sage

Elena Toschi, MD[1]*, David O'Neal, MD[2,3,4]*, Medha Munshi, MD[1], and Alicia Jenkins, MBBS, MD, FRACP, FRCP[2,3,4,5,6]



CGM Target	Current	Healthy	Intermediate	Poor Health
Time-Below-Range TBR%/min	<3.9 mmol/L <1% (60 min/day)	<3.9 mmol/L 0 min/day	<3.9 mmol/L 0 min/day	<3.9 mmol/L 0 min/day
Hypoglycaemia Buffer Zone %/min	N/A	3.9-5.0 mmol/L <4%	3.9-5.6 mmol/L <4%	3.9-5.6 mmol/L <4%
Time-in-Range TIR%/min	3.9-10.0 mmol/L >70%	5.0-11.0 mmol/L >70%	5.6-11.1 mmol/L >70%	5.6-13.9 mmol/L >70%
Time-above-Range TAR%/min	>10.0 mmol/L <50% >13.9 <10%	>10.0 mmol/L <25% >13.9 <10%	>11.1 mmol/L <25% TAR>13.9 <10%	>13.9 mmol/L <25%

Table 3 Key studies investigating insulin pump therapy and AID systems in older people with diabetes

Study	Type of diabetes	Sample size	Age (years)[a]	Comparison	Follow-up (weeks)	Main outcomes
Prospective, observational, single-centre study, Pintaudi et al 2023 [58]	T1D	18	74.1 ± 7.1	HCL system (MiniMed 780G)	48	HCL system was associated with a significant improvement in HbA_{1c} (mean ± SD 59.9 ± 10.5 mmol/mol [7.6% ± 3.1%] at baseline vs 53.2 ± 6.0 mmol/mol [7.0% ± 2.7%] at 1 year, p=0.01; mean difference 6.8 ± 10.3 mmol/mol [2.8% ± 3.1%]) and increase in TIR at 48 weeks (p<0.0001)
Open-label, randomised crossover trial (ORACL), McAuley et al 2022 [59]	T1D	30	67 ± 5	HCL system (MiniMed 670G) vs SAP	16	Mean (SD) TIR was higher in the HCL group than SAP group (75.2% [6.3] vs 69.0% [9.1], respectively; difference 6.2 percentage points [95% CI 4.4, 8.0]; p<0.0001) and the HCL group had a lower time in hypoglycaemia (<3.9 mmol/l) by a median of 0.5 percentage points (95% CI 0.3, 1.1; p=0.0005) vs SAP therapy
Retrospective analysis of electronic health records, Toschi et al 2022 [60]	T1D	48	70 ± 4	HCL system (Control-IQ)	12	CGM metrics showed an increase in mean ± SD TIR (from 62% ± 13% to 76% ± 9%; p<0.001) and a reduction in median (IQR) TBR (<3.9 mmol/l; from 2% [1–3%] to 1% [1–2%]; p=0.03) and mean ± SD TAR (>10.0 mmol/l; from 30% ± 11% to 20% ± 9%; p<0.001) at 3 months
Cross-sectional survey, Chakrabarti et al 2022 [61]	T1D	30	69 ± 5	–	–	Insulin pump therapy was associated with high levels of self-confidence in managing diabetes around exercise
Multinational, randomised, open-label crossover trial, Boughton et al 2022 [62]	T1D	37	Median [IQR] 68 [63–70]	HCL system (CamAPS FX) vs SAP	16	HCL system was associated with an improvement in TIR of 8.6 percentage points vs SAP through a reduction in time spent with glucose levels >16.7 mmol/l. There were no differences in TBR (<3.9 mmol/l) between the two groups
Post hoc analysis of a RCT, Thabit et al 2023 [63]	T1D	37	Median [IQR] 68 [63–70]	HCL system (CamAPS FX) vs SAP	16	There were no significant differences in sleep traits between the HCL and SAP groups

[a]Data are mean ± SD unless indicated otherwise

HCL, hybrid closed-loop; SAP, sensor-augmented pump; T1D, type 1 diabetes; T2D, type 2 diabetes; TAR, time above range; TBR, time below range; TIR, time in range

Closed-Loop Insulin Delivery Versus Sensor-Augmented Pump Therapy in Older Adults With Type 1 Diabetes (ORACL): A Randomized, Crossover Trial FREE

Sybil A. McAuley; Steven Trawley; Sara Vogrin; Glenn M. Ward; Spiros Fourlanos; Charlotte A. Grills; Melissa H. Lee; Andisheh Mohammad Alipoor; David N. O'Neal; Niamh A. O'Regan; Vijaya Sundararajan; Peter G. Colman; Richard J. MacIsaac

Corresponding author: Sybil A McAuley, sybil@unimelb.edu.au

Diabetes Care 2022;45(2):381–390

https://doi.org/10.2337/dc21-1667 **Article history**

PubMed:34844995

- Closed-loop insulin delivery vs with sensor-augmented pump therapy among older adults with type 1 diabetes
- Open-label, randomized (1:1), crossover trial compared 4 months of closed-loop versus sensor-augmented pump therapy
- Adults were aged ≥60 years, diabetes duration ≥10 years, using an insulin pump
- 30 participants (mean age 67 [SD 5] years), median type 1 diabetes duration of 38 years

Table 2—Primary and secondary outcomes

	Closed-loop stage (n = 30)	Sensor-augmented pump stage (n = 30)	Difference	P value
Glucose and insulin outcomes				
Proportion of time at glucose concentration				
3.9–10.0 mmol/L, %*	75.2 (6.3)	69.0 (9.1)	6.2 (4.4 to 8.0)	<0.0001
3.9–7.8 mmol/L, %	48.2 (6.1)	42.8 (9.1)	5.4 (3.6 to 7.2)	<0.0001
>10.0 mmol/L, %	23.6 (6.6)	29.0 (9.8)	−5.4 (−7.3 to −3.5)	<0.0001
>13.9 mmol/L, %	3.9 (2.2–5.9)	4.9 (3.1–10.6)	−1.2 (−2.9 to −0.9)	0.0022
>16.7 mmol/L, %	0.66 (0.38–1.32)	0.87 (0.69–3.54)	−0.62 (−1.01 to −0.29)	<0.0001
<3.9 mmol/L, %	1.21 (0.60–1.68)	1.69 (1.00–2.54)	−0.47 (−1.05 to −0.25)	0.0005
<3.3 mmol/L, %	0.37 (0.12–0.49)	0.41 (0.20–0.78)	−0.19 (−0.36 to −0.06)	0.025
<3.0 mmol/L, %	0.13 (0.03–0.24)	0.16 (0.10–0.38)	−0.11 (−0.16 to −0.05)	0.0078
Mean glucose concentration, mmol/L	8.4 (8.0–8.8)	8.7 (7.9–9.2)	−0.2 (−0.5 to −0.1)	0.035
SD of glucose concentration, mmol/L	2.6 (2.4–2.9)	2.9 (2.8–3.5)	−0.4 (−0.5 to −0.2)	<0.0001
CV of glucose concentration, %	31.3 (29.9–33.9)	35.3 (32.9–36.1)	−3.4 (−4.5 to −1.7)	<0.0001
HbA_{1c}, %	7.3 (7.1–7.5)	7.5 (7.1–7.9)	−0.2 (−0.3 to 0)	0.13
HbA_{1c}, mmol/mol	56 (54–59)	59 (54–62)	−2 (−3 to 0)	0.11
Insulin total daily dose, units	38.3 (30.1–60.9)	38.2 (31.2–59.2)	−0.5 (−1.8 to 0.3)	0.26
Psychosocial well-being outcomes				
Gold score	3 (2–4)	3 (2–4)	0 (0 to 0)	0.48
Clarke score	2 (1–4)	2 (1–4)	0 (−1 to 0)	0.43
Hypoglycemia Fear Survey				
Total scale	7.5 (4–10)	7.5 (5–10)	−1 (−3 to 1)	0.72
Worry subscale	4.5 (2–7)	4.5 (3–7)	0 (−1 to 0)	0.14
Behavior subscale	2 (1–4)	2 (1–4)	0.0 (−2 to 0)	0.087
Diabetes distress (PAID-5)	4.3 (2.9)	4.6 (3.2)	−0.3 (−1.1 to 0.5)	0.46
Geriatric Depression Scale	1 (0–2)	1 (0–2)	0 (0 to 0)	>0.99
Impact of diabetes on quality of life (DIDP raw score)	4.5 (4.3–4.8)	4.7 (4.4–5.0)	0.0 (−0.2 to 0.0)	0.46
Perceived sleep quality (PSQI score)	5 (3–8)	5.5 (3–7)	0 (−1 to 1)	0.79

Results presented as mean (SD) or median (interquartile range); analyses using period-adjusted mixed effect linear regression or period-adjusted sign test, respectively. Differences presented as mean or median difference (95% CI). DIDP, Diabetes Attitudes, Wishes and Needs (DAWN) Impact of Diabetes Profile; PAID, Problem Areas in Diabetes; PSQI, Pittsburgh Sleep Quality Index. *Primary outcome. Sensor glucose and insulin outcomes are for the final 3 months of each stage.

THE LANCET
Healthy Longevity

ARTICLES | VOLUME 3, ISSUE 3, E135-E142, MARCH 2022 Download Full Issue

Hybrid closed-loop glucose control compared with sensor augmented pump therapy in older adults with type 1 diabetes: an open-label multicentre, multinational, randomised, crossover study

Charlotte K Boughton, PhD • Sara Hartnell • Hood Thabit, PhD • Womba M Mubita, RN • Katharine Draxlbauer, RN • Tina Poettler, RN • et al. Show all authors

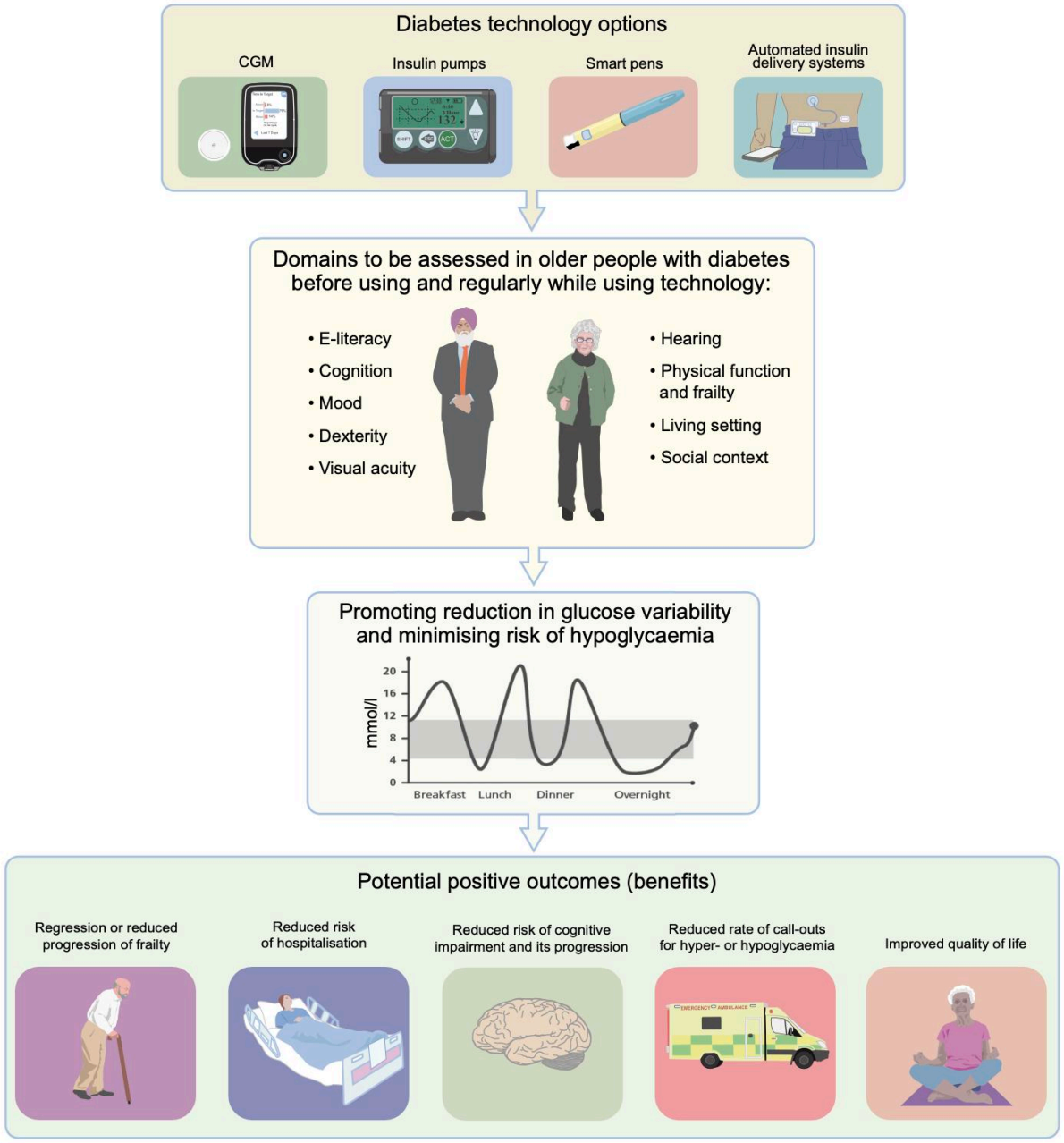
Open Access • Published: March, 2022 • DOI: https://doi.org/10.1016/S2666-7568(22)00005-8 •

- Hybrid closed-loop vs sensor-augmented pump (SAP) therapy in older adults with type 1 diabetes
- Open-label, multicentre, multinational, randomised, crossover study
- Adults aged 60 years and older with type 1 diabetes using insulin pump therapy underwent two 16-week periods comparing hybrid closed-loop (CamAPS FX, CamDiab, Cambridge, UK) and SAP therapy in random order
- 37 participants **(median [IQR] age 68 [63**–70**] years,** mean [SD] baseline glycated haemoglobin **[HbA1c]; 7·4% [0·9%]; 57 [10] mmol/mol)**

	Closed-loop group (n=36)	Sensor-augmented pump therapy group (n=37)	Treatment difference (95% CI)	p value*
Primary endpoint†				
Time with glucose 3·9 to 10·0 mmol/L, %	79·9% (7·9)	71·4% (13·2)	8·6 (6·3 to 11·0)	<0·0001
Key secondary endpoints†				
Time with glucose >10·0 mmol/L, %	16·7% (11·4 to 23·9)	21·4% (16·9 to 36·5)	−8·5% (−10·9 to −6·1)	<0·0001
Mean glucose, mmol/L	7·8 (0·7)	8·5 (1·1)	−0·7 (−0·9 to −0·5)	<0·0001
HbA_{1c}, mmol/mol	49·3 (7·9)	52·1 (9·2)	−2·7 (−4·2 to −1·2)	0·0008
HbA_{1c},%	6·7% (0·7%)	6·9% (0·9%)	−0·2% (−0·4 to −0·1)	0·0008
Time with glucose <3·9 mmol/L, %	1·7 (1·3 to 2·4)	1·7 (0·9 to 2·7)	−0·1 (−0·3 to 0·2)	0·54
Other secondary endpoints‡				
Time with glucose				
<3·5 mmol/L, %	0·7% (0·5 to 1·1)	0·7% (0·4 to 1·2)	0·0% (−0·2 to 0·1)	0·69
<3·0 mmol/L, %	0·2% (0·1 to 0·3)	0·2% (0·1 to 0·3)	0·0% (-0·1 to 0·1)	0·69
>16·7 mmol/L, %	0·5% (0·2 to 0·8)	0·8% (0·2 to 2·8)	−0·7% (−1·0 to −0·3)	<0·0001
Glucose, mmol/L	2·6 (0·5)	2·8 (0·6)	−0·2 (−0·3 to −0·1)	<0·0001
Glucose coefficient of variation, %	32·5 (4·2)	32·7 (4·5)	−0·3 (−1·2 to 0·6)	0·49
Total daily insulin, units per day	46·3 (36·9 to 53·5)	42·9 (36·6 to 53·0)	1·2 (−0·6 to 3·0)	0·20
Total daily basal insulin, units per day	27·7 (18·9 to 32·0)	21·5 (15·9 to 27·0)	4·7 (3·2 to 6·1)	<0·0001
Total daily bolus insulin, units per day	20·2 (13·5 to 26·1)	23·4 (17·0 to 29·6)	−3·5 (−4·9 to −2·0)	<0·0001
Total daily dose, units per kg/day	0·5 (0·5 to 0·6)	0·5 (0·4 to 0·6)	0·0 (0·0 to 0·0)	0·35
Time using continuous glucose monitoring, %	99·7 (99·3–99·9)	99·4 (98·8–99·9)	0·45 (0·06–0·85)	0·026
Time using closed-loop, %	96·7% (95·1–98·0)	..	..	..

Data are mean (SD) or median (IQR). Endpoints calculated from all randomised subjects with at least 168 h of CGM data in at least one period. Glucose data are based on sensor glucose measurements. Treatment difference is calculated as closed loop minus sensor augmented pump therapy. One participant randomised to initial use of sensor-augmented pump therapy did not cross over to closed-loop insulin delivery. *Based on a linear mixed model adjusting for period as a fixed effect and site as a random effect. †Tested in hierarchy as listed to control the type 1 error using the fixed-sequence method. ‡Adjusted for multiple comparisons using Benjamini-Hochberg procedure to control false discovery rate. HbA_{1c}=glycated haemoglobin

Table 2: **Glucose control, insulin delivery, and usage endpoints in the intention-to-treat analysis population**

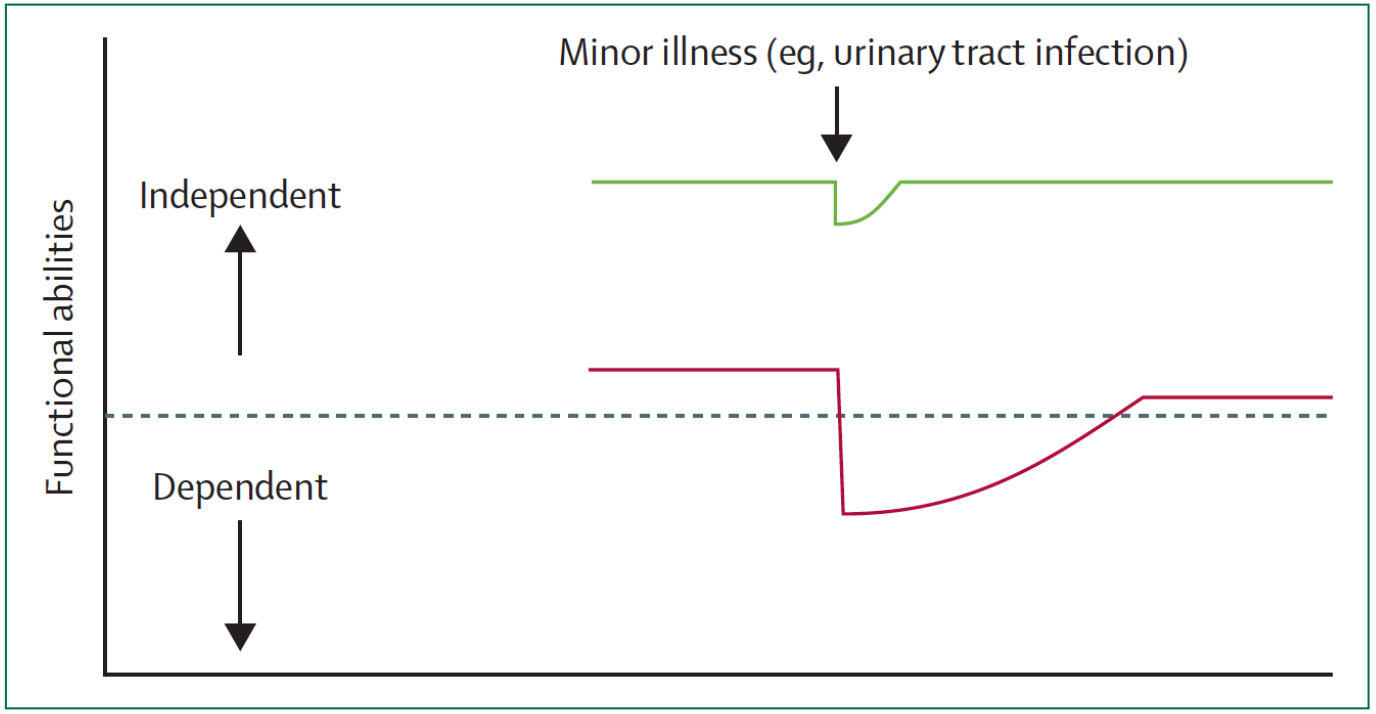

Diabetes technology options
CGM
Insulin pumps
Smart pens
Automated insulin delivery systems
Domains to be assessed in older people with diabetes before using and regularly while using technology:
• E-literacy
• Cognition
• Mood
• Dexterity
• Visual acuity
• Hearing
• Physical function and frailty
• Living setting
• Social context
Promoting reduction in glucose variability and minimising risk of hypoglycaemia
mmol/l
20
16
12
8
4
0
Breakfast
Lunch
Dinner
Overnight
Potential positive outcomes (benefits)
Regression or reduced progression of frailty
Reduced risk of hospitalisation
Reduced risk of cognitive impairment and its progression
Reduced rate of call-outs for hyper- or hypoglycaemia
Improved quality of life

Frailty

- What's frailty?
- How do measure frailty in clinical practice?
- What do we know about the relationship between frailty and diabetes?
- Why should we consider and estimate frailty in our patients?
- Can target frailty and intervene to prevent progression and change the outcome?

Frailty in elderly people

Andrew Clegg, John Young, Steve Iliffe, Marcel Olde Rikkert, Kenneth Rockwood

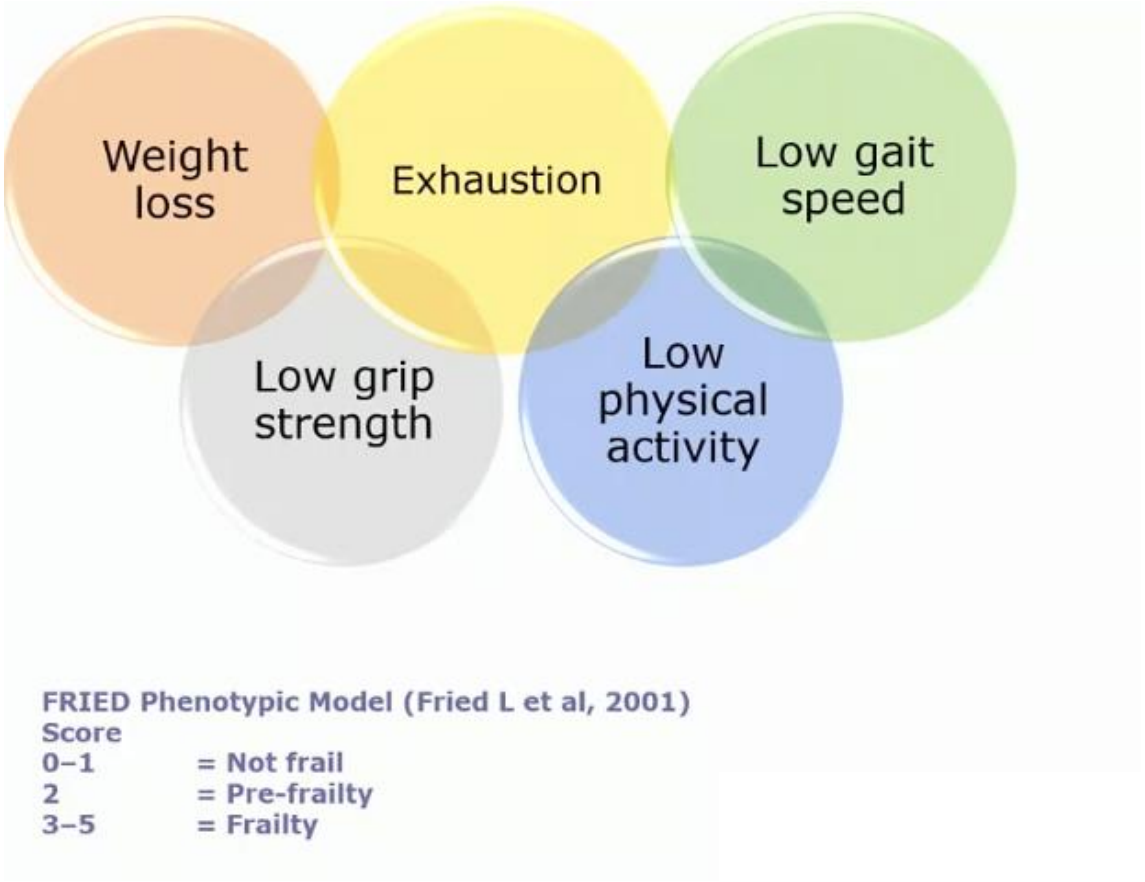


Lancet 2013; 381: 752–62

Commonly used measures of frailty

- Fried phenotype
- Frailty Index (FI)
- Electronic FI (eFI)
- Clinical Frailty Scale (CFS)
- FRAIL scale (5 item-scale)
- Gait speed
- Timed up and go test
- Grip strength

Early concepts of Frailty – A multisystem impairment associated with increased vulnerability to stressors



Based on data from the Cardiovascular Health Study, 2001

Research Article
TheScientificWorld (2001) 1, 323–336
ISSN 1532-2246; DOI 10.1100/tsw.2001.58

TheScientificWorld
www.thescientificworld.com

Accumulation of Deficits as a Proxy Measure of Aging

Arnold B. Mitnitski[1,2], Alexander J. Mogilner, and Kenneth Rockwood[2,*]

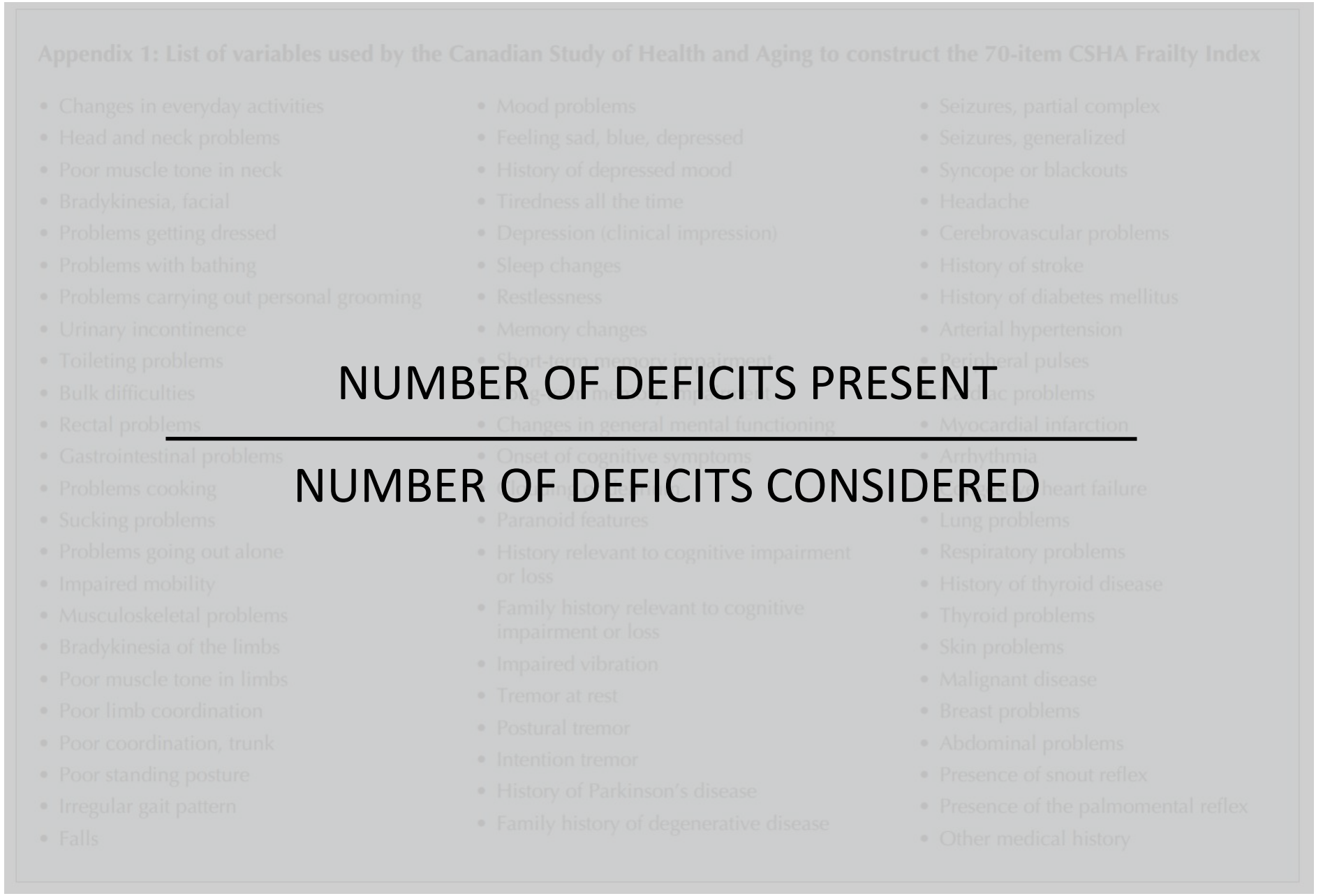
[1]Department of Mechanical Engineering, Ecole Polytechnique, Montreal P.O. Box 6079, Station Centre-ville Montreal, Quebec H3C 3A7; [2]Queen Elizabeth II, Health Sciences Centre, Geriatric Medicine Research Unit, Room 1421,5955 Veterans' Memorial Lane, Halifax, Nova Scotia B3H 2E1

"…a method for appraising **health status** in elderly people.
A frailty index was defined as the proportion of accumulated deficits (**symptoms, signs, functional impairments, and laboratory abnormalities**).
It serves as an individual state variable, reflecting severity of illness and **proximity to death**…"

Appendix 1: List of variables used by the Canadian Study of Health and Aging to construct the 70-item CSHA Frailty Index

- Changes in everyday activities
- Head and neck problems
- Poor muscle tone in neck
- Bradykinesia, facial
- Problems getting dressed
- Problems with bathing
- Problems carrying out personal grooming
- Urinary incontinence
- Toileting problems
- Bulk difficulties
- Rectal problems
- Gastrointestinal problems
- Problems cooking
- Sucking problems
- Problems going out alone
- Impaired mobility
- Musculoskeletal problems
- Bradykinesia of the limbs
- Poor muscle tone in limbs
- Poor limb coordination
- Poor coordination, trunk
- Poor standing posture
- Irregular gait pattern
- Falls
- Mood problems
- Feeling sad, blue, depressed
- History of depressed mood
- Tiredness all the time
- Depression (clinical impression)
- Sleep changes
- Restlessness
- Memory changes
- Short-term memory impairment
- Long-term memory impairment
- Changes in general mental functioning
- Onset of cognitive symptoms
- Clouding or delirium
- Paranoid features
- History relevant to cognitive impairment or loss
- Family history relevant to cognitive impairment or loss
- Impaired vibration
- Tremor at rest
- Postural tremor
- Intention tremor
- History of Parkinson's disease
- Family history of degenerative disease
- Seizures, partial complex
- Seizures, generalized
- Syncope or blackouts
- Headache
- Cerebrovascular problems
- History of stroke
- History of diabetes mellitus
- Arterial hypertension
- Peripheral pulses
- Cardiac problems
- Myocardial infarction
- Arrhythmia
- Congestive heart failure
- Lung problems
- Respiratory problems
- History of thyroid disease
- Thyroid problems
- Skin problems
- Malignant disease
- Breast problems
- Abdominal problems
- Presence of snout reflex
- Presence of the palmomental reflex
- Other medical history

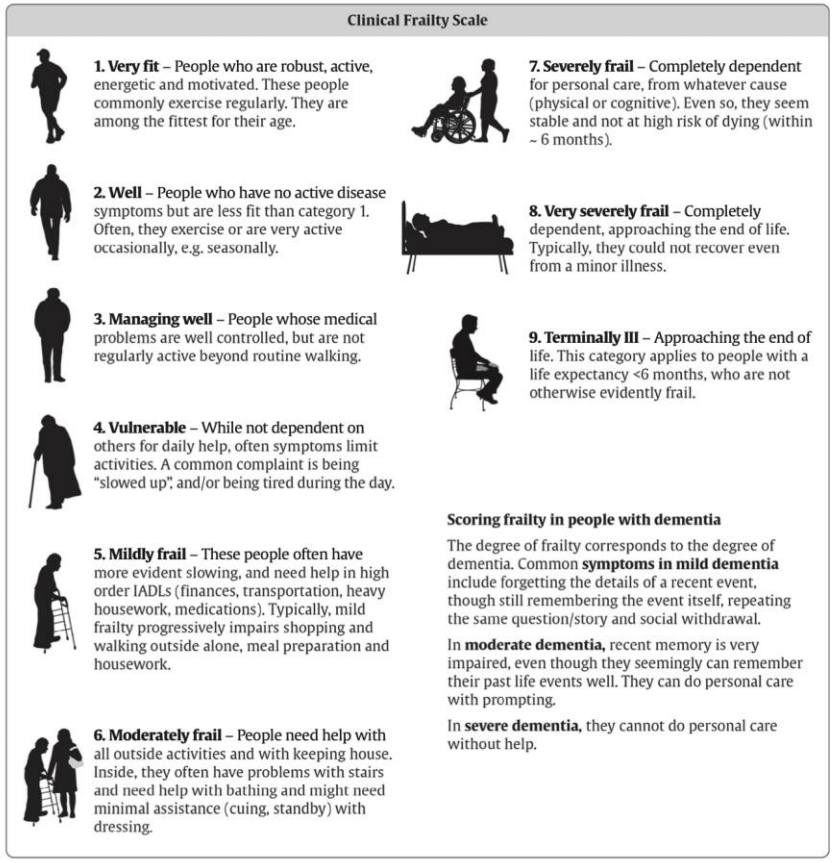
Rockwood K et al. *CMAJ* 2005;173:489-95



$$\frac{\text{NUMBER OF DEFICITS PRESENT}}{\text{NUMBER OF DEFICITS CONSIDERED}}$$

Rockwood K et al. *CMAJ* 2005;173:489-95

Measuring frailty – Clinical Frailty Scale (CFS) and Electronic Frailty Index (eFI)



Clinical Frailty Scale

1. Very fit – People who are robust, active, energetic and motivated. These people commonly exercise regularly. They are among the fittest for their age.

2. Well – People who have no active disease symptoms but are less fit than category 1. Often, they exercise or are very active occasionally, e.g. seasonally.

3. Managing well – People whose medical problems are well controlled, but are not regularly active beyond routine walking.

4. Vulnerable – While not dependent on others for daily help, often symptoms limit activities. A common complaint is being "slowed up", and/or being tired during the day.

5. Mildly frail – These people often have more evident slowing, and need help in high order IADLs (finances, transportation, heavy housework, medications). Typically, mild frailty progressively impairs shopping and walking outside alone, meal preparation and housework.

6. Moderately frail – People need help with all outside activities and with keeping house. Inside, they often have problems with stairs and need help with bathing and might need minimal assistance (cuing, standby) with dressing.

7. Severely frail – Completely dependent for personal care, from whatever cause (physical or cognitive). Even so, they seem stable and not at high risk of dying (within ~ 6 months).

8. Very severely frail – Completely dependent, approaching the end of life. Typically, they could not recover even from a minor illness.

9. Terminally Ill – Approaching the end of life. This category applies to people with a life expectancy <6 months, who are not otherwise evidently frail.

Scoring frailty in people with dementia

The degree of frailty corresponds to the degree of dementia. Common **symptoms in mild dementia** include forgetting the details of a recent event, though still remembering the event itself, repeating the same question/story and social withdrawal.

In **moderate dementia,** recent memory is very impaired, even though they seemingly can remember their past life events well. They can do personal care with prompting.

In **severe dementia,** they cannot do personal care without help.

eFI tool

- The eFI consists of 36 deficits which have been constructed using around 2,000 primary care Read codes

Requires a software system in place, e.g. EMIS Web

- The eFI calculates a frailty score by dividing the number of deficits present by the total possible: uses 36 validated deficits

- **Scores**

Robust - 0-0.12; Mild - 0.13-0.24; Moderate – 0.25-0.36; Severe =>0.36

- The score is a robust predictor of those who are at greater risk of adverse outcomes

An eFI > 0.36 have a six-fold increased risk of admission to a care home in the next 12 months and a five-fold increased mortality risk compared to fit older people

Clegg A et al, 2016

FRAIL TEST – non – invasive frailty screening tool – a preferred frailty measure, Morley JE at al 2012

The clinician asks:

Fatigue: Are you fatigued?

Resistance: Are you unable to walk up one flight of stairs?

Aerobic: Are you unable to walk one block?(equivalent of about 200m)

Illnesses: Do you have more than 5 illnesses?

Loss of weight: Have you lost more than 5% of your weight in the past 6 months?

Interpretation: Answers yes to:

1-2: indicates pre-frailty, and ≥3: indicates frailty

Advantages of Test

- Simple, easy to learn
- Does not require a face to face consultation
- Utilises 4 components of the Cardiovascular Study Index (Fried Criteria) and 1 component from the Rockwood Clinical Frailty Scale
- Correlates well with IADL, gait speed and SPPB
- Valid in late middle age and older adults

Rosas-Carrasco O et al, 2010 (Mexicans);
Li Y et al 2015 (Chinese); Ravindrarajah R et al 2013 (Europeans)

Frailty measurement, prevalence, incidence, and clinical implications in people with diabetes: a systematic review and study-level meta-analysis

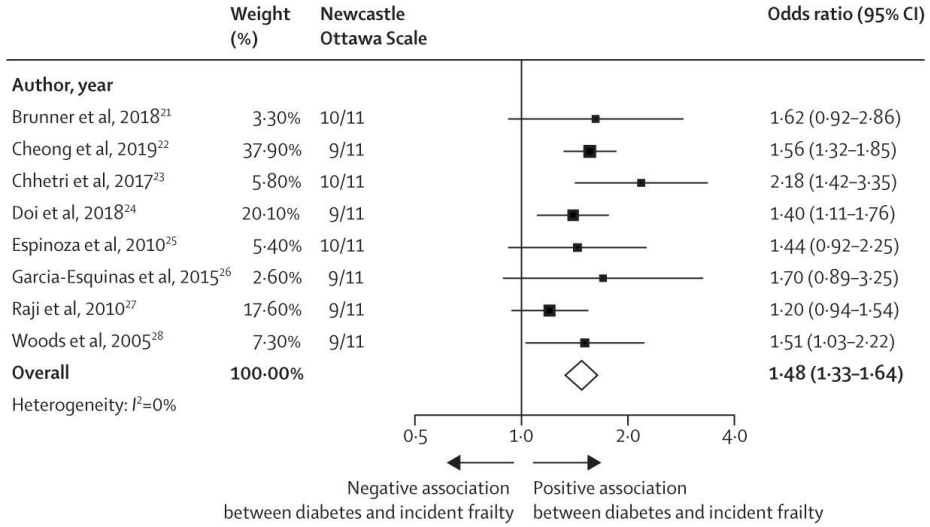
Peter Hanlon, Isabella Fauré, Neave Corcoran, Elaine Butterly, Jim Lewsey, David McAllister, Frances S Mair**

Aims: to quantify the *prevalence of frailty in people with diabetes*, and to summarise the *association between frailty and generic outcomes* (e.g. mortality) and *diabetes-specific outcomes* (eg. hypoglycaemia).

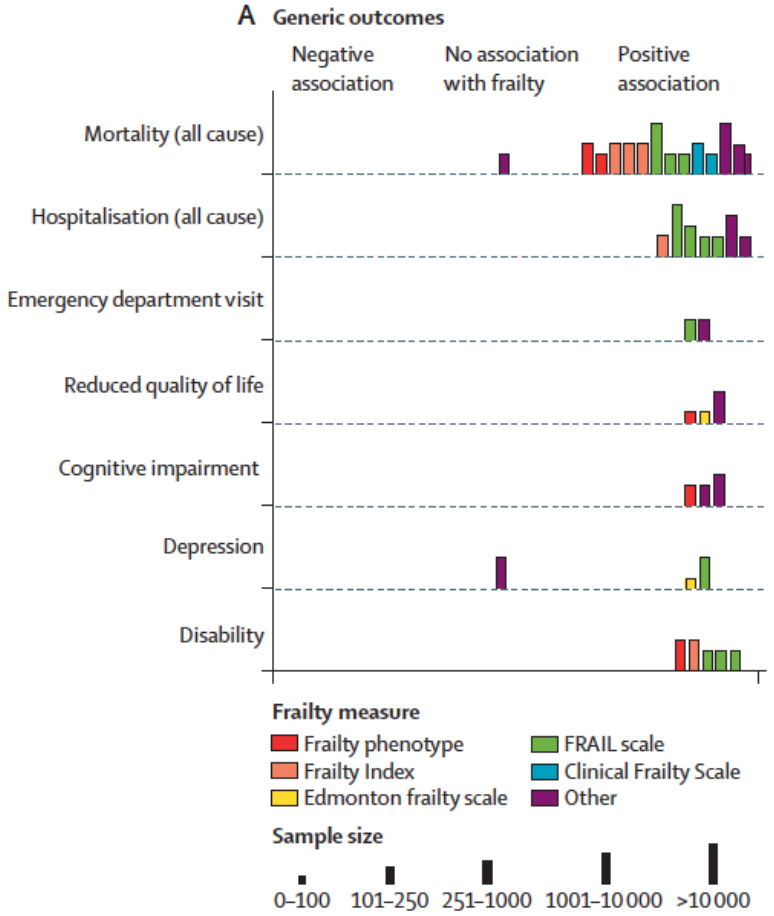
.

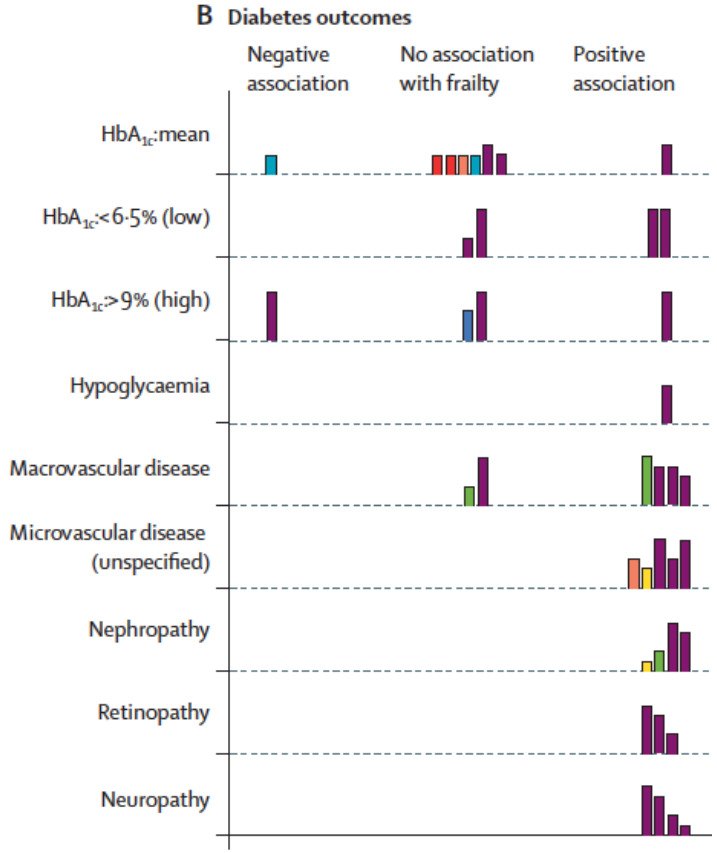
Key Findings

- Of 3,038 studies, 118 studies using 20 different frailty measures were eligible for inclusion
- Studies were heterogenous in setting (88 studies were community-based, 18 were outpatient-based, 10 inpatient-based, and 2 were based in LCT facilities)
- Mean age ranged from 50.4 years to 88.0 years (median 72.8 [IQR 69·6–74·4])
- Median community frailty prevalence using frailty phenotype was 13% (IQR 9–21)



Lancet Healthy Longevity **2020; e106–16**





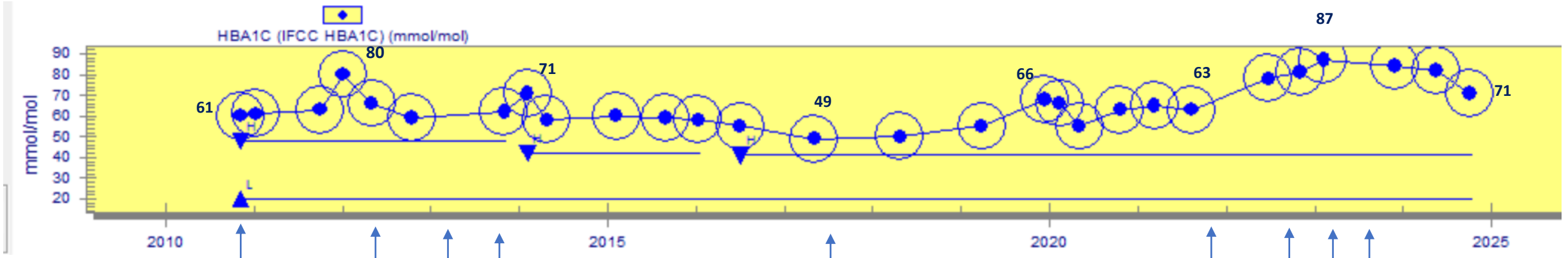
Frailty was consistently associated with:

1. **Mortality** in 13 (93%) of 14 studies assessing this outcome (pooled hazard ratio 1·51 [95% CI 1·30–1·76])
2. **Hospital admission** in seven (100%) of seven
3. **Disability** in five (100%) of five studies.

Frailty was also associated with

1. **Hypoglycaemia** events in one study (<1%)
2. **Microvascular and macrovascular complica**tions in nine (82%) of 11 studies
3. Lower **quality of life** in three (100%) of three studies assessing quality of life
4. **Cognitive impairment** in three (100%) of three studies assessing cognitive impairment.

83-year-old gentleman type 1 diabetes since 1962



Referred to Epsom and St Helier in 2010

He was on basal-bolus regimen with Glargine and NovoRapid

Alan Nebarro Medal

In March 2012 he attended the ALFFI (Advanced Learning for Food and Insulin)

He started insulin pump therapy in November 2013 at the age of 72 due to impaired hypo-awareness and one episode of hypoglycaemia requiring third-party assistance

In 2017 he upgraded Medtronic VEO pump

In 2022 he upgraded Medtronic 640G

A Mini-Cog was administered

Admitted to hospital with DKA

Diagnosed with dementia

Examples of cognition assessment tools

Tool/Test	Advantage	Disadvantage	Time
Mini-Cog	Brief, minimal language, educational and racial bias	Use of different word lists may affect scoring	2-4 min
Montreal cognitive assessment (MoCA)	Can identify mild cognitive impairment, available in multiple languages	Educational and cultural bias, limited published data	10-15 min
Mini Mental State Examination (MMSE)	Widely used and studied	Subject to age and cultural bias, ceiling effects	7-10 min

Mini-Cog©

Instructions for Administration & Scoring

ID: _____ Date: _____

Step 1: Three Word Registration

Look directly at person and say, "Please listen carefully. I am going to say three words that I want you to repeat back to me now and try to remember. The words are [select a list of words from the versions below]. Please say them for me now." If the person is unable to repeat the words after three attempts, move on to Step 2 (clock drawing).

The following and other word lists have been used in one or more clinical studies.[1-3] For repeated administrations, use of an alternative word list is recommended.

Version 1	Version 2	Version 3	Version 4	Version 5	Version 6
Banana	Leader	Village	River	Captain	Daughter
Sunrise	Season	Kitchen	Nation	Garden	Heaven
Chair	Table	Baby	Finger	Picture	Mountain

Step 2: Clock Drawing

Say: "Next, I want you to draw a clock for me. First, put in all of the numbers where they go." When that is completed, say: "Now, set the hands to 10 past 11."

Use preprinted circle (see next page) for this exercise. Repeat instructions as needed as this is not a memory test. Move to Step 3 if the clock is not complete within three minutes.

Step 3: Three Word Recall

Ask the person to recall the three words you stated in Step 1. Say: "What were the three words I asked you to remember?" Record the word list version number and the person's answers below.

Word List Version: _____ Person's Answers: _____ _____ _____

Scoring

Word Recall: _____ (0-3 points)	1 point for each word spontaneously recalled without cueing.
Clock Draw: _____ (0 or 2 points)	Normal clock = 2 points. A normal clock has all numbers placed in the correct sequence and approximately correct position (e.g., 12, 3, 6 and 9 are in anchor positions) with no missing or duplicate numbers. Hands are pointing to the 11 and 2 (11:10). Hand length is not scored. Inability or refusal to draw a clock (abnormal) = 0 points.
Total Score: _____ (0-5 points)	Total score = Word Recall score + Clock Draw score. A cut point of <3 on the Mini-Cog™ has been validated for dementia screening, but many individuals with clinically meaningful cognitive impairment will score higher. When greater sensitivity is desired, a cut point of <4 is recommended as it may indicate a need for further evaluation of cognitive status.

DIABETES RESEARCH AND CLINICAL PRACTICE 100 (2013) e23–e25

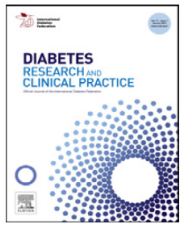
ELSEVIER

Contents available at Sciverse ScienceDirect

Diabetes Research and Clinical Practice

journal homepage: www.elsevier.com/locate/diabres

International Diabetes Federation



Short communication

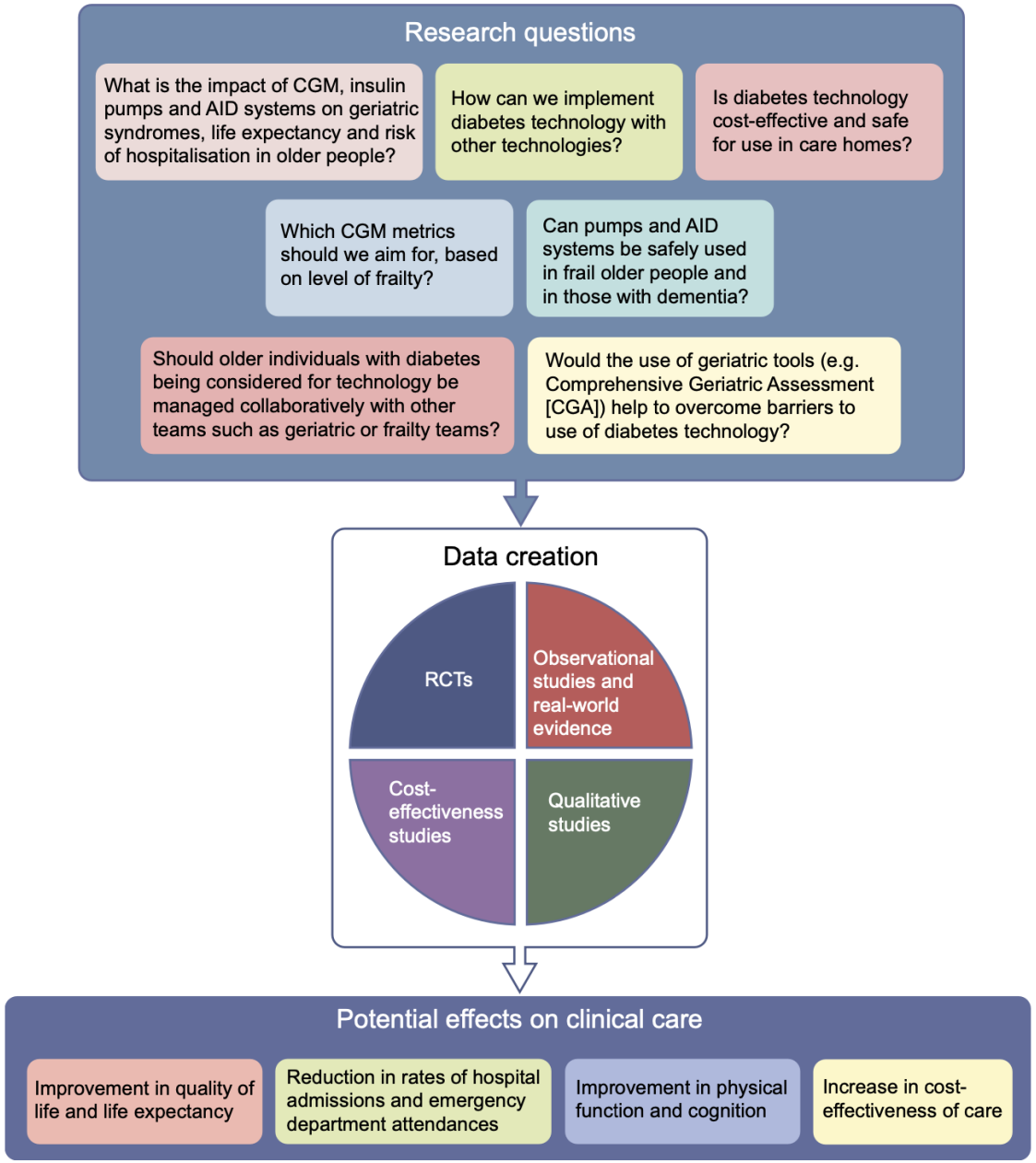
Brief report: Use of the Mini-Cog as a screening tool for cognitive impairment in diabetes in primary care

A.J. Sinclair [a,*], *R. Gadsby* [a], *R. Hillson* [b], *A. Forbes* [c], *A.J. Bayer* [d]

- In a GP study of older people with type 2 diabetes, Mini-Cog had sensitivity of 86%, specificity of 91%, positive predictive value of 54% and negative predictive value of 98% for dementia.
- Not influenced by education, culture or language; performance comparable to MMSE.

Key barriers to the use of diabetes technology in older people

Maltese et al. Diabetologia 2024



Maltese et al. Diabetologia 2024

Conclusions

- The heterogeneity characterising the group of older people with diabetes is a key factor contributing to pronounced glucose variability, and an increased risk of hypoglycaemia
- Individually tailored adoption of CGM devices, pumps and AID systems appears to be the most sensible strategy to improve TIR and reduce the risk of hypo- and hyperglycaemia in this group. This, in turn, may enhance physical and cognitive function as well as overall quality of life
- Key characteristics, such as advanced age, limited digital literacy, cognitive decline and physical impairments, should be carefully considered when implementing technology solutions for older individuals
- Implementation of technology should be considered after a holistic assessment of each individual, looking at multiple domains including social context and living setting
- Future research should explore the impact of diabetes technology on outcomes relevant to older people with diabetes.