SID Società Italiana di Diabetologia

LA TECNOLOGIA PER LA CURA DEL DIABETE

# Overview della tecnologia nel diabete

**Dott. Federico Boscari**
**UOC Malattie Del Metabolismo**
**Azienda Ospedale Università di Padova**

DALLA SMART MDI ALL'HYBRID CLOSED LOOP

ROMA 1-2 Aprile 2025

Il dr. **Federico Boscari** dichiara di aver ricevuto negli ultimi due anni compensi o finanziamenti dalle seguenti Aziende Farmaceutiche e/o Diagnostiche:

- Movi
- Roche Diabetes Care
- Sanofi Aventis
- Glooko
- Tandem
- Novo Nordisk

Dichiara altresì il proprio impegno ad astenersi, nell'ambito dell'evento, dal nominare, in qualsivoglia modo o forma, aziende farmaceutiche e/o denominazione commerciale e di non fare pubblicità di qualsiasi tipo relativamente a specifici prodotti di interesse sanitario (farmaci, strumenti, dispositivi medico-chirurgici, ecc.).

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16.30 Overview della tecnologia nel diabete
***Federico Boscari***

16.50 Selezione del paziente e comunicazione efficace: i vantaggi dell'Hybrid Closed Loop verso la terapia MDI
***Elena Succurro***

DALLA SMART MDI ALL'HYBRID CLOSED LOOP

ROMA 1-2 Aprile 2025


Nuzzo, M.G.; Schettino, M. Advanced Technology (Continuous Glucose Monitoring and Advanced Hybrid Closed-Loop Systems) in Diabetes from the Perspective of Gender Differences. *Diabetology* 2023, *4*, 519-526. https://doi.org/10.3390/diabetology4040045

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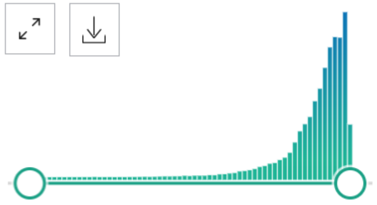
RESULTS BY YEAR




PUBLICATION DATE

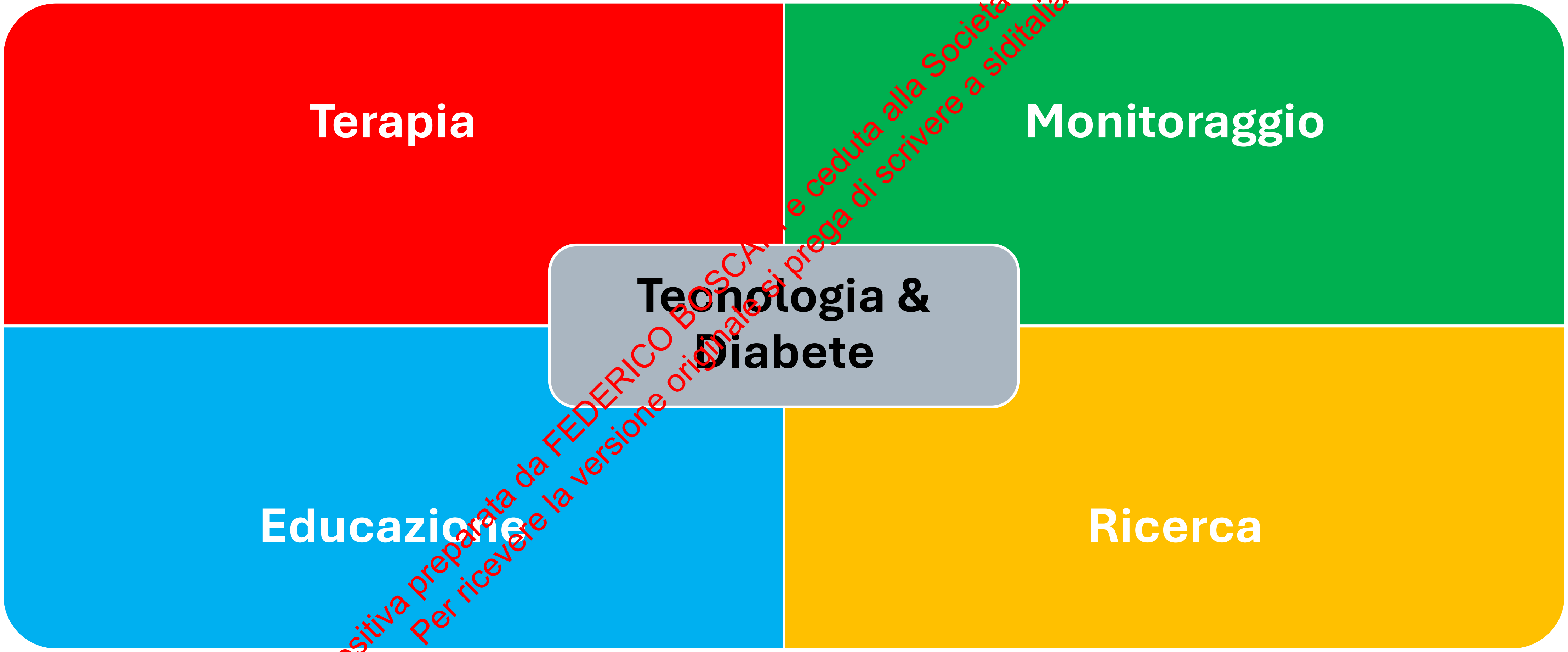
- 1 year
- 5 years
- 10 years

1 Digital health **technology** and **diabetes** management.
Cahn A, Akirov A, Raz I.
J Diabetes. 2018 Jan;10(1):10-17. doi: 10.1111/1753-0407.12606. Epub 2017 Nov 6.
PMID: 28872765 Review.
**Diabetes** care is largely dependent on patient self-management and empowerment, given that patients with **diabetes** must make numerous daily decisions as to what to eat, when to exercise, and determine their insulin dose and timing if required. ...Better understanding ...
Cite Share

2 **Diabetes Technology** and the Human Factor.
Liberman A, Barnard K.
Diabetes Technol Ther. 2019 Feb;21(S1):S138-S147. doi: 10.1089/dia.2019.2511.
PMID: 30785329 Review. No abstract available.
Cite Share

# In che modo la tecnologia interviene nella gestione del diabete

# In che modo la tecnologia interviene nella gestione del diabete



# In che modo la tecnologia interviene nella gestione del diabete

Terapia

Tecnologia & Diabete

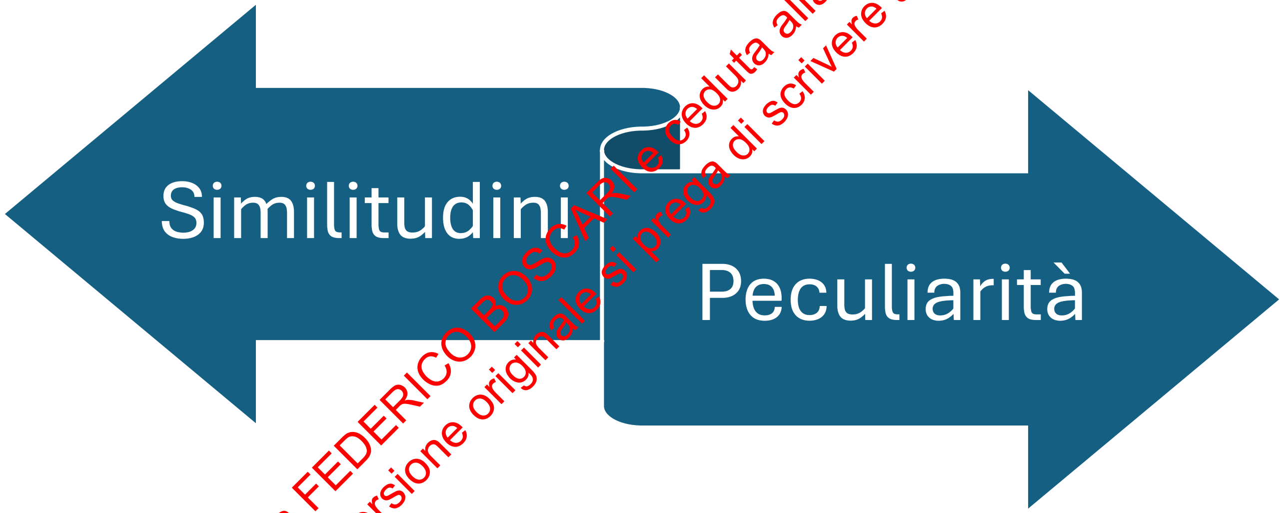
# Somministrazione di insulina

- Microinfusori di insulina
- Sistemi automatici per la somministrazione di insulina
- Smart Pen

# AID (Automated Insulin Delivery)

Struttura generale

Sistemi ibridi




Tipo di sensore

Tipo di microinfusore

Algoritmo

Condivisione dati

Indicazioni cliniche

# AID

| Outcome | No. of comparisons | No. of patients | | Mean difference or relative risk (95% CI) | *P* value |
|---|---|---|---|---|---|
| | | Intervention | Control | | |
| Time in range | 62 | 2,292 | 2,008 | 11.74 (9.37 to 14.12) | <0.001 |
| Time below range | 60 | 2,242 | 1,958 | –1.20 (–1.62 to –0.79) | <0.001 |
| Time above range | 54 | 1,979 | 1,684 | –10.17 (–13.18 to –7.16) | <0.001 |
| Coefficient of variation, % | 41 | 1,682 | 1,402 | –1.31 (–2.16 to –0.47) | 0.002 |
| HbA1c, % | 25 | 1,453 | 1,171 | –0.36 (–0.44 to –0.28) | <0.001 |
| Glycemia risk index | 6 | 139 | 139 | –3.74 (–6.34 to –1.14) | 0.005 |
| Insulin dose | 44 | 1,538 | 1,376 | 0.03 (–0.08 to 0.15) | 0.577 |
| Severe hypoglycemia | 21 | 1,134 | 977 | 0.92 (0.65 to 1.31) | 0.661 |
| Diabetic ketoacidosis | 9 | 554 | 445 | 1.15 (0.47 to 2.80) | 0.766 |

CI, confidence interval; HbA1c, glycosylated hemoglobin.

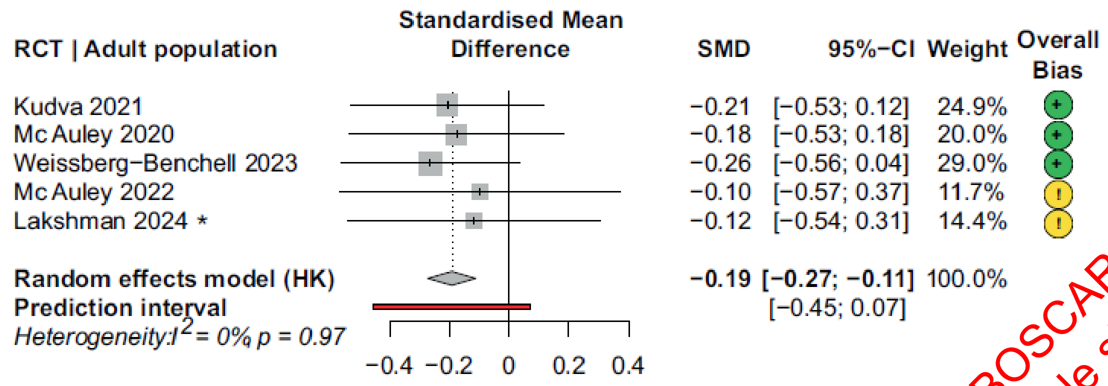
Fan W, Deng C, Xu R, Liu Z, Leslie RD, Zhou Z, Li X. Efficacy and Safety of Automated Insulin Delivery Systems in Patients with Type 1 Diabetes Mellitus: A Systematic Review and Meta-Analysis. Diabetes Metab J. 2025 Mar;49(2):235-251. doi: 10.4093/dmj.2024.0130. Epub 2024 Nov 13. PMID: 39533812.

| Outcomes and subgroups | No. of comparisons | No. of patients | | Mean difference between AID systems and other insulin therapy (95% CI), % | *P* value for overall effect | *P* value for subgroup differences | Weight, % | $I^2$, % |
|---|---|---|---|---|---|---|---|---|
| | | Intervention | Control | | | | | |
| Time in range, % | | | | | | | | |
| Total comparisons | 62 | 2,292 | 2,008 | | | | | |
| Timing of intervention | | | | | | | | |
| 24 hours | 60 | 2,251 | 1,968 | 11.812 (9.396 to 14.229) | <0.001 | 0.479 | 97.22 | 94.8 |
| Overnight | 2 | 41 | 40 | 9.485 (3.516 to 15.454) | 0.002 | | 2.78 | 0.0 |
| Hormone | | | | | | | | |
| Single | 54 | 2,107 | 1,822 | 11.021 (8.494 to 13.549) | <0.001 | 0.056 | 87.59 | 95.0 |
| Dual | 8 | 185 | 186 | 16.950 (11.412 to 22.488) | <0.001 | | 12.41 | 79.6 |
| Age | | | | | | | | |
| Adults | 23 | 814 | 713 | 13.107 (8.815 to 17.400) | <0.001 | 0.245 | 36.68 | 93.3 |
| Children and adolescents | 26 | 834 | 658 | 11.871 (8.191 to 15.551) | <0.001 | | 41.68 | 95.5 |
| Mixed population | 13 | 644 | 637 | 8.933 (5.819 to 12.048) | <0.001 | | 21.64 | 82.7 |
| Baseline HbA1c, % | | | | | | | | |
| <7.5 | 21 | 660 | 661 | 8.844 (5.906 to 11.782) | <0.001 | 0.039 | 34.13 | 91.6 |
| ≥7.5 | 41 | 1,632 | 1,347 | 13.245 (10.270 to 16.220) | <0.001 | | 65.87 | 92.9 |
| Diabetes duration, yr | | | | | | | | |
| <20 | 38 | 1,543 | 1,258 | 11.217 (8.443 to 13.991) | <0.001 | 0.555 | 64.51 | 94.2 |
| ≥20 | 21 | 707 | 708 | 12.756 (8.470 to 17.041) | <0.001 | | 35.49 | 93.7 |
| Type of closed-loop | | | | | | | | |
| Dual-hormone full closed-loop | 6 | 143 | 143 | 19.643 (13.736 to 25.550) | <0.001 | 0.027 | 9.41 | 78.5 |
| Single-hormone full closed-loop | 2 | 245 | 131 | 11.671 (8.676 to 14.666) | <0.001 | | 3.45 | 0.0 |
| Hybrid closed-loop | 54 | 1,904 | 1,734 | 10.873 (8.310 to 13.436) | <0.001 | | 87.14 | 95.0 |
| Type of algorithm | | | | | | | | |
| MPC | 37 | 1,261 | 1,105 | 11.411 (8.736 to 14.086) | <0.001 | 0.915 | 59.29 | 88.7 |
| PID | 15 | 595 | 568 | 11.595 (7.654 to 15.537) | <0.001 | | 24.09 | 87.8 |
| Other | 10 | 436 | 335 | 13.091 (5.751 to 20.431) | <0.001 | | 16.62 | 98.6 |

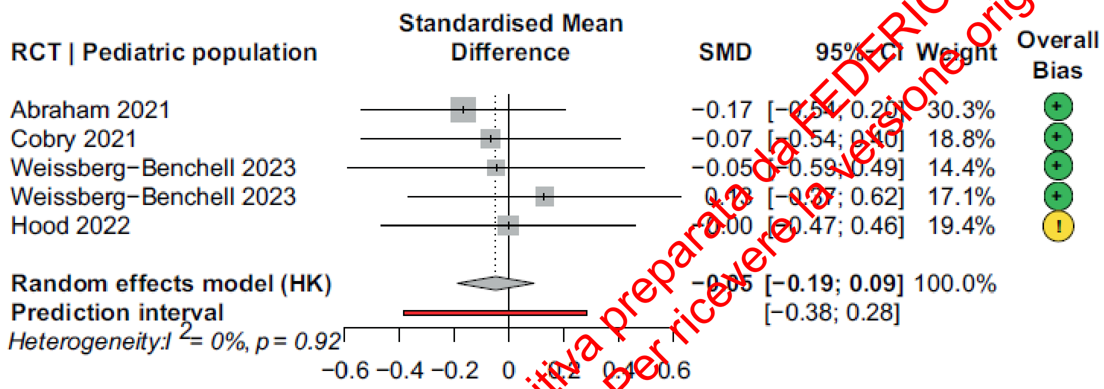
# AID & QoL

(a) RCT meta-analysis shows a small beneficial effect of AID on DD in adults

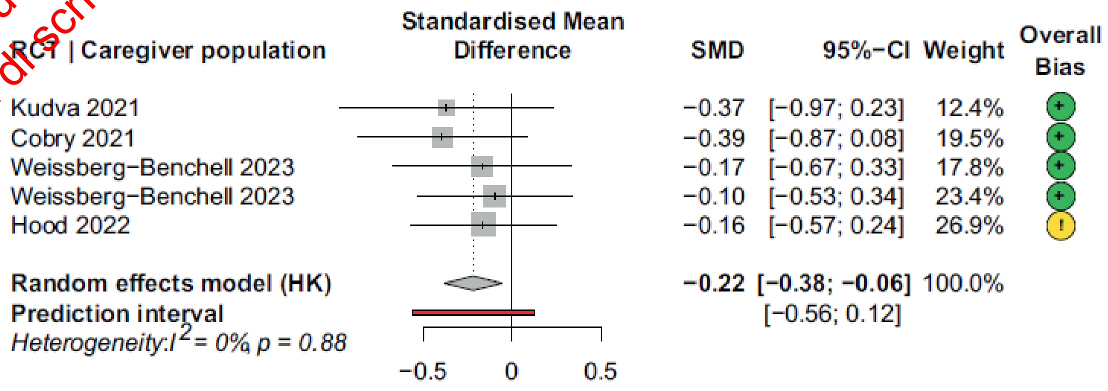
* Only study which included a fully closed-loop system




(c) RCT meta-analysis shows no effect of AID on DD in children/teenagers

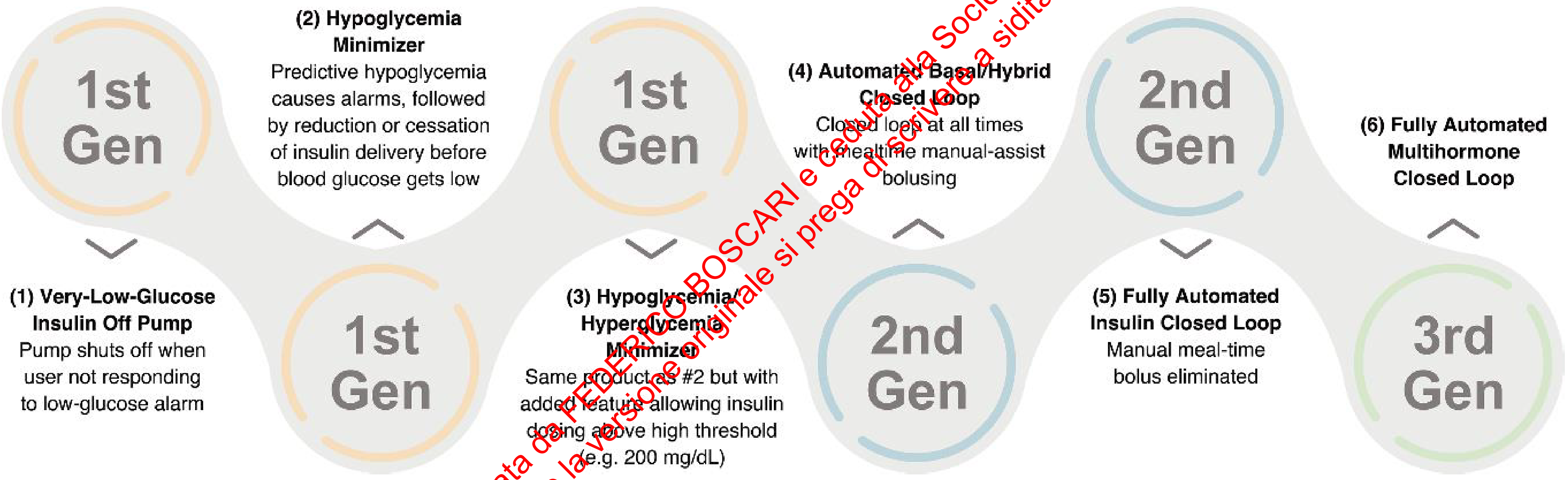



(b) RCT meta-analysis shows a small beneficial effect of AID on DD in caregivers




Canha D, McMahon V, Schmitz S, De Beaufort C, Alzaid F, Reznik Y, Riveline JP, Fagherazzi G, Aguayo GA. The effect of automated insulin delivery system use on diabetes distress in people with type 1 diabetes and their caregivers: A systematic review and meta-analysis. Diabet Med. 2025 Apr;42(4):e15503. doi: 10.1111/dme.15503. Epub 2024 Dec 26. PMID: 39726162; PMCID: PMC11929561.

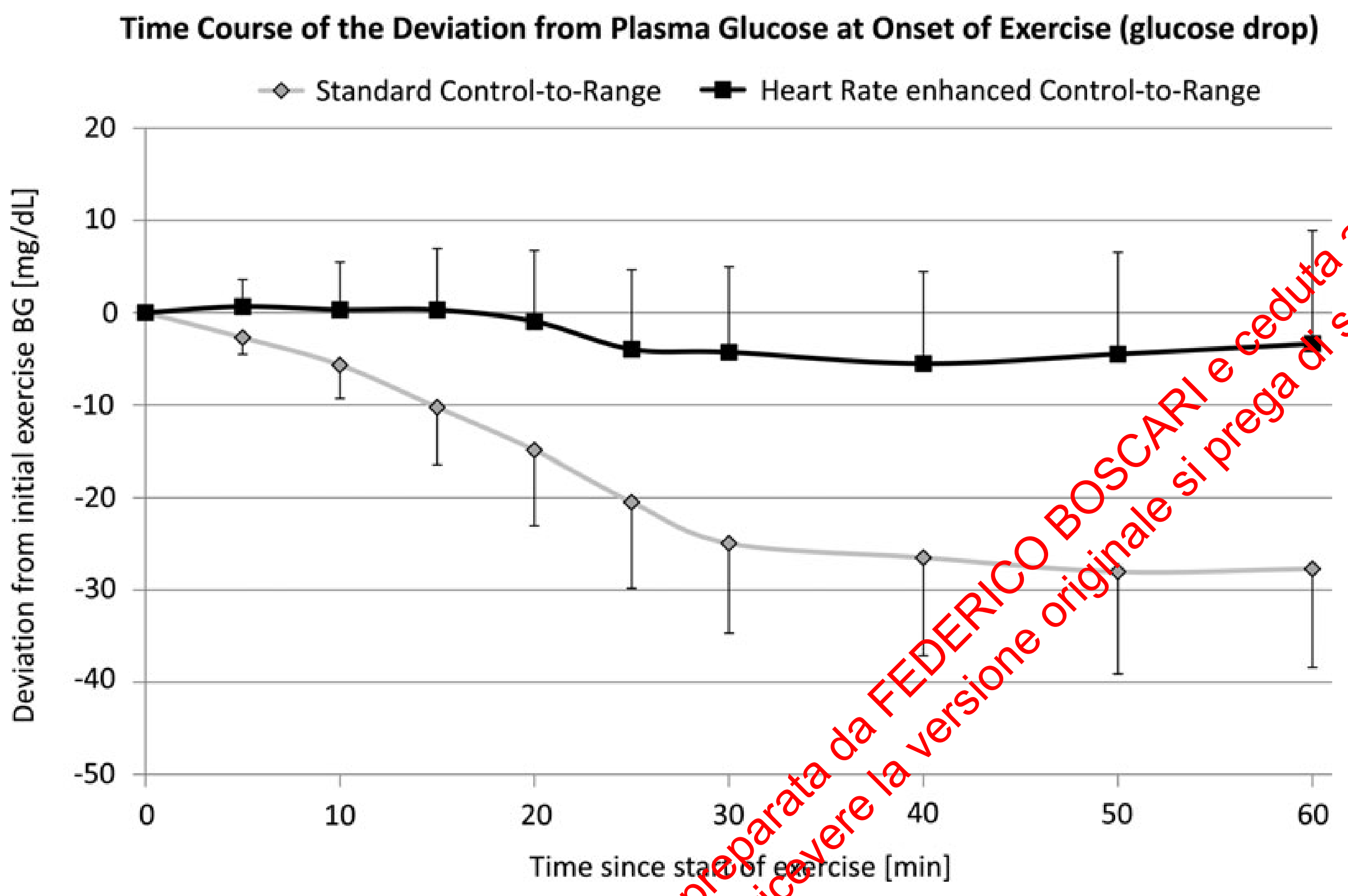
# AID:prospettive future

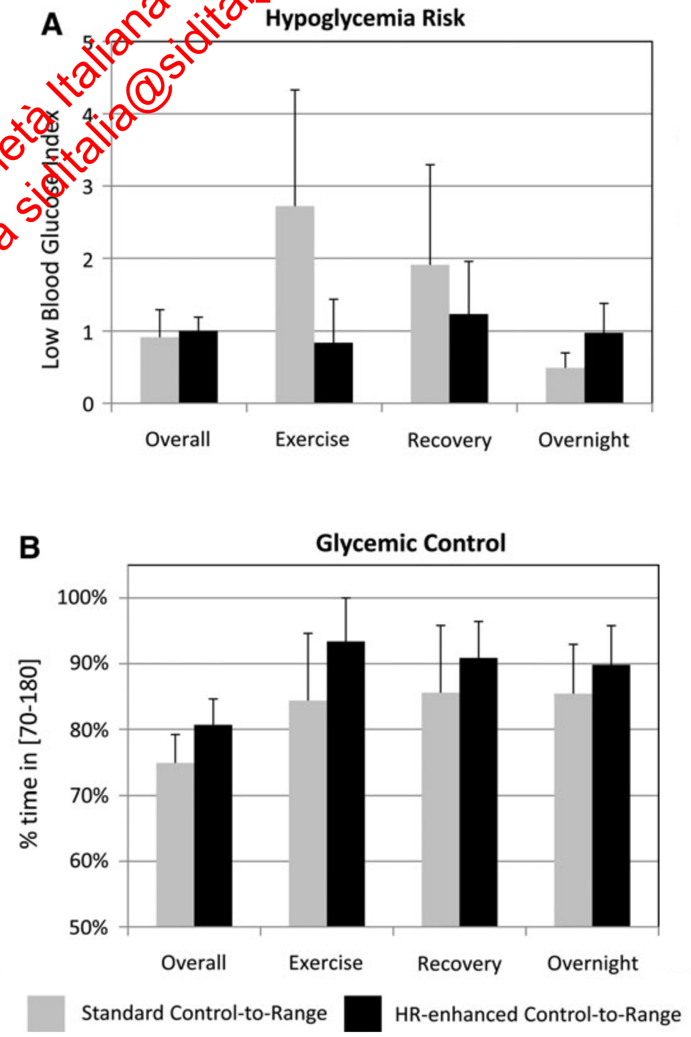





Zimmer RT, Auth A, Schierbauer J, Haupt S, Wachsmuth N, Zimmermann P, Voit T, Battelino T, Sourij H, Moser O. (Hybrid) Closed-Loop Systems: From Announced to Unannounced Exercise. Diabetes Technol Ther. 2023 Dec 22. doi: 10.1089/dia.2023.0293. Epub ahead of print. PMID: 38133645.

# Verso il full closed loop



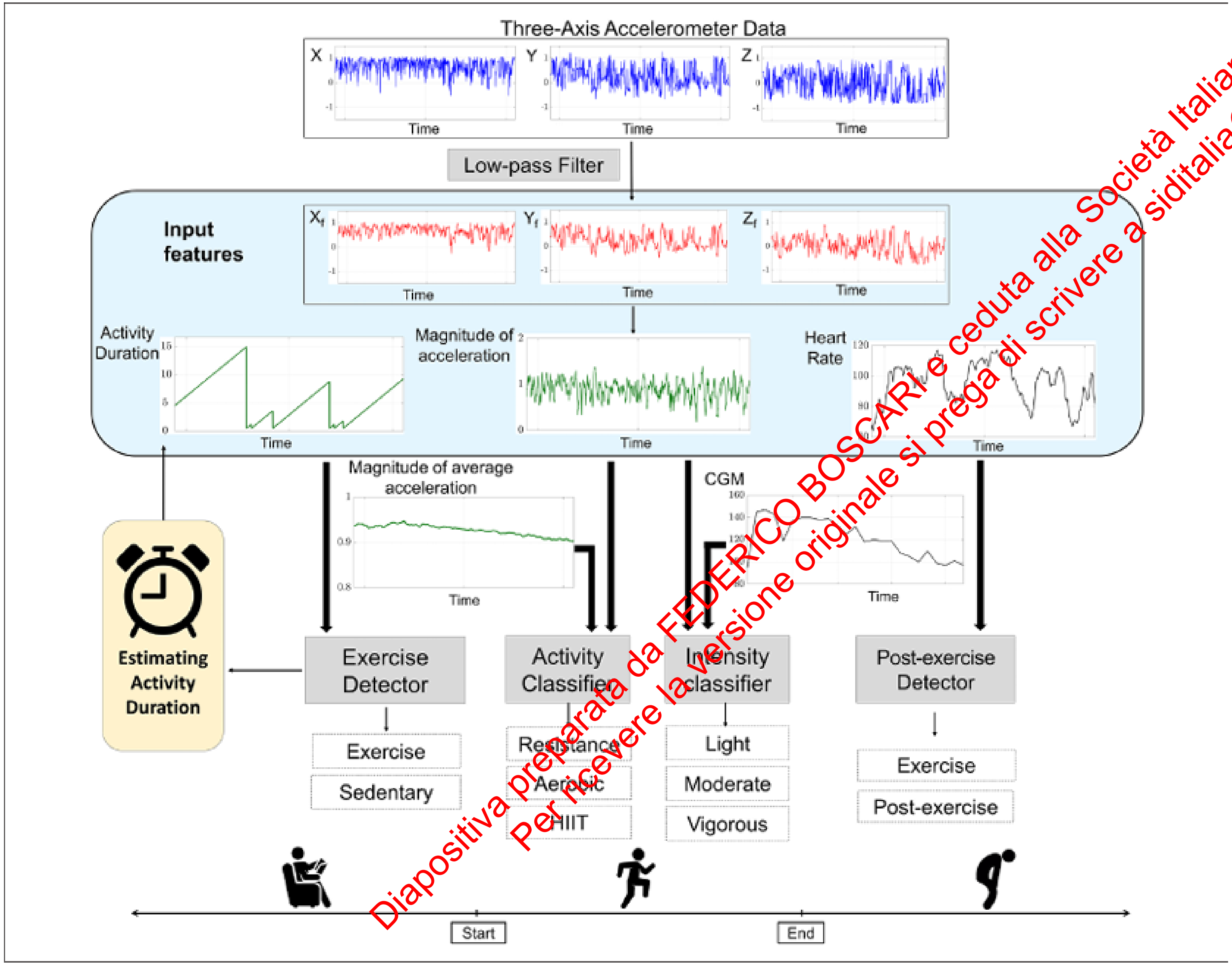







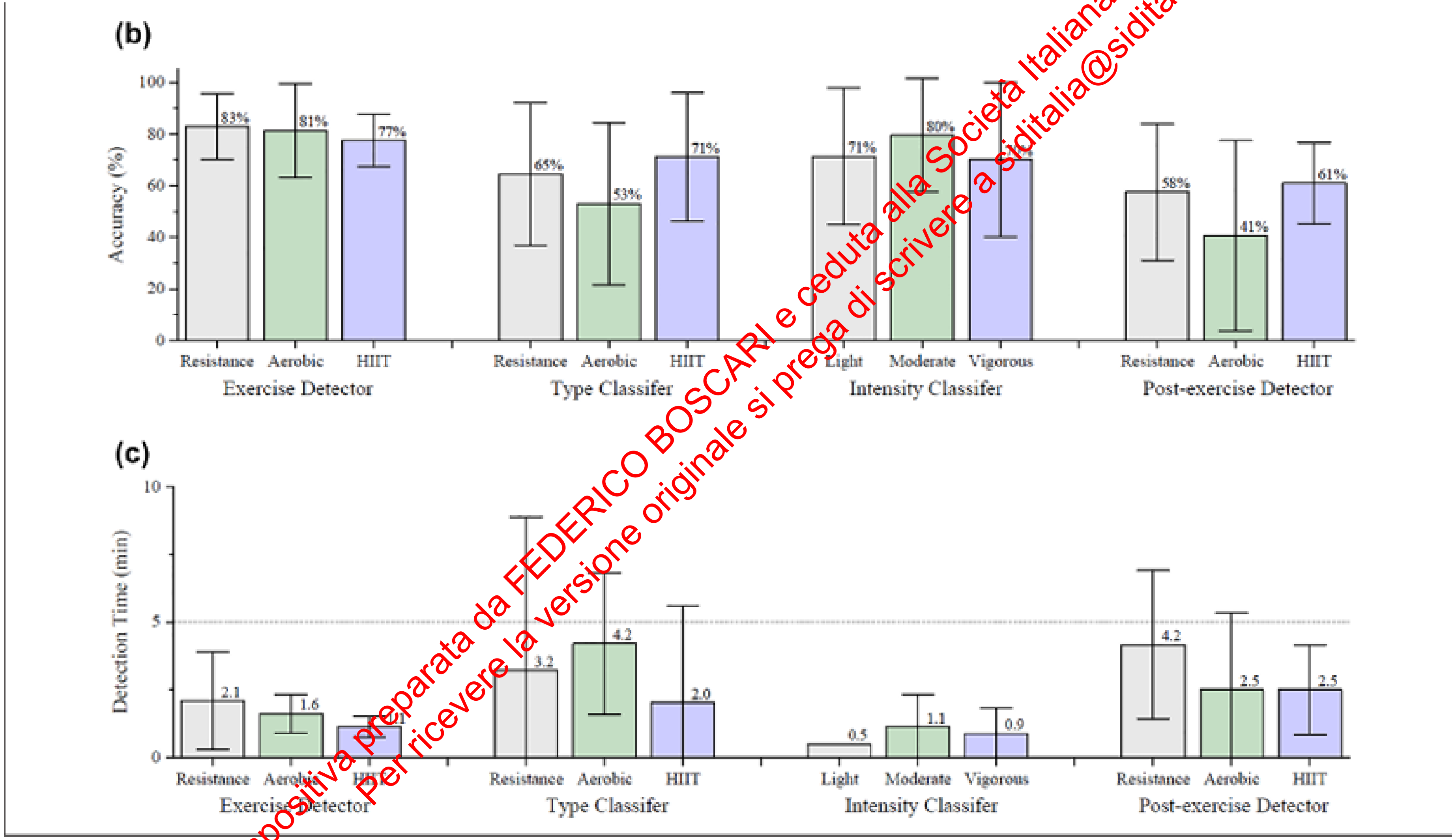
Breton MD, Brown SA, Karvetski CH, Kollar L, Topchyan KA, Anderson SM, Kovatchev BP. Adding heart rate signal to a control-to-range artificial pancreas system improves the protection against hypoglycemia during exercise in type 1 diabetes. Diabetes Technol Ther. 2014 Aug;16(8):506-11. doi: 10.1089/dia.2013.0333. Epub 2014 Apr 4. PMID: 24702135; PMCID: PMC4116126.

# Come identificare attività fisica

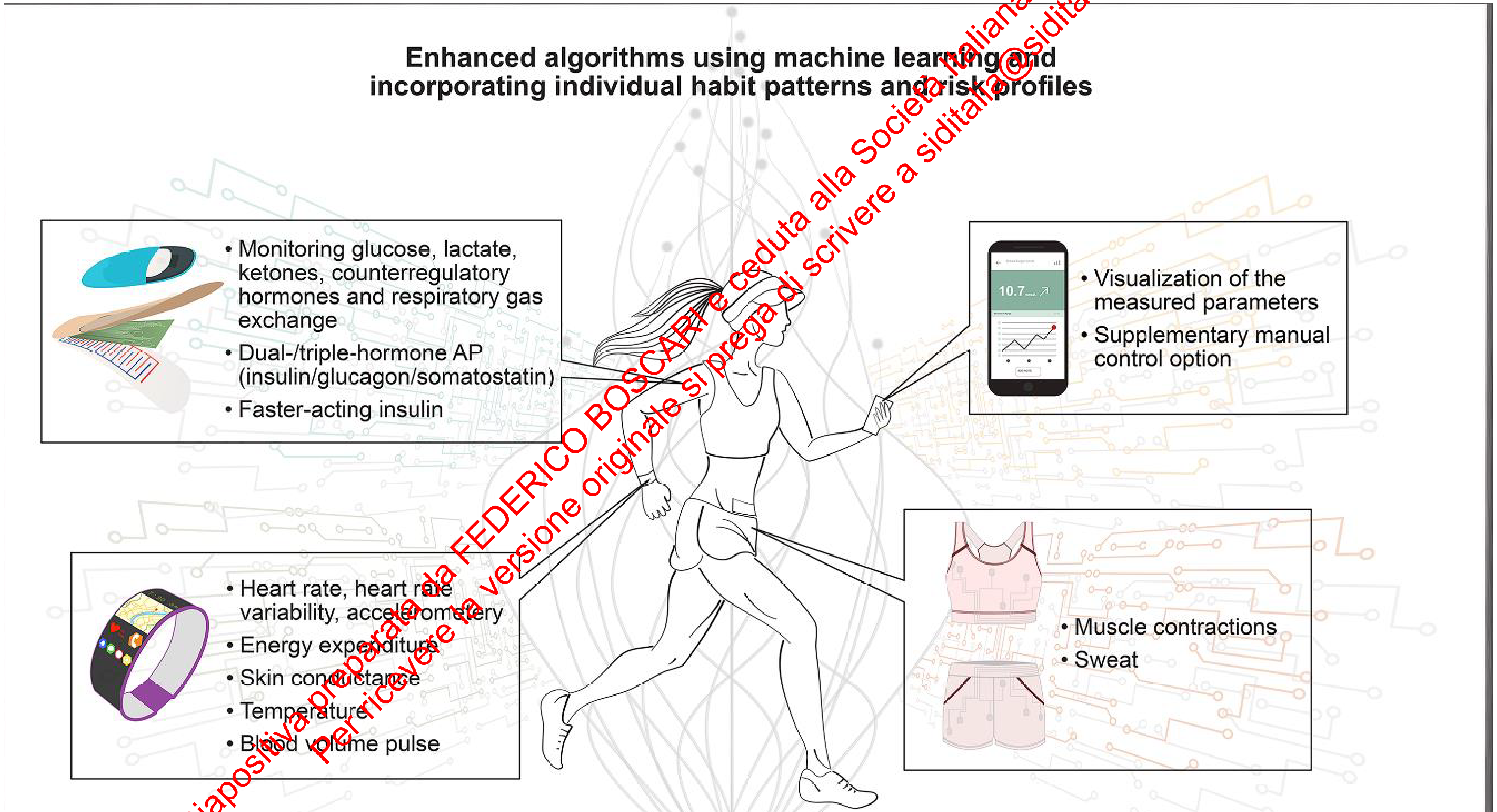



Cho S, Aiello EM, Ozaslan B, Riddell MC, Calhoun P, Gal RL, Doyle FJ 3rd. Design of a Real-Time Physical Activity Detection and Classification Framework for Individuals With Type 1 Diabetes. J Diabetes Sci Technol. 2024 Sep;18(5):1146-1156. doi: 10.1177/19322968231153896. Epub 2023 Feb 17. PMID: 36799284; PMCID: PMC11418461.

# Come identificare attività fisica



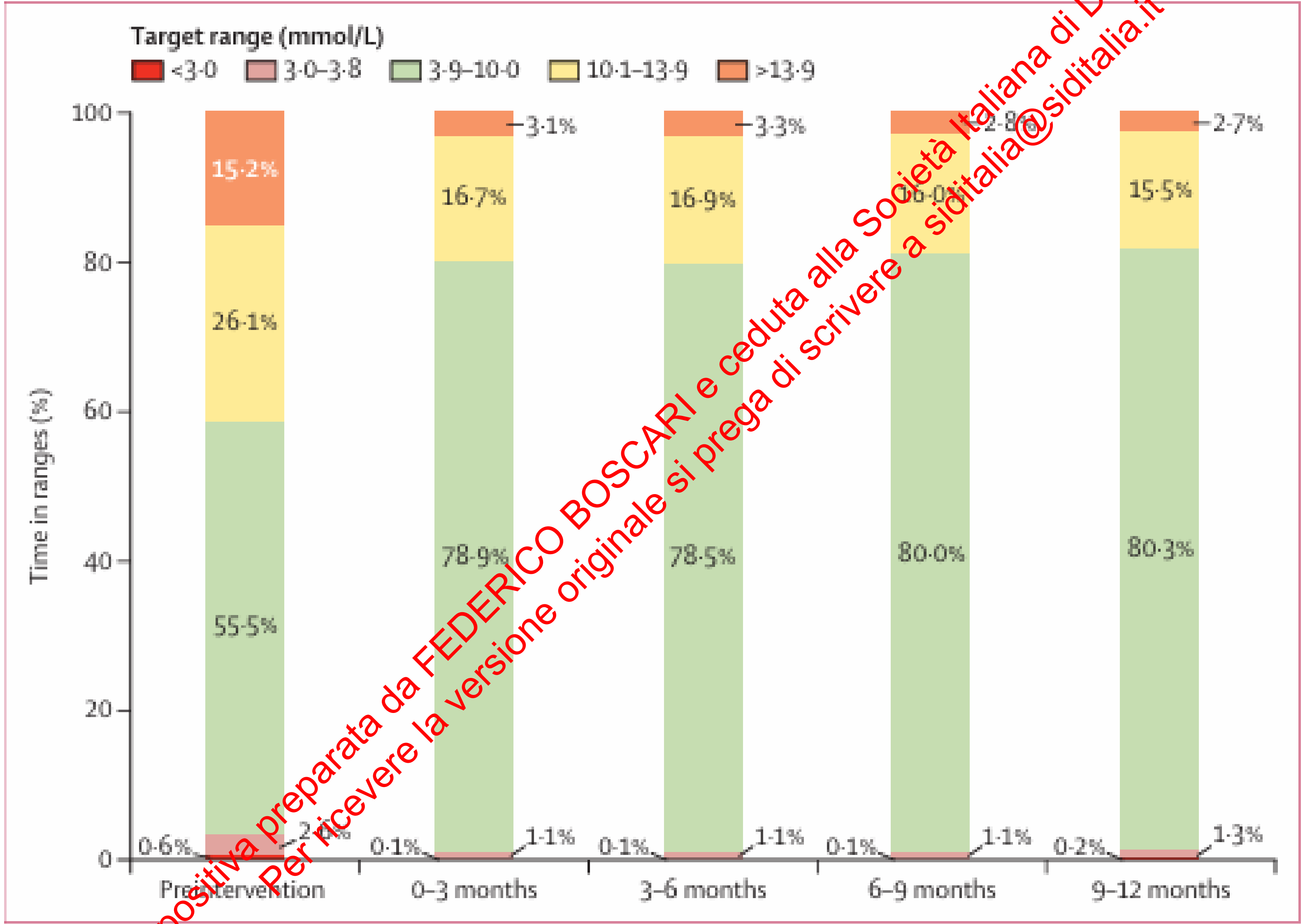
# AID:prospettive future






Zimmer RT, Auth A, Schierbauer J, Haupt S, Wachsmuth N, Zimmermann P, Voit T, Battelino T, Sourij H, Moser O. (Hybrid) Closed-Loop Systems: From Announced to Unannounced Exercise. Diabetes Technol Ther. 2023 Dec 22. doi: 10.1089/dia.2023.0293. Epub ahead of print. PMID: 38133645.

# Pancreas biormonale full closed loop



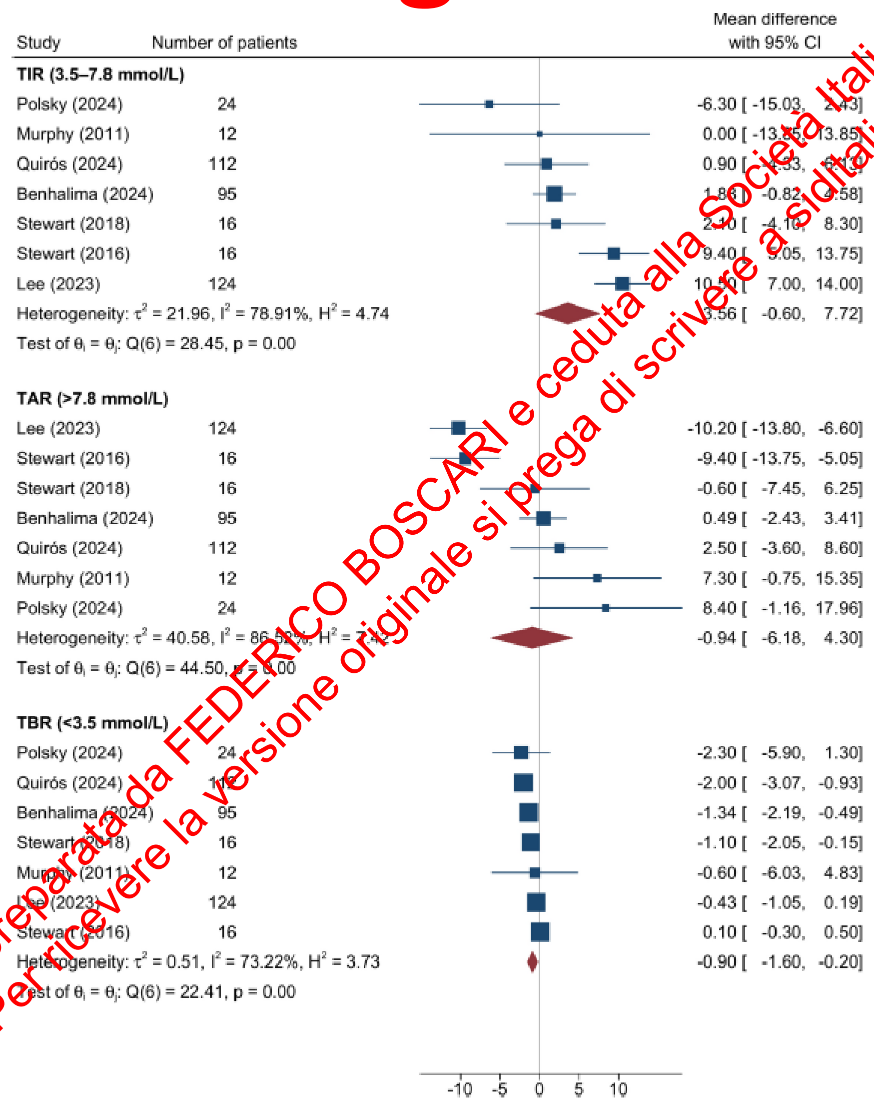



van Bon AC, Blauw H, Jansen TJP, Laverman GD, Urgert T, Geessink-Mennink J, Mulder AH, Out M, Groote Veldman R, Onvlee AJ, Schouwenberg BJJW, Vermeulen MAR, Diekman MJM, Gerding MN, van Wijk JPH, Klaassen M, Witkop M, DeVries JH. Bihormonal fully closed-loop system for the treatment of type 1 diabetes: a real-world multicentre, prospective, single-arm trial in the Netherlands. Lancet Digit Health. 2024 Apr;6(4):e272-e280. doi: 10.1016/S2589-7500(24)00002-5. Epub 2024 Mar 4. PMID: 38443309.

# AID: indicazioni

- DM1
  - gravidanza

# AID in gravidanza






Yang Q, Hao J, Cui H, Yang Q, Sun F, Zeng B. Automated insulin delivery in pregnant women with type 1 diabetes: a systematic review and meta-analysis. Acta Diabetol. 2025 Jan 17. doi: 10.1007/s00592-025-02454-x. Epub ahead of print. PMID: 39821308.

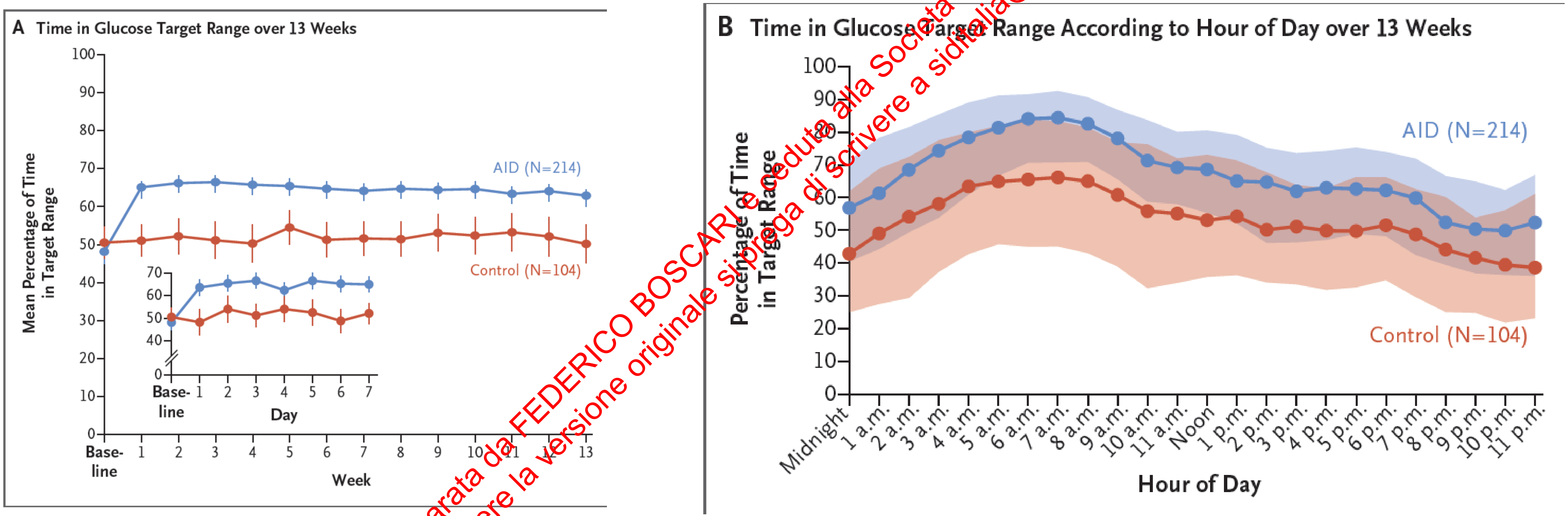
| Name study, registration number | Intervention vs comparator | Countries, centers, study end | Study design | Primary outcome(s) | (Main) secondary outcomes | Main results |
|---|---|---|---|---|---|---|
| AiDAPT study (Automated insulin Delivery Amongst Pregnant women with Type 1 diabetes), ISRCTN56898625[29,48] | CamAPS FX AID (Dana Diabecare RS + Dexcom G6 vs CSII or MDI) with Dexcom G6 CGM | UK, 9 centers, Nov 2022 | Multicenter, open-label, RCT<br>N = 124<br>1:1 randomization with stratification by site;<br>Eligibility: GA <14 weeks, HbA1c ≥48 mmol/mol (≥6.5%) and ≤86 mmol/mol (≤10%), 18-45 years, T1D diagnosis ≥1 year, intensive insulin therapy;<br>Run-in phase of masked Dexcom G6 for baseline data collection | TIRp 3.5-7.8 mmol/L (63-140 mg/dL) between 16 weeks until delivery | HbA1c; DKA; severe hypoglycemic episodes; mode of delivery; GA at delivery; infant birth weight; LGA; SGA; neonatal morbidity; NICU admission; pregnancy loss <24 weeks; stillbirth; neonatal death; fear of hypoglycemia, health status, diabetes distress; sleep quality; cost-effectiveness | AID led to a significant increase in TIRp of 10.5% (mean TIR 68.2% ± 10.5% in the AID group vs 55.6% ± 12.5% in the standard of care group), less TARp (difference of 10.2%), higher TIRp overnight (difference of 12.3%), without increase in TBRp and without unanticipated safety problems. Pregnancy outcomes were similar except for a significantly lower rate of hypertensive disorders (20% vs 42%) and less gestational weight gain (11.1 ± 6.1 vs 14.1 ± 6.1 kg) in the AID group vs comparator group. |
| CIRCUIT study (Closed-loop Insulin delivery by glucose Responsive Computer algorithms In Type 1 diabetes pregnancies), NCT04902378[47] | Tandem t: slim X2 pump with control IQ with Dexcom G6 CGM vs SoC (MDI or pump) with Dexcom G6 | Canada, 9 centers + Australia, 5 centers, 2026 | Multicentric open-label RCT<br>N = 94;<br>Eligibility: GA <14 weeks, HbA1c ≥48 mmol/mol-<86 mmol/mol (≥6.5-<10%), 18-45 years, T1D diagnosis ≥1 year, intensive insulin therapy;<br>Run-in phase of one week with Dexcom G6 CGM | TIRp 3.5-7.8 mmol/L (63-140 mg/dL) GA 16-34 weeks gestation | TARp; TBRp; mean blood glucose; Severe hypoglycemia; DKA; fear of hypoglycemia, fear of hyperglycemia,; sleep quality; work productivity, preeclampsia; gestational hypertension; worsening chronic hypertension events; C-sections; preterm delivery; LGA; SGA; mean neonatal birthweight; neonatal hypoglycemia; NICU admission; pregnancy loss | Expected in 2025 |
| CRISTAL study (Closed-loop insulin delivery in pregnant women with type 1 diabetes: a randomized controlled trial), NCT04520971[7,46] | MiniMed 780G system with Guardian 3 or 4 CGM vs continue SoC (MDI or open-loop pump) with any type of sensor | Belgium, 11 centers and the Netherlands 1 center, May 2023 | Multicenter, open-label RCT<br>N = 95<br>1:1 randomization with stratification by center, HbA1c and treatment (pump or MDI), GA <14 weeks;<br>Eligibility: GA <12 weeks, HbA1c ≤86 mmol/mol (≤10%), 18-45 years, T1D diagnosis ≥1 year, intensive insulin therapy;<br>Run-in phase of 10 days with masked Guardian 3 CGM as needed | TIRp 3.5-7.8 mmol/L (63-140 mg/dL) at GA 14-17, 20-23, 26-29, 33-36 weeks | Prespecified: time <3.5 mmol/L (63 mg/dL); overnight time<3.5 mmol/L (63 mg/dL); overnight TIRp 3.5-7.8 mmol/L (63-140 mg/dL)<br>Exploratory: device deficiencies; time >7.8 mmol/L (140 mg/dL); >10 mmol/L (180 mg/dL); time <2.8 mmol/L (50 mg/dL); <3.0 mmol/L (54 mg/dL); severe hypoglycemias; DKA; miscarriage; stillbirth; neonatal death; LGA; respiratory distress; birth trauma; shoulder dystocia; neonatal hypoglycemia; NICU admission; fear of hypoglycemia, health status, diabetes-related emotional distress, treatment satisfaction, cost-effectiveness | The TIRp increased from baseline to the antenatal period [averaged over the four prespecified time points (14–17,20–23,26–29, and 33–36 weeks of gestation)] in both groups: from 60.5% ± 14.2% to 66.5% ± 10.0% in the AID group and from 57.6% ± 13.7% to 63.2% ± 12.4% in the SoC group (adjusted mean difference, 1.88%; 95% CI, -0.82 to 4.58; *P* = .17). Overnight TIRp was higher (adjusted mean difference, 6.58%; 95% CI, 2.31 to 10.85, *P* = .0026), and TBRp overall (adjusted mean difference, -1.34%; 95% CI, -2.19 to -0.49, *P* = .0020) and overnight (adjusted mean difference, -1.86%; 95% CI, -1.86 to -0.81, *P* = .0005) were lower in women with AID compared with the SoC. |

Benhalima K, Polsky S. Automated Insulin Delivery in Pregnancies Complicated by Type 1 Diabetes. J Diabetes Sci Technol. 2025 Mar 12:19322968251323614. doi: 10.1177/19322968251323614. Epub ahead of print. PMID: 40071788; PMCID: PMC11904923.

# AID: indicazioni

- DM1
- DM2

# AID nel DM2




Kudva YC, Raghinaru D, Lum JW, Graham TE, Liljenquist D, Spanakis EK, Pasquel FJ, Ahmann A, Ahn DT, Aleppo G, Blevins T, Kruger D, Brown SA, Levy CJ, Weinstock RS, Steenkamp DW, Spaic T, Hirsch IB, Broyles F, Rickels MR, Tsoukas MA, Raskin P, Hatipoglu B, Desjardins D, Terry AN, Singh LG, Davis GM, Schmid C, Kravarusic J, Coyne K, Casaubon L, Espinosa V, Jones JK, Estrada K, Afreen S, Levister C, O'Malley G, Liu SL, Marks S, Peleckis AJ, Pasqua MR, Tardio V, Kurek C, Luker RD, Churchill J, Tajrishi FZ, Dean A, Dennis B, Fronczyk E, Perez J, Mukhashen S, Dhillon J, Ipek A, Bzdick S, Atakov Castillo A, Driscoll M, Averkiou X, Dalton-Bakes CV, Moore A, Jordan LF, Lesniak A, Pinsker JE, Sasson-Katchalski R, Campos T, Spanbauer C, Kanapka L, Kollman C, Beck RW; 2IQP Study Group. A Randomized Trial of Automated Insulin Delivery in Type 2 Diabetes. N Engl J Med. 2025 Mar 19. doi: 10.1056/NEJMoa2415948. Epub ahead of print. PMID: 40105270.

# AID: indicazioni

- DM1
- DM2
- Ospedale

# AID in Ospedale

| *Patient population* | *Rationale for AID use* |
|---|---|
| Steroid use | Corticosteroid doses are often variable in the hospital and lead to new or rapid changes in insulin requirements |
| Enteral or parenteral nutrition | Rapid adaptation needed for temporary or unanticipated discontinuation of feeding tubes, cycling of enteral nutrition with oral intake |
| Type 1 Diabetes | High glycemic variability and hypoglycemia risk |
| Perioperative period | Acute stress with rapid changes in insulin sensitivity, frequent short term steroid exposure |
| Pregnancy | Enhanced monitoring and safety are essential for tighter glycemic control during pregnancy to protect both mother and fetus. Insulin needs change throughout pregnancy, sometimes complicated by steroid use for premature deliveries, and dramatically fall after placenta delivery. |
| Uncontrolled type 2 diabetes | During the acute illness, many patients do not respond to conventional therapy or insulin needs are unknown. |

Hughes MS, Pasquel FJ, Davis GM, Lal RA, Buckingham BA, Boughton CK, Brown SA, Bally L. Toward Automation: The Road Traveled and Road Ahead for Integrating Automated Insulin Delivery into Inpatient Care. Diabetes Technol Ther. 2025 Mar;27(3):217-242. doi: 10.1089/dia.2024.0343. Epub 2024 Dec 2. PMID: 39618315.

# Tecnologia in Ospedale

*Recommendations*

**16.6** In people with diabetes using a personal continuous glucose monitoring (CGM) device, the use of CGM should be continued during hospitalization if clinically appropriate, with confirmatory point-of-care (POC) blood glucose measurements for insulin dosing decisions and hypoglycemia assessment, if resources and training are available, and according to an institutional protocol. **B**

**16.7** Continue use of insulin pump or automated insulin delivery in people with diabetes who are hospitalized when clinically appropriate, with confirmatory POC blood glucose measurements for insulin dosing decisions and hypoglycemia assessment and treatment. This is contingent upon availability of necessary supplies, resources, and training, ongoing competency assessments, and implementation of institutional diabetes technology protocols. **C**



Diabetes Care in the Hospital: Standards of Care in Diabetes— 2025 Diabetes Care 2025;48(Suppl. 1):S321–S334 | https://doi.org/10.2337/dc25-S016

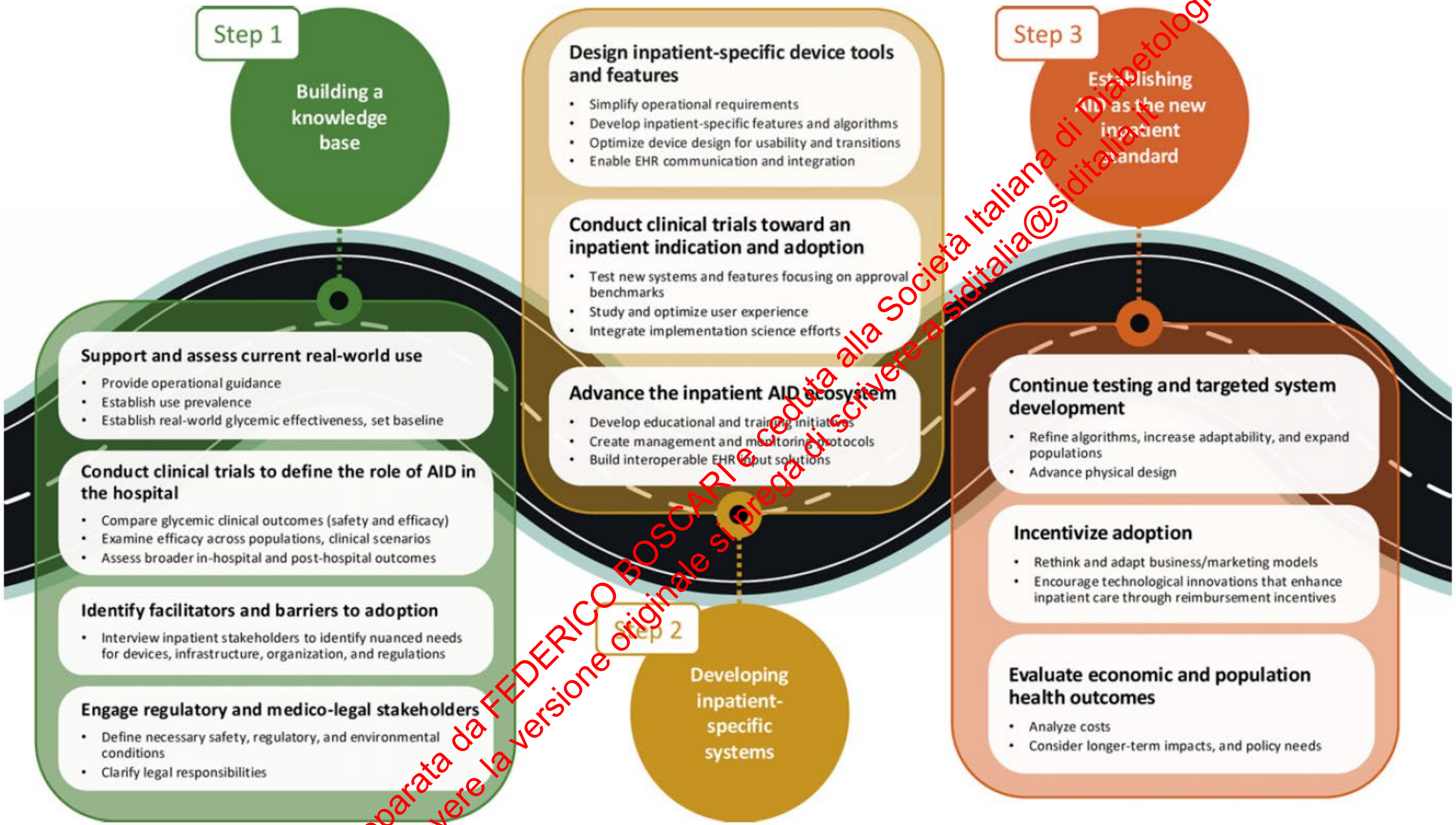
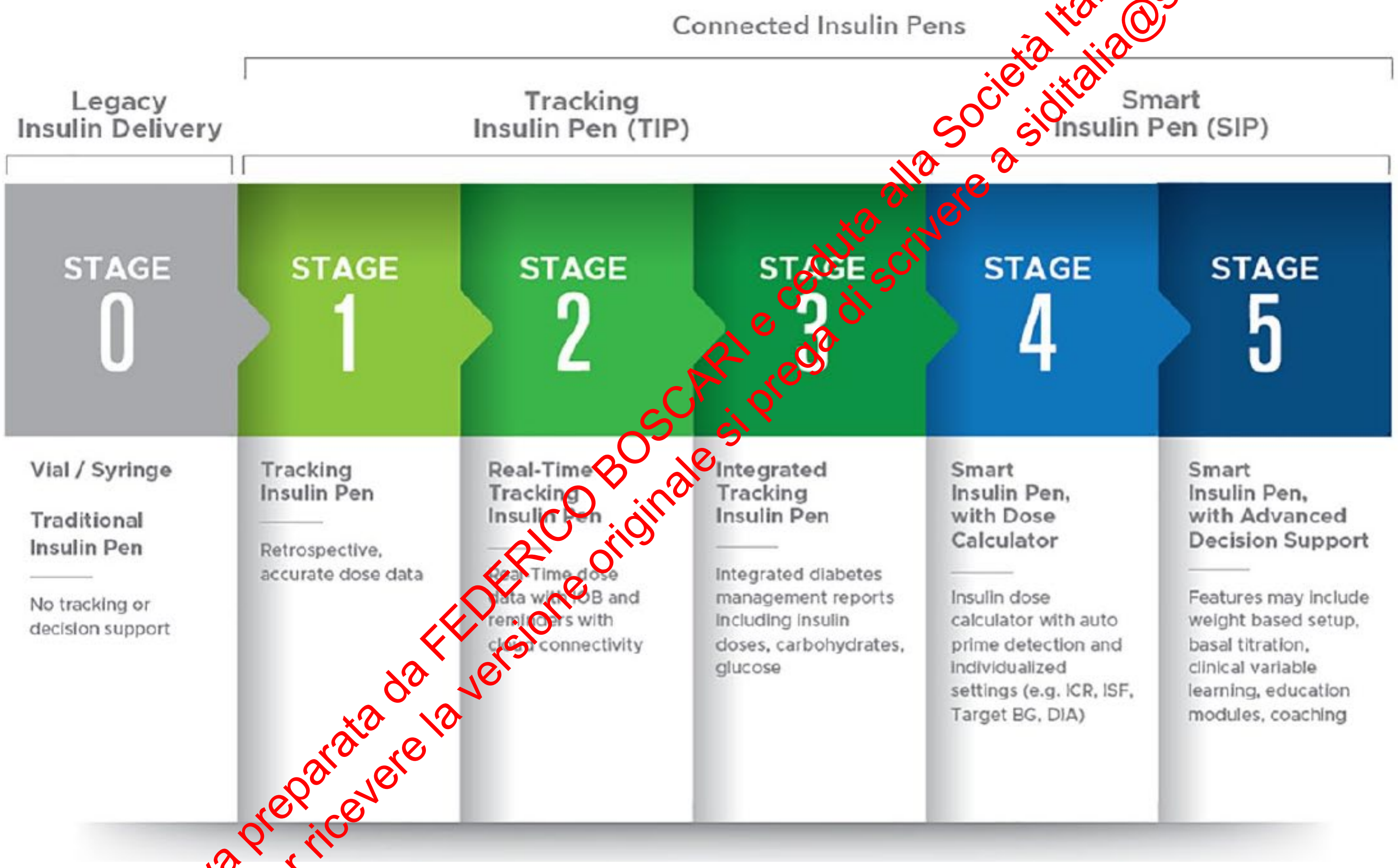



FIG. 1. A roadmap toward making AID an inpatient reality.

Hughes MS, Pasquel FJ, Davis GM, Lal RA, Buckingham BA, Boughton CK, Brown SA, Bally L. Toward Automation: The Road Traveled and Road Ahead for Integrating Automated Insulin Delivery into Inpatient Care. Diabetes Technol Ther. 2025 Mar;27(3):217-242. doi: 10.1089/dia.2024.0343. Epub 2024 Dec 2. PMID: 39618315.

# Smart MDI






MacLeod J, Vigersky RA. A Review of Precision Insulin Management With Smart Insulin Pens: Opening Up the Digital Door to People on Insulin Injection Therapy. J Diabetes Sci Technol. 2023 Mar;17(2):283-289. doi: 10.1177/19322968221134546. Epub 2022 Nov 3. PMID: 36326233; PMCID: PMC10012386.

# In che modo la tecnologia interviene nella gestione del diabete

Monitoraggio

Tecnologia & Diabete

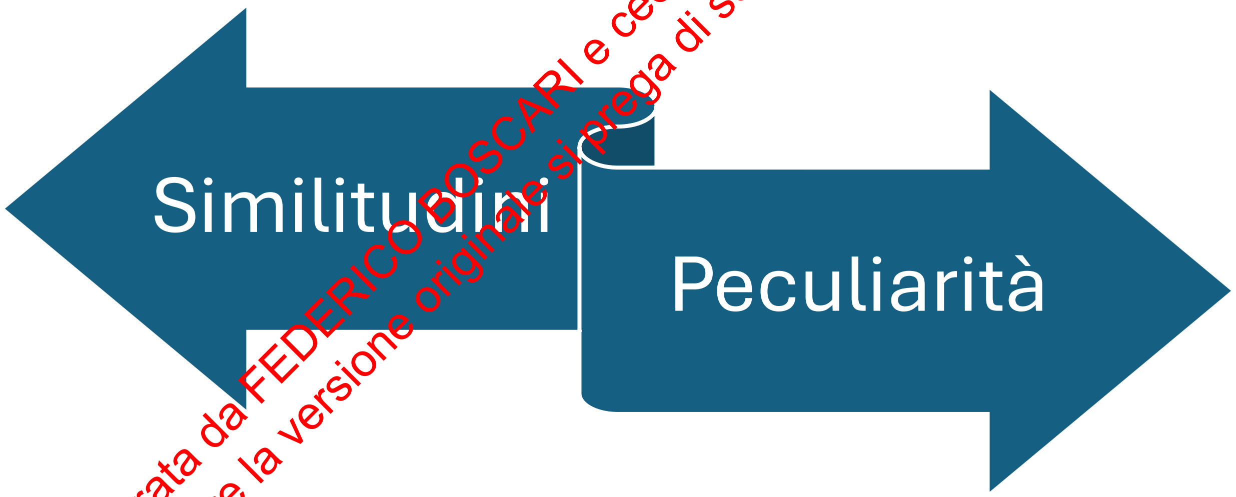
# Continuous Glucose Monitoring

**Lettura sottocutanea**

**Andamento glicemico**

**Frecce di tendenza**

**Allarmi**




**Applicazione**

**Durata**

**Calibrazioni**

**Interferenze**

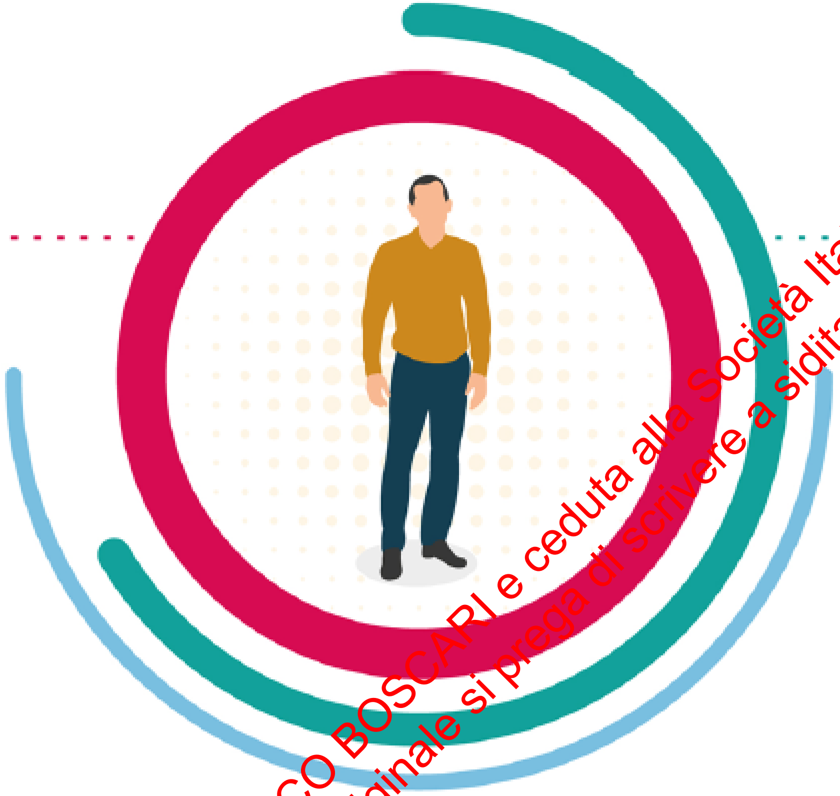
**Connettività**

**Accuratezza**

## ESSENTIAL FEATURES

(i.e., features that are absolutely necessary for all patients):

- **accuracy**
- **certification**



## MAJOR DRIVERS OF CHOICE

(i.e., features that address more relevant clinical issues and/or meet the needs of specific subgroup of patients):

- **approved indications of use**
- **alerts (optional, predictive, on body vibration)**
- **interoperability / integration**
- **approved application sites**
- **visualization devices**
- **transmitter removal**
- **cost of devices**

## ADDITIONAL FEATURES

(i.e., features that improve patient's experience):

- **preassembled vs. non-preassembled systems**
- **other alerts (snooze, delay)**
- **device size**
- **notes entry**
- **calibration**
- **allergens**
- **interferences**
- **impermeability**

Di Molfetta S, Rossi A, Boscari F, Irace C, Laviola L, Bruttomesso D. Criteria for Personalised Choice of a Continuous Glucose Monitoring System: An Expert Opinion. Diabetes Ther. 2024 Nov;15(11):2263-2278. doi: 10.1007/s13300-024-01654-y. Epub 2024 Sep 30. Erratum in: Diabetes Ther. 2025 Jan;16(1):135. doi: 10.1007/s13300-024-01666-8. PMID: 39347900; PMCID: PMC11467157.

# La rivoluzione del CGM

- Miglioramento del controllo
- Nuove metriche
- Nuove popolazioni target
- Nuovo ruolo del CGM

# CGM e Obesità

*Consensus statements. People living with obesity and at-risk of progression to type 2 diabetes mellitus*

- Periodic use of CGM should be considered in people living with obesity and at-risk of developing type 2 diabetes mellitus based on established risk factors,[33] to assess glycemic risks and support early intervention.
- Measures of CGM-defined glycemic risk amongst people living with obesity centred on time above tight range (TATR) >140 mg/dL (7.8 mmol/L) and glycemic variability may be used to identify persons at-risk of intermediate hyperglycemia.

- The application of CGM should be considered during proactive efforts to modify diet and physical activity in people living with obesity, in order to provide immediate feedback on the glycemic impact of dietary choices, as well as the glycemic benefits of physical activity and exercise.

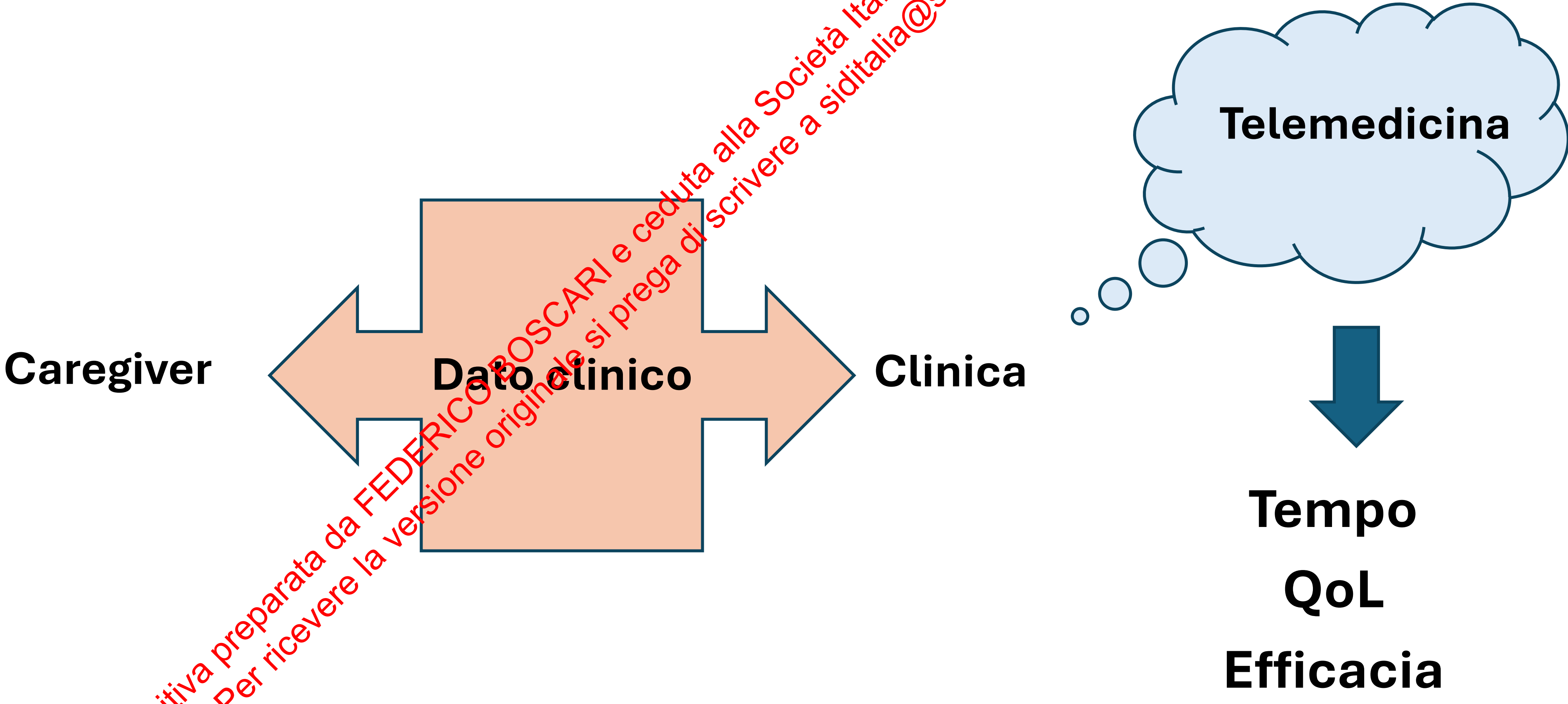
Battelino T, Lalic N, Hussain S, Ceriello A, Klobucar S, Davies SJ, Topsever P, Heverly J, Ulivi F, Brady K, Tankova T, Galhardo J, Tagkalos K, Werson E, Mathieu C, Schwarz P. The use of continuous glucose monitoring in people living with obesity, intermediate hyperglycemia or type 2 diabetes. Diabetes Res Clin Pract. 2025 Mar 19:112111. doi: 10.1016/j.diabres.2025.112111. Epub ahead of print. PMID: 40118193.

# CGM e Prediabete

*Consensus statements. People living with intermediate hyperglycemia and at-risk of progression to type 2 diabetes mellitus*

- Periodic use of CGM should be considered in people living with intermediate hyperglycemia, based on established risk factors for type 2 diabetes mellitus,[33] to assess glycemic risks and support early intervention when needed.
- For persons with prior intermediate hyperglycemia and a recent diagnosis of type 2 diabetes mellitus and able to meet CGM targets for >70% TIR, setting targets for TITR can be considered to aim for near-normal glycemia or remission.
- Remission criteria for people being treated for type 2 diabetes mellitus should mirror diagnostic criteria, and include: FPG <126 mg/dL (7.0 mmol/L), mean glucose levels <100 mg/dL (5.6 mmol/L), GMI <6.5% (<48 mmol/mol), sustained over 3 months in the absence of pharmacotherapy.
- Use of CGM should be considered as part of proactive efforts to modify diet and physical activity in people living with intermediate hyperglycemia, in order to provide immediate feedback on the glycemic impact of dietary choices and physical activity or exercise.

# Condivisione dato



# In che modo la tecnologia interviene nella gestione del diabete

Tecnologia & Diabete

Educazione

# Ruolo educativo

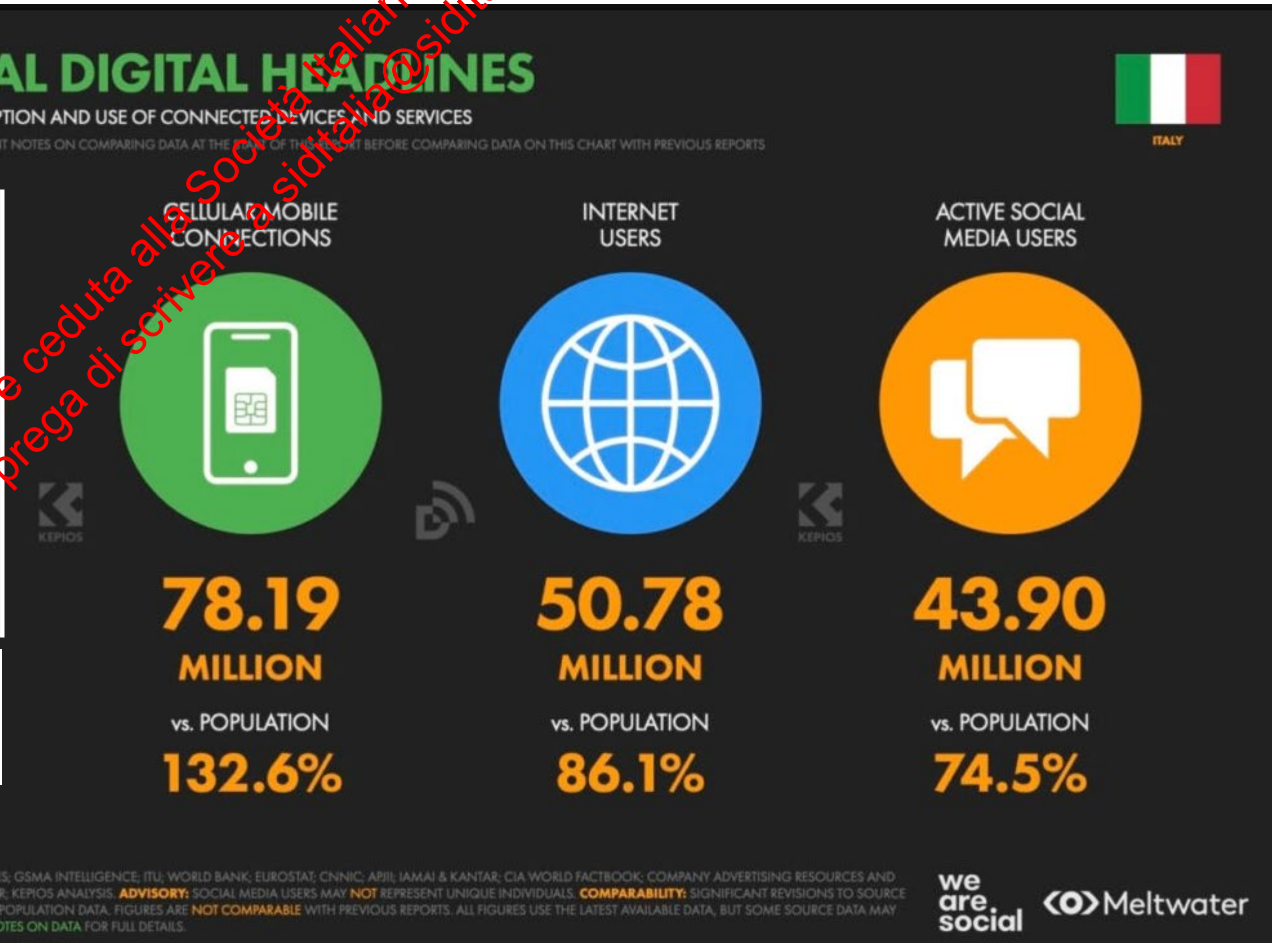
**1.3** Care systems should facilitate in-person and virtual team-based care, include those knowledgeable and experienced in diabetes management as part of the team, and utilize patient registries, decision support tools, proactive care planning, and community involvement to meet needs of individuals with diabetes. **B**

Improving Care and Promoting Health in Populations: Standards of Care in Diabetes—2025
Diabetes Care 2025;48(Suppl. 1):S14–S26 | https://doi.org/10.2337/dc25-S001

**use of video games, mobile applications, simulators and online interventions, which aim to promote knowledge about DM1, encourage self-care, and improve patients' quality of life. The use of technological resources, which are more attractive and focused on reality, can facilitate training, stimulate reasoning and the ability to solve problems**

Morgado PC, Silva LF, Aguiar RCB, Moraes JRMM, Luquez TMS, Brandão ES, Nunes MDR, Lopes IF, Campos DC. Educational technologies for families and children with type 1 diabetes: a scoping review. Rev Esc Enferm USP. 2024;58:e20240134. https://doi.org/10.1590/1980-220X-REEUSP-2024-0134en

# Ruolo educativo




**Due italiani su tre utilizzano app e device digitali per controllare il proprio stato di salute**

di Salvo Cagnazzo

*Le app più gettonate sono quelle dedicate a dieta e alimentazione (28%), al monitoraggio di pressione e battito cardiaco (24%), alla regolarità del ciclo mestruale (20%)*

*La Repubblica, 7 Dicembre 2021*

# APP & Diabete

- Registrare dati clinici
- Ruolo nel CHO Counting e calcolo del bolo
- Condivisione dati
- Ruolo nell'adottare stili di vita salutari
- Migliorare conoscenza diabete
- Prevenire complicanze
- Interazione

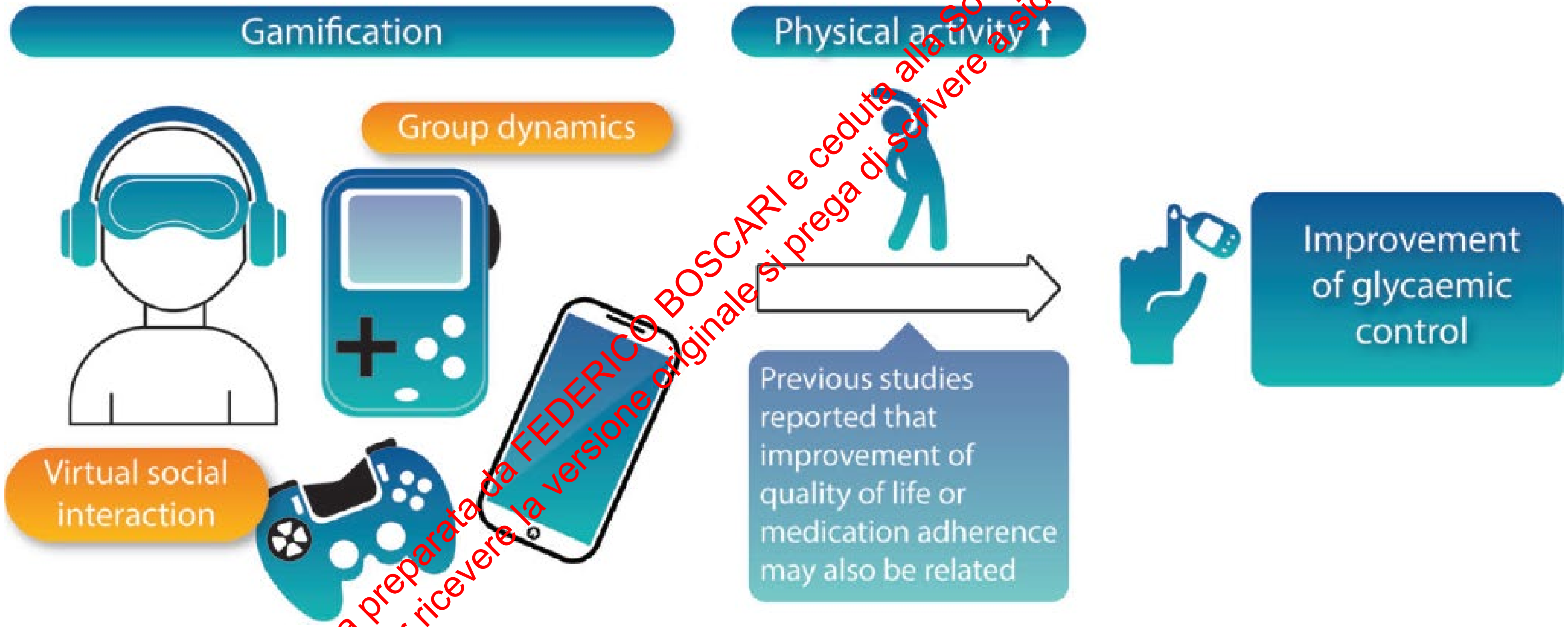
# APP & CHO Counting

**Table 2.** Carbohydrate counting and glycemic control outcomes (at baseline and follow-up).

| Outcomes | Baseline | | | Follow-up | | | Coefficient |
|---|---|---|---|---|---|---|---|
| | iSpy (n=22) | Usual care (n=22) | *P* value | iSpy (n=21) | Usual care (n=22) | *P* value | |
| Absolute error (% of total grams), mean (SD) | 31.97 (11.36) | 32.03 (10.01) | .99 | 27.45 (10.90) | 38.00 (14.74) | .008 | –10.479 |
| Errors >10 g (%), mean (SD) | 25.00 (14.06) | 27.73 (15.10) | .54 | 21.43 (16.82) | 32.27 (16.31) | .047 | –9.851 |
| Total time (seconds), mean (SD) | 79.95 (23.88) | 80.73 (27.82) | .92 | 74.86 (31.78) | 78.23 (44.97) | .79 | –2.741 |
| $HbA_{1c}$[a] (%), mean (SD) | 8.41 (1.84) | 8.35 (1.32) | .91 | 8.06 (1.43) | 8.80 (1.60) | .03 | –0.603 |

Alfonsi JE, Choi EEY, Arshad T, Sammott SS, Pais V, Nguyen C, Maguire BR, Stinson JN, Palmert MR. Carbohydrate Counting App Using Image Recognition for Youth With Type 1 Diabetes: Pilot Randomized Control Trial. JMIR Mhealth Uhealth. 2020 Oct 28;8(10):e22074. doi: 10.2196/22074. PMID: 33112249; PMCID: PMC7657721.

# APP & Diabete






Kaihara T, Intan-Goey V, Scherrenberg M, Falter M, Frederix I, Akashi Y, Dendale P. Impact of gamification on glycaemic control among patients with type 2 diabetes mellitus: a systematic review and meta-analysis of randomized controlled trials. Eur Heart J Open. 2021 Oct 18;1(3):oeab030. doi: 10.1093/ehjopen/oeab030. PMID: 35919887; PMCID: PMC9242065.

| Name of the Game | Description of the Game | Features of the Game | Game Themes | Game Mechanics | Operating Systems |
|---|---|---|---|---|---|
| Gluco Bear | The game aims to provide education regarding the best nutrition for diabetic patients. It involves a bear which get through different levels by matching healthy food and keeping the blood glucose level low. | • Available in three languages. (English, German, Portuguese)<br>• Includes quizzes<br>• More than 100 types of food with different sugar levels.<br>• Targeted age group +3 | Quizzes | Levels | Android |
| Pandabetic | It aims to educate type I diabetic children through entertainment. The children need to maintain the glucose level of the character through managing insulin and carbohydrates. | • Available in three languages: (English, Spanish, Italian)<br>• Social interaction through the support of game center. (for iOS)<br>• It supports family sharing feature for up to six family members. (for iOS)<br>• Targeted age group +3 | Taking care of a character | Levels and points | Both Android and iOS |
| Diapets | The game encourages the diabetic child to check the blood levels on time, help to overcome the fear of insulin needles and to count carbs. This is done through taking care of a baby dragon character. | • Notification feature for reminding for the eating time and for using blood glucose meter. It supports family sharing feature for up to six family members. Targeted age group +4, 6–8 | Taking care of a character | Points | iOS |
| GlucoZor World | The game aims to provide education about diabetes in general by taking care of the game character. The user can choose the color and the weight of the character. The user can feed the character, entertain him by many activities that need to be unlocked, and managing his blood glucose level. | • Available in four languages. (English, Dutch, Italian, Spanish)<br>• It includes quizzes<br>• It supports family sharing feature for up to six family members.<br>• Targeted age group +3 | Taking care of a character | Levels, points and dashboard | Both Android and iOS |
| Diabetes control | The game is generally a glycemic index which include certain type of food and their amount of sugar. The user shall choose among two type of food which include less amount of sugar. | • More than 30 comparison of more than 60 types of food<br>• Great to memorize<br>• Targeted age group +3 | Quizzes | N/A | Android |

Alsalman D, Bu Ali ZM, Alnosaier ZF, Alotaibi NA, Alanzi TM. Gamification for Diabetes Type 1 Management: A Review of the Features of Free Apps in Google Play and App Stores. J Multidiscip Healthc. 2020 May 14;13:425-432. doi: 10.2147/JMDH.S249664. PMID: 32523349; PMCID: PMC7236238.

Medication Adherence Apps (MAA)

Telemedicine Apps (TA)

Behavioral Support Apps (BSA)

Education and Knowledge Support Apps (EKSA)

Comprehensive Management Apps (CMA)

| | Study | Experimental Total | Experimental Mean | Experimental SD | Control Total | Control Mean | Control SD | Mean Difference[95%CI] | P value | Weight |
|---|---|---|---|---|---|---|---|---|---|---|
| MAA | T. Kamat 2011 | 59 | -1.70 | 0.21 | 59 | -0.80 | 0.23 | -0.90[-0.98,-0.82] | <0.001 | 2.85% |
| | Z. Huang 2019 | 25 | 3.00 | 1.69 | 25 | 0.80 | 1.70 | 2.20[1.26,3.14] | <0.001 | 1.50% |
| TA | M. M. Bujnowska-Fedak 2011 | 50 | -0.26 | 1.09 | 50 | -0.18 | 1.21 | -0.08[-0.53,0.37] | 0.728 | 2.37% |
| | P. Klee, C 2018 | 28 | -0.33 | 0.99 | 27 | 0.21 | 0.65 | -0.54[-0.98,-0.10] | 0.016 | 2.39% |
| | M. J. Crowley 2016 | 25 | -1.30 | 0.29 | 25 | -0.30 | 0.29 | -1.00[-1.16,-0.84] | <0.001 | 2.79% |
| | J. S. Baron 2017 | 45 | -0.51 | 1.91 | 36 | 0.05 | 1.25 | -0.56[-1.25,0.13] | 0.112 | 1.92% |
| | M. S. Ruiz De Adana 2020 | 163 | 0.01 | 0.61 | 167 | -0.04 | 0.53 | 0.05[-0.07,0.17] | 0.427 | 2.82% |
| BSA | S. Goyal 2017 | 46 | 0.00 | 0.94 | 46 | 0.04 | 0.88 | -0.04[-0.41,0.33] | 0.833 | 2.51% |
| | E. Knox 2019 | 24 | 0.18 | 0.98 | 25 | 0.24 | 0.83 | -0.06[-0.57,0.45] | 0.817 | 2.26% |
| | M. A. Sevick 2012 | 131 | -0.60 | 1.57 | 132 | -0.20 | 1.26 | -0.40[-0.74,-0.06] | 0.023 | 2.55% |
| | M. M. Ruissen 2023 | 111 | -0.40 | 0.93 | 115 | -0.10 | 0.93 | -0.30[-0.54,-0.06] | 0.015 | 2.70% |
| | Hilmarsdóttir 2021 | 15 | -0.70 | 1.41 | 15 | 1.34 | 0.01 | -2.04[-2.75,-1.33] | <0.001 | 1.88% |
| EKSA | H. Buysse 2020 | 81 | -0.40 | 2.67 | 72 | -0.50 | 2.51 | 0.10[-0.72,0.92] | 0.811 | 1.69% |
| | W. B. Zhou 2016 | 50 | -1.95 | 1.68 | 50 | -0.79 | 1.79 | -1.16[-1.84,-0.48] | <0.001 | 1.94% |
| | C. Or 2016 | 33 | -0.20 | 0.56 | 30 | -0.20 | 0.53 | 0.00[-0.27,0.27] | 1.000 | 2.67% |
| | M. Moattari 2013 | 22 | -2.03 | 0.95 | 22 | -0.60 | 1.25 | -1.43[-2.09,-0.77] | <0.001 | 1.98% |
| | M. C. Rossi 2013 | 64 | -0.49 | 0.08 | 64 | -0.48 | 0.08 | -0.01[-0.04,0.02] | 0.480 | 2.86% |
| | K. C. Gunawardena 2019 | 35 | -2.32 | 1.06 | 32 | -1.27 | 0.52 | -1.05[-1.44,-0.66] | <0.001 | 2.47% |
| CMA | Y. B. Lee 2023 | 91 | -0.28 | 0.46 | 92 | 0.07 | 0.61 | -0.35[-0.51,-0.19] | <0.001 | 2.79% |
| | Y. Zhai 2020 | 60 | -2.15 | 0.85 | 58 | -1.83 | 0.88 | -0.32[-0.63,-0.01] | 0.045 | 2.60% |
| | C. Sun 2019 | 44 | -1.00 | 0.57 | 47 | -0.66 | 0.61 | -0.34[-0.58,-0.10] | 0.006 | 2.70% |
| | P. C. Tang 2013 | 202 | -1.14 | 1.25 | 213 | -0.95 | 1.35 | -0.19[-0.44,0.06] | 0.137 | 2.69% |
| | D. Sunil Kumar 2021 | 150 | -0.26 | 0.77 | 150 | 0.13 | 1.04 | -0.39[-0.60,-0.18] | <0.001 | 2.74% |
| | G. Wang 2017 | 106 | -1.10 | 0.53 | 106 | -0.60 | 0.92 | -0.50[-0.70,-0.30] | <0.001 | 2.75% |
| | C. Y. Han 2023 | 212 | -0.57 | 0.78 | 206 | -0.05 | 0.83 | -0.52[-0.67,-0.37] | <0.001 | 2.80% |
| | C. C. Quinn 2011 | 62 | -1.90 | 1.49 | 56 | -0.70 | 1.34 | -1.20[-1.71,-0.69] | <0.001 | 2.26% |
| | R. Zamanillo-Campos 2023 | 96 | -1.40 | 0.99 | 111 | -1.40 | 0.86 | 0.00[-0.25,0.25] | 1.000 | 2.69% |
| | K. Waki 2015 | 15 | -0.60 | 0.70 | 7 | 0.30 | 0.38 | -0.90[-1.35,-0.45] | <0.001 | 2.37% |
| | L. Zhang 2019 | 78 | -1.10 | 0.98 | 78 | -1.34 | 0.86 | 0.24[-0.05,0.53] | 0.104 | 2.64% |
| | C. Riangkam 2022 | 43 | -0.60 | 0.37 | 43 | -0.20 | 0.44 | -0.40[-0.57,-0.23] | <0.001 | 2.78% |
| | Y. Wang 2019 | 60 | -1.50 | 1.68 | 60 | -0.76 | 1.68 | -0.74[-1.34,-0.14] | 0.016 | 2.09% |
| | M. Kirwan 2013 | 36 | -1.10 | 0.84 | 36 | 0.07 | 0.82 | -1.17[-1.55,-0.79] | <0.001 | 2.49% |
| | R. Iljaz 2017 | 58 | -0.70 | 1.07 | 60 | -0.10 | 1.07 | -0.60[-0.99,-0.21] | 0.002 | 2.48% |
| | Alfonsi Jeffrey E 2020 | 22 | -0.35 | 1.30 | 22 | 0.45 | 1.14 | -0.80[-1.52,-0.08] | 0.030 | 1.86% |
| | Anzaldo-Campos M. C 2016 | 102 | -3.02 | 1.59 | 100 | -1.30 | 1.91 | -1.72[-2.21,-1.23] | <0.001 | 2.31% |
| | Bisio 2022 | 57 | -0.30 | 1.13 | 23 | -0.30 | 1.32 | 0.00[-0.61,0.61] | 1.000 | 2.06% |
| | Charpentier 2011 | 59 | -0.70 | 0.84 | 61 | 0.19 | 0.82 | -0.89[-1.19,-0.59] | <0.001 | 2.63% |
| | Chatzakis 2019 | 40 | -0.90 | 0.36 | 40 | -0.30 | 0.38 | -0.60[-0.76,-0.44] | <0.001 | 2.79% |
| | Derkaoui 2023 | 32 | -0.90 | 1.70 | 30 | -0.20 | 0.90 | -0.70[-1.37,-0.03] | 0.041 | 1.96% |
| | Forjuoh 2014 | 99 | -1.10 | 1.07 | 95 | -0.70 | 1.21 | -0.40[-0.72,-0.08] | 0.015 | 2.59% |
| | Franc 2020 | 231 | -0.41 | 0.84 | 221 | -0.20 | 0.76 | -0.21[-0.36,-0.06] | 0.005 | 2.80% |
| | **Random effects model** | **2962** | | | **2907** | | | **-0.49[-0.65,-0.32]** | **<0.001** | **100.00%** |

*Heterogeneity: $I^2 = 95\%$, $tau^2 = 0.25$, $p < 0.001$*

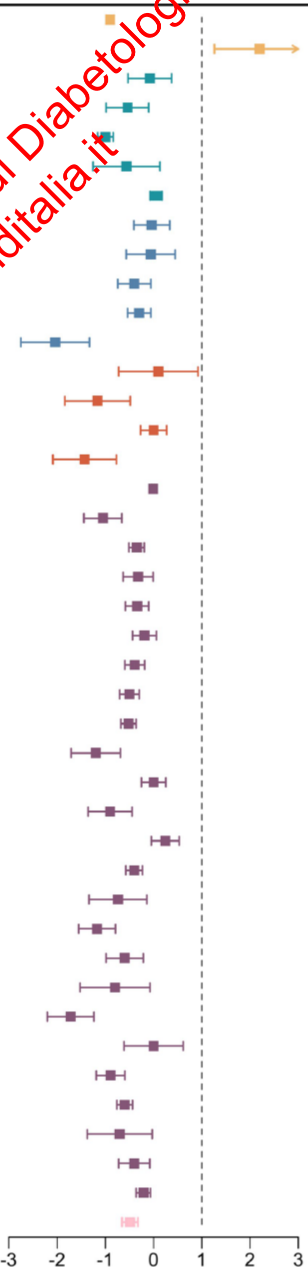
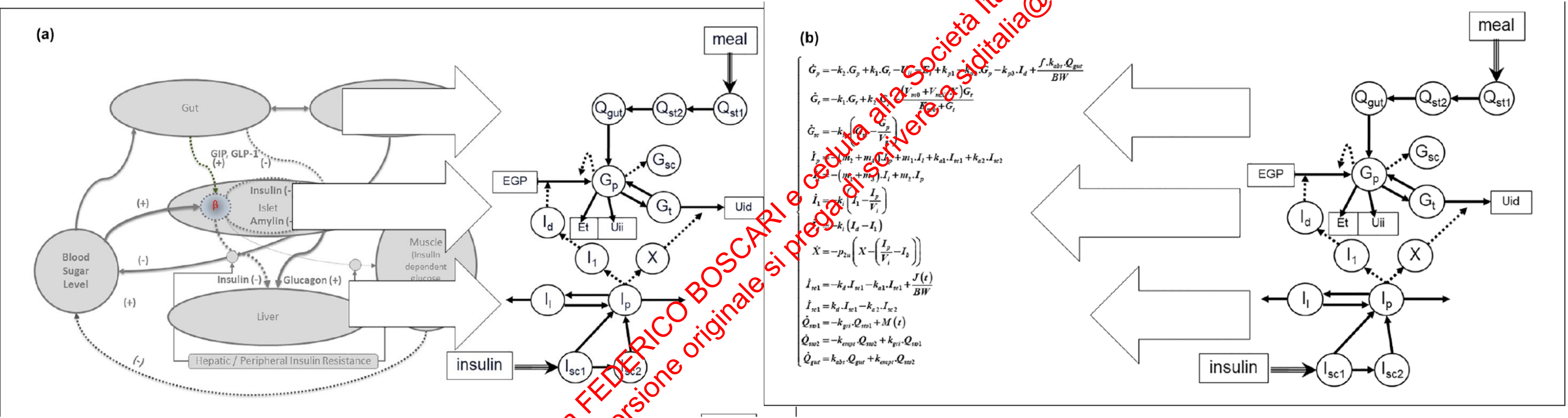



FIGURE 2
Forest plot illustrating the effect of mobile health on HbA1c.

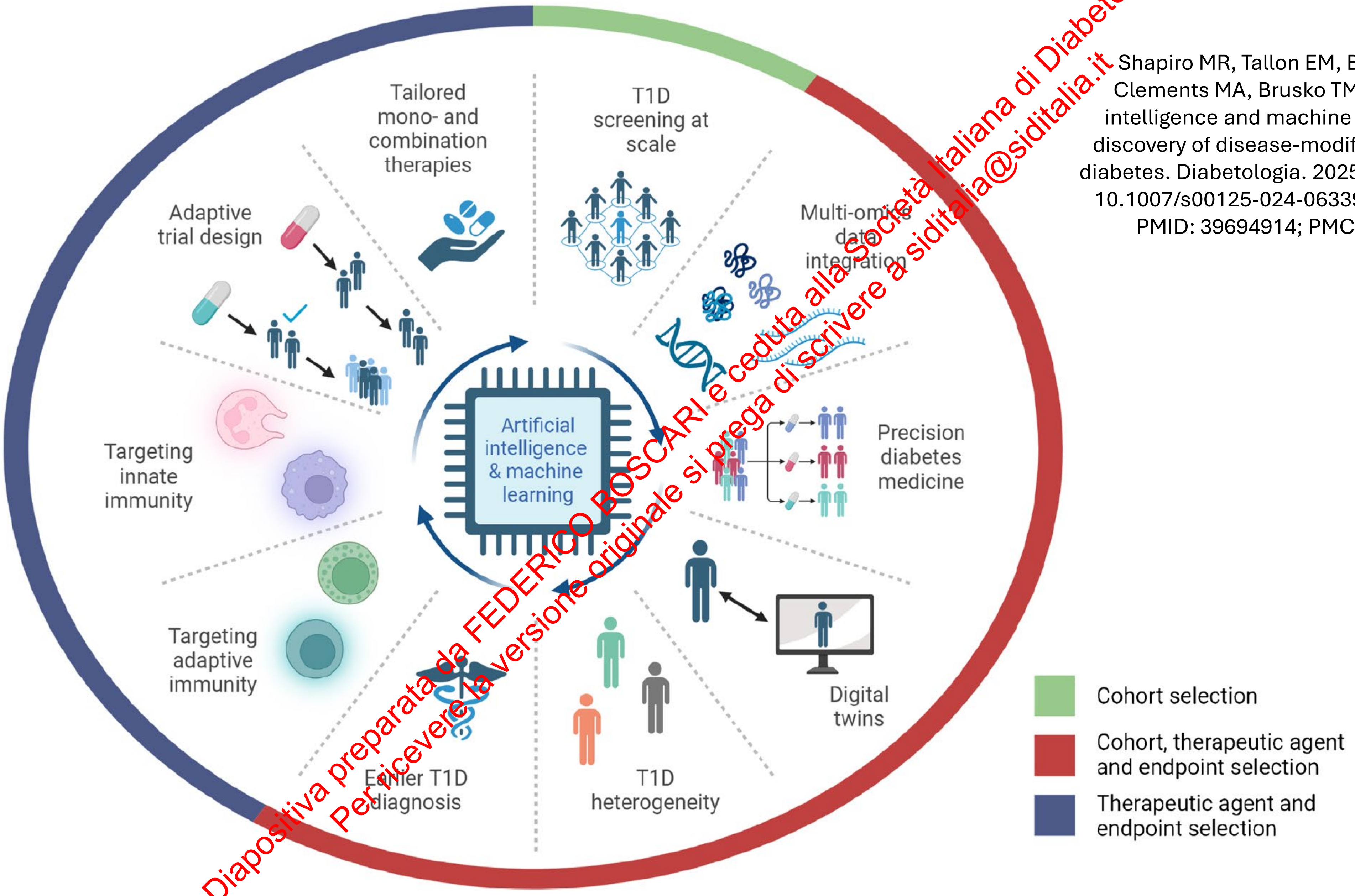
Yu X, Wang Y, Liu Z, Jung E. Technological functionality and system architecture of mobile health interventions for diabetes management: a systematic review and meta-analysis of randomized controlled trials. Front Public Health. 2025 Feb 20;13:1549568. doi: 10.3389/fpubh.2025.1549568. PMID: 40051514; PMCID: PMC11884075.

# In che modo la tecnologia interviene nella gestione del diabete

# Tecnologia & Ricerca




Cobelli C, Kovatchev B. Developing the UVA/Padova Type 1 Diabetes Simulator: Modeling, Validation, Refinements, and Utility. J Diabetes Sci Technol. 2023 Nov;17(6):1493-1505. doi: 10.1177/19322968231195081. Epub 2023 Sep 25. PMID: 37743740; PMCID: PMC10658679.




Shapiro MR, Tallon EM, Brown ME, Posgai AL, Clements MA, Brusko TM. Leveraging artificial intelligence and machine learning to accelerate discovery of disease-modifying therapies in type 1 diabetes. Diabetologia. 2025 Mar;68(3):477-494. doi: 10.1007/s00125-024-06339-6. Epub 2024 Dec 19. PMID: 39694914; PMCID: PMC11832708.

# I limiti della tecnologia

- Educazione
- Formazione paziente/clinico
- Diffusione
- Equità

**Table 1. Prevalence of type 1 diabetes and usage of diabetes technology by selected countries and regions[a]**

| | Overall prevalence of diabetes (percentage of overall population with diabetes) | Percentage of overall population with diabetes that have type 1 diabetes | Percentage of patients with type 1 diabetes that use medical technology (pump/CSII, CGM, or closed-loop hybrid system/automated insulin delivery system) | Percentage of adolescent and young adult patients with type 1 diabetes that use medical technology (pump/CSII, CGM, or closed-loop hybrid system/ automated insulin delivery system) |
|---|---|---|---|---|
| **North America** | | | | |
| Canada | 5.88 million<br>15% of population [10] | 5%-10% [11] | 35% pump<br>24% CGM [12] | No data |
| United States | 38.4 million<br>11.6% of population [13] | 5%-10% [13] | 66% CGM [14]<br>41% pump [14] | 40% CGM [14] |
| **Latin America** | | | | |
| Mexico | 14.1 million<br>14.1% of population | 6% [15] | 21% CSII [15]<br>9% CGM | No data |
| **Asia** | | | | |
| Korea | 4.4 million<br>13.9% of population | 1.1% | 10.7% CGM [16, 17] | 14.0% pump<br>39.3% CGM [18] |
| Japan | 11.96 million<br>14.6% of population [19] | 2.4% [20, 21] | 39% pump<br>11% SAP<br>48.4% CGM [22] | 21%-28% SAP [22] |
| Taiwan | 2.186 million<br>11.3% of adults [23] | 0.24% | No data | No data |
| Malaysia | 3.6 million<br>19% of population [24] | 0.62% [25] | <10% [26] | |
| India | 101 million<br>11.4% of population [25] | 5%-10% | <10% pump<br>No data on CGM | |
| **Africa** | | | | |
| Rwanda | 400 000 [1]<br>4.5% of population | 0.9% [1] | Technology not available | |
| Kenya | 460 000 [27]-821 500 [28]<br>4.2% [27] to 5.1% [28] of population | ≤10% [27] | 3% CGM [29] | |
| South Africa | 4.6 million [30]<br>10.5% [30] to 11.3% of population [28] | 7% [1, 28] | 1% pump<br>16% CGM [29]; | |
| **Europe/Australia/New Zealand** | | | | |
| Australia | 1.3 million<br>5.3% population [31] | 9.6% [31] | 33.3% pump<br>80.3% CGM | pump 45%<br>CGM 70% [32] |
| New Zealand | 268 700<br>6.2% of population | 5-10% [33] | No data | For children <15 years:<br>40% pump<br>67% CGM<br>2.3% AID |
| Switzerland | 400 000-500 000 of 8.74 million (~5% of the population) [28, 34] | 0.8%-1% [1] | No data | No national data. One center experience: aged <20 years: 50% pump (SAP or AID)<br>95% CGM; |
| Other Europe | 61 million<br>7% of population | 5% | Germany:<br>57% pump<br>49% CGM [35]<br>Denmark:<br>39% pump<br>60% CGM [36]<br>Norway:<br>74% pump<br>52% CGM [37]<br>Sweden:<br>70% pump (children) [38] and 30% pump (adults) [39]<br>80% CGM [38] | Technology is generally fully covered for children |

Conway RB, Snell-Bergeon J, Honda-Kohmo K, Peddi AK, Isa SB, Sulong S, Sibomana L, Gerard Gonzalez A, Song J, Lomax KE, Lo CN, Kim W, Haynes A, de Bock M, Burckhardt MA, Schwab S, Hong K. Disparities in Diabetes Technology Uptake in Youth and Young Adults With Type 1 Diabetes: A Global Perspective. J Endocr Soc. 2024 Nov 28;9(1):bvae210. doi: 10.1210/jendso/bvae210. PMID: 39703363; PMCID: PMC11655873.

# Conclusioni

- La tecnologia ha un ruolo fondamentale nelle gestione complessiva del diabete
- Ruolo dei clinici e delle società scientifiche deve essere quello di garantire un accesso equo a tali risorse e di formare il personale alla corretta gestione delle tecnologie stesse