In the Range: Real Talk on Diabetes Monitoring Best Practices

Episode 6: Patient Portal: Leveraging Technology to Improve Safety with Clinical Decision-Making for People with Diabetes

Cornerstone Medical Education

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Burden of Diabetic Ketoacidosis (DKA) + Gaps in Current Monitoring Strategies

Rising Burden of DKA over 21 Years

- Long-term real-world data on DKA in UK adults: incidence, recurrence, and predictors in type 1 (T1D) and type 2 diabetes (T2D) using linked primary and secondary care records (1999 to 2019)

- Results: (N=78,856 T1, N=577,088 T2)
  - 16.4% of T1D and 1.29% of T2D experienced at least 1 DKA episode
  - Annual incidence rose from 1.21% to 4.17% (T1D), and 0.06% to 0.34% (T2D)
  - Of those who experienced DKA, recurrence affected 31.5% of people with T1D and 12.1% with T2D
  - Recent DKA was the strongest predictor of recurrence
    - Other predictors included: female sex, younger age, socioeconomic deprivation, multimorbidity

Table 1– 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)

All associations shown were statistically significant at P < 0.001 (quasi-Poisson model, adjusted for

Seidu SI, et al. *ATTD*. 2026.

New Data: Risk Factors for DKA

Prevalence: Studies show T2D makes up a significant minority of DKA cases, with some reports citing it as high as 82.9% in specific high-risk, under-resourced populations.

Incidence Rates: In older adults (60-90 years), the incidence is roughly 5-7 per 100,000 person-years.

Ketosis-Prone Type 2 (KPD): A specific subset of T2D patients is prone to ketosis, which can cause DKA. Or those misdiagnosed and are T1D (Single or Multiple antibody positive)

Precipitating Factors: Common causes include infection (especially COVID-19), missing medication or insulin doses, and use of SGLT2 inhibitors.

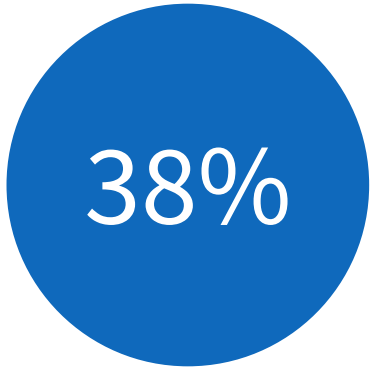
Rising Incidence: Data from the CDC indicates that DKA hospitalizations, including those in T2D, have increased over time, potentially due to factors like COVID-19 or SGLT2 inhibitor use

Wysham C, et al. *Diabetes*. 2026.

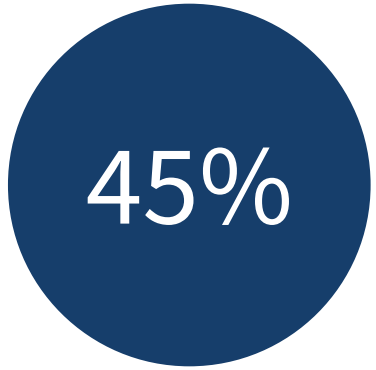
Burden of DKA: Why is it Such a Problem?

Lack of Self-Monitoring-But WHY???

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



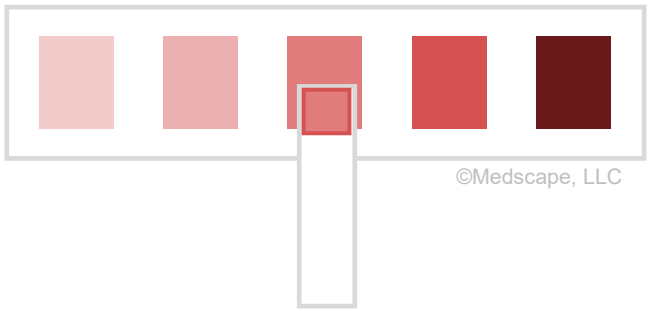
Never test ketones when nauseated and/or vomiting



Never test ketone levels when they detect a fever

Albanese-O'Neil A, et al. Diabetes Care. 2017; Viridi N, et al. *Diabetes Technology & Therapeutics.* 2023.

Current Assessment for Ketosis in the Outpatient Setting



	Blood Capillary Meter	Urinary Analysis
What does it measure?	β-hydroxybutyrate	Acetoacetate
Method of measuring	Discrete values	Colorimetric test
Cost	Expensive	Relatively affordable

Nguyen KT, et al. *J Diabetes Sci Technol*. 2022.

Current Assessment for Ketones in the Outpatient Setting: Are they Adequate?

European Association for the Study of Diabetes (EASD) 2025 Data: Real World Ketone Testing Behaviors and Glucose Levels

Results (N=3,023,587 ketone tests among 165,108 readers from 89 countries):

- Among tests, 82.3% were normal, 8.0% elevated, 2.6% high, and 1.7% DKA-risk for ketones
- Across the readers, the proportion of readers with at least one ketone value falling within each range was 60.1% (normal), 10.0% (elevated), 8.7% (high), and 4.8% (DKA risk).
- Most (72.4%) ketone tests had a glucose value within 20 minutes prior to the test.
  - The median glucose within 20 minutes prior to a ketone test was 311 mg/dL (IQR: 260 - 370 mg/dL) with most (78.7%) ketone tests performed when the glucose was ≥ 250 mg/dL (see the top panel of the figure).
  - Median of average glucose at different time points prior to ketone testing are shown in the bottom panel of the figure.
  - The mean and median number of ketone tests per day on a day where ketones were tested was 1.4±1.0 and 1.0 (IQR: 1.0 - 2.0), and 2.4±2.0 and 2.0 (IQR: 1.0 - 3.0) on days with ketone levels > 0.5 mmol/L.

Quadri F, et al. *Diabetologia*. 2025.

Current Assessment for Ketones in the Outpatient Setting: Are they Adequate?

What Does this Study Tell Us?

Most ketone tests were performed **after the glucose was ≥ 250 mg/dL**. This observation aligns with recommendations to perform a ketone test when the glucose is elevated; however, this **may lead to people with diabetes missing episodes of ketonemia that can occur at lower glucose levels**. Adherence to ketone monitoring guidelines is known to be poor, which was observed in our data set. Ketone monitoring adherence could improve if measurement was more convenient.

Quadri F, et al. *Diabetologia*. 2025.

Continuous Ketone Monitoring (CKM) Rationale

Continuous Ketone Monitoring (CKM) Can Detect DKA Earlier Than Standard Care

- Objective: assess the feasibility of CKM during DKA and the agreement between interstitial and venous beta-hydroxybutyrate (BOHB)
- N=34 (mean age of 40.8 years, 56% male, 50% Black, 79% T1D, and mean presenting BOHB 7.0 mmol/L (range 2.5–13.5)
- **CKM values were strongly correlated with venous BOHB ($r = 0.96$, $p < 0.001$).**
- The CKM value was lower than venous for 79% of paired values.
- **DKA resolution was detected 55 min earlier (mean, 95% CI 26–84, $p = 0.001$) via CKM than standard care.**
- No device-related complications occurred, and CKM application and removal were well tolerated by all patients.
- **Conclusion: CKM during DKA treatment was feasible, provided clinically accurate BOHB readings, and detected DKA resolution earlier than standard care. CKM-guided DKA treatment is a promising strategy with the potential to improve the quality and value of DKA care.**

Haas NL, et al. *Diabetes Technol Ther*. 2026.

Continuous Ketone Monitoring (CKM) Can Detect DKA Better Than Standard Care

Study: Correlation Between Blood Glucose and BHB Rise (DKA Risk)

Background

- **The metabolic dynamics between blood glucose and ketone during insulin deficiency remains unknown**. In this study, we aim to observe and track the changes in β-hydroxybutyrate (BHB) and glucose during insulin pump suspension among patients with T1D by using continuous ketone monitoring (CKM).

Methods

- The study is a single-center feasibility trial involving adult T1D patients (≥18 years) receiving Continuous Subcutaneous Insulin Infusion (CSII). Two in-clinic visits with frequent venous blood draws were randomly scheduled. BHB and glucose were measured by biochemical analyzers. Two CKM sensors were attached to each upper arm. During the in-clinic visit, patients' insulin pumps will be suspended for no longer than 6 hours.

Results

- 14 patients with T1D on CSII were recruited with a total of 27 in-clinic visits (mean±SD Age: 31.4±10.2 years, female: n=7. median duration of CSII use: 5.9 years). Among the 27 visits, the baseline BHB was 0.13±0.09 mmol/L, and peak level was 1.04±0.41 mmol/L. 89% exceeded BHB level of 0.6mmol/L at 5 hours after insulin pump suspension, and 44% exceeded 1.0 mmol/L at 7 hours after suspension. BHB reached 1.0 mmol/L while glucose was ≤ 13.9 mmol/L in 5 (18.5%) visits. During the visit, CKM demonstrated a strong concordance with venous blood BHB in trends.

Conclusions

- Our study confirmed that **glucose may not rise significantly while BHB was elevated**. The study highlights the **necessity of CKM** during the CSII treatment to ensure patient safety.

Liu P, et al. *Diabetes Technol Ther*. 2026.

Perspectives from ATTD: Is CKM Needed and/or Wanted?

Survey (45-item questionnaire): adults from French SFDT1 cohort with T1D ≥ 12 months

Results (N=553, mean age 46 years; T1D duration 28 years; HbA1c 7.0%; CGM 93%).

- 62% reported prior DKA
- Awareness was high: 95% had heard of ketosis, 91% of DKA, and 88% recognized its severity, though 30% misattributed non-specific symptoms
    - Knowledge was higher among CSII/Automated Insulin Delivery (AID) users, those aged <25 years or with prior DKA
- 39% were regularly reminded by clinicians to monitor ketones; 3% tested often and 58% sometimes, with higher rates in CSII/AID users and individuals with prior DKA
- Interest in a dual glucose-ketone sensor was high (82%)
- 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%.

Conclusions

- Despite strong awareness in this well-controlled cohort, challenges remain around symptom recognition, equipment, and time. **High interest in dual glucose-ketone sensors highlights limitations of current methods and the need for accessible, patient-centric solutions to support DKA prevention**.

Cosson E, et al. *Diabetes Technol Ther*. 2026.

The Clinical Benefits of CKM

Beta-Hydroxybutyrate Detection

Primary ketone in DKA
Measured by CKM via the interstitial fluid of subcutaneous tissue

Early Detection of Ketone Changes

CKM detects rising ketones earlier than urine tests, helping prevent life-threatening DKA

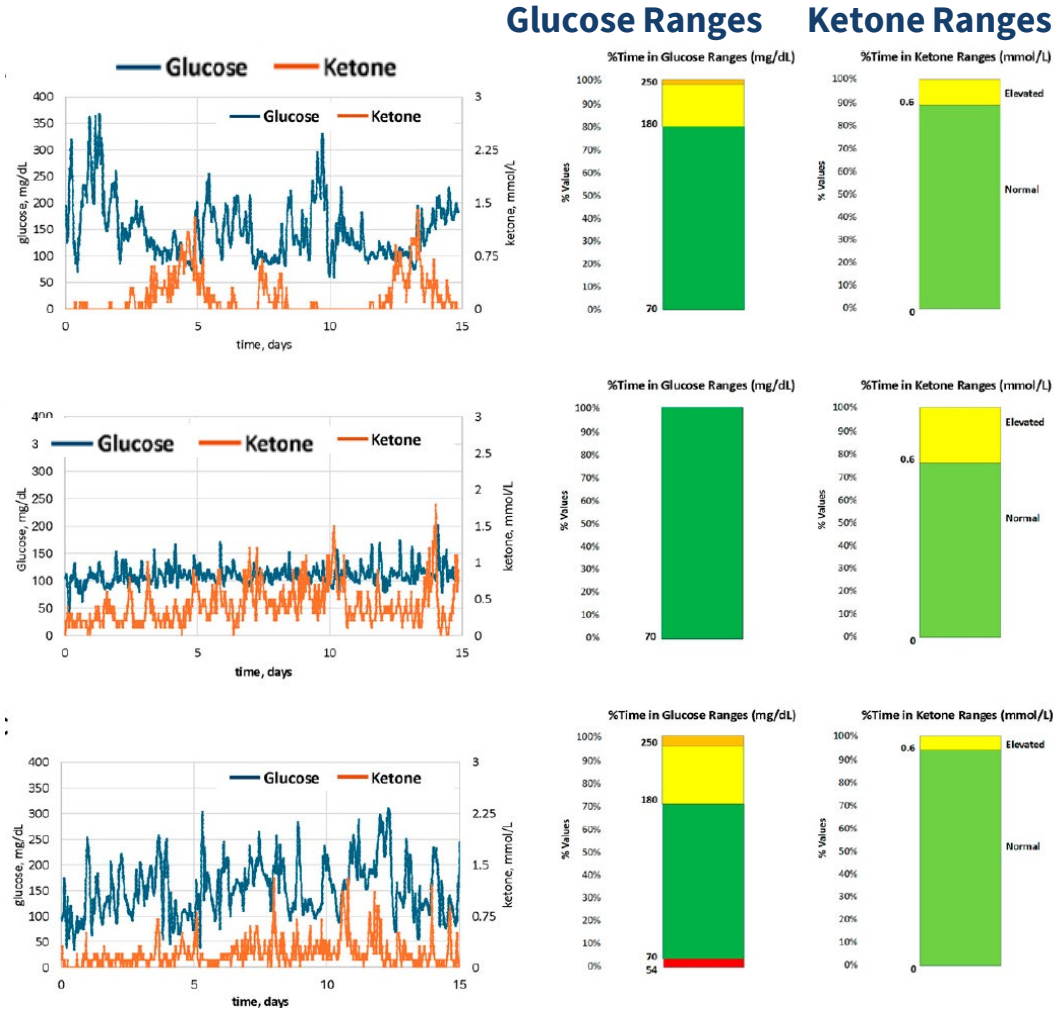
Versatile Across Care Settings

Useful for diabetes management in both inpatient and outpatient settings

Ketone testing is limited by access and delays
CKM offers a +real-time, proactive solution

Huang J, et al. *J Diabetes Sci Technol.* 2024.

How Can Dual Monitoring Impact Practice: Case Studies from the Real World



A 62-year-old woman with T2D and stage 3 **CKD**

A 59-year-old man with T2D treated with **SGLT2 inhibitor**

A 73-year-old woman with T1D using an **AID system**

Bergenstal RM, et al. *Diabetes Technol Ther*. 2025.

The Future is Now

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*

BeyondType1.org; Dhatariya K, et al. *Lancet Diab Endocrinol*. 2026.

Interprofessional Team Overview in DKA Care

- Nurse coordinators
- Social workers
- Psychologists
- Advanced practice providers (NPs and PAs)
- Pharmacists
- Diabetes care and education specialists
- School nurses
- Dieticians

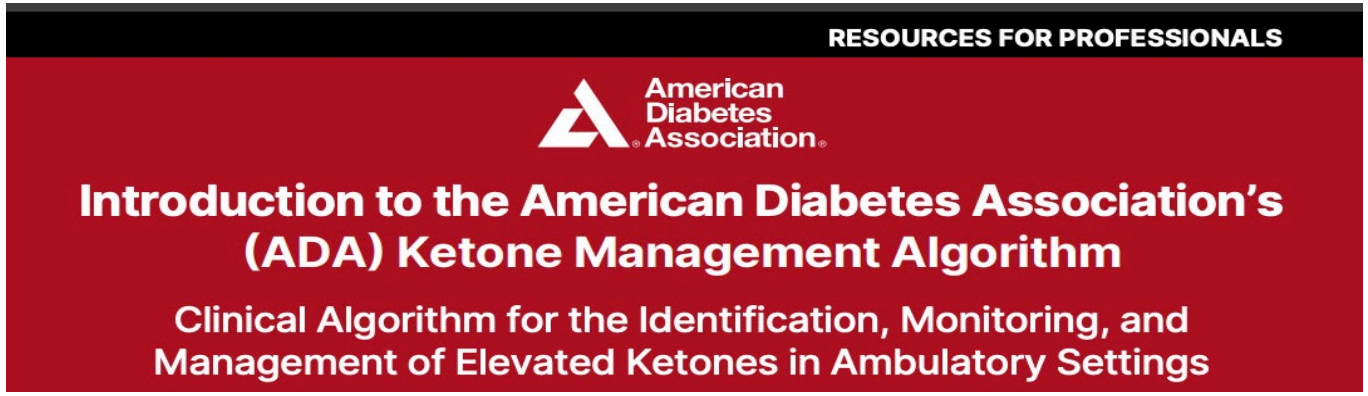
International Consensus + ADA Algorithm- How To Use It All In Practice

ADA's Ketone Management Algorithm

5 Step Process:

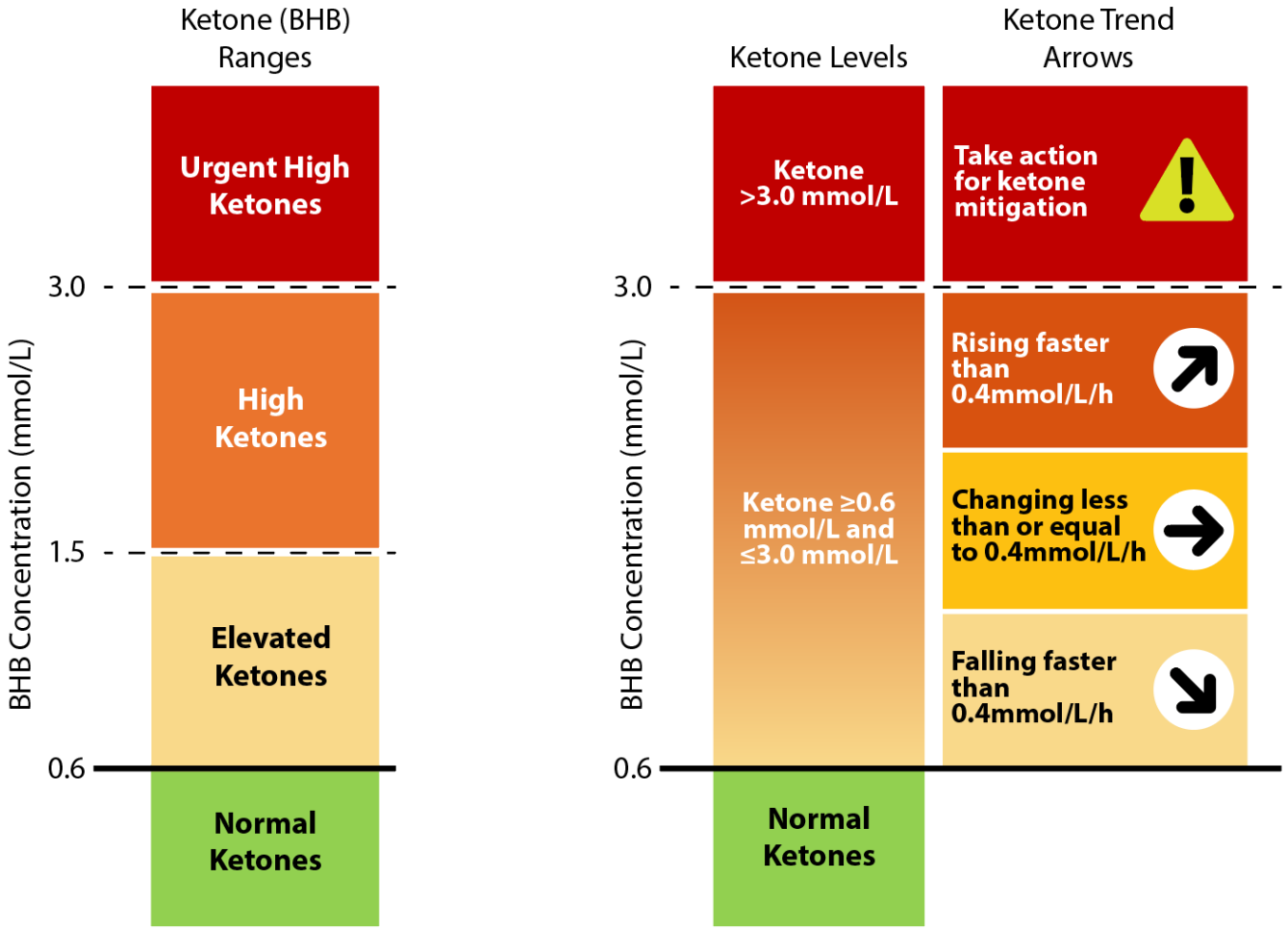
- WHO- Identify which patients should measure ketones
- HOW- Specifying the testing modality (capillary, continuous, or urine)
- EVALUATE- Defining threshold-based action zones
- ASSESS- Determining whether home management is appropriate
- DO (at home)- Executing a structured home treatment protocol to prevent DKA progression.

Overall: EDUCATION IS KEY- everyone at risk for DKA needs a personalized monitoring and management plan.



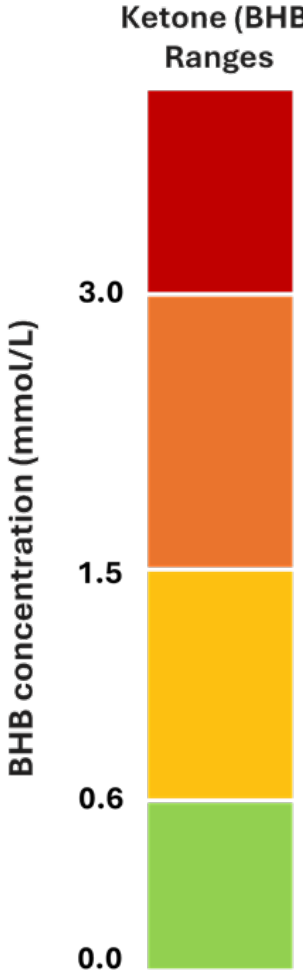
ADA. 2026.

Ketone Range Comparisons



Dhatariya K, et al. *Lancet Diab Endocrinol*. 2026; ADA. 2026.

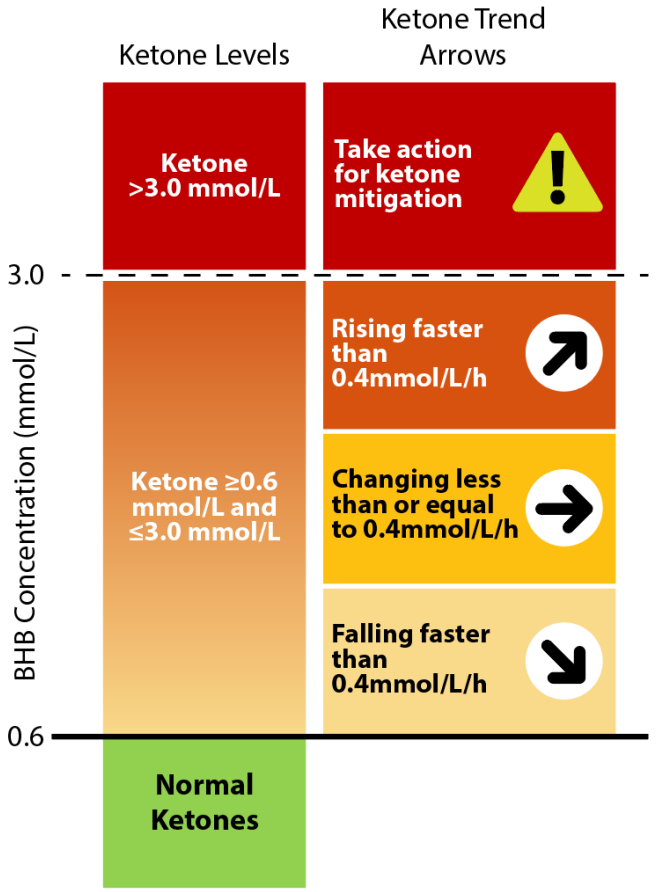
Digging Deep in Ketone Ranges: 2025 Ketone Consensus Statement



Ketone (BHB) Ranges	Watch for symptoms*	Action to be taken by person with diabetes†
Urgent High Ketones	• Deep breathing • Dry lips • Fruity breath • Confusion or difficulty paying attention • Nausea • Vomiting • Abdominal pain • Excess thirst • Frequent urination	**Seek immediate medical attention at a hospital or emergency care facility** – Monitor glucose levels frequently – Check insulin pump is working as expected or confirm insulin injections have not been missed – Take fluids, carbohydrates and insulin as recommended by your HCP
High Ketones	• Difficulty breathing • Fruity breath • Confusion or difficulty paying attention • Nausea • Vomiting • Abdominal pain • Fatigue	**Follow your HCPs guidance (including changes in medication) and:** – Monitor glucose levels frequently – Check insulin pump is working as expected or confirm insulin injections have not been missed – Take fluids, carbohydrates and insulin as recommended by HCP – Contact your HCP
Elevated Ketones	• Nausea • Vomiting • Abdominal pain • Fatigue	**Follow your HCPs guidance (including changes in medication) and:** – Monitor glucose levels frequently – Check insulin pump is working as expected or confirm insulin injections have not been missed – Take fluids, carbohydrates and insulin as recommended by HCP
Normal Ketones		**No action necessary**

Dhatariya K, et al. *Lancet Diab Endocrinol*. 2026.

Digging Deep in Ketone Ranges: 2026 ADA Ketone Algorithm



Consider general principles for ketone management:

- Confirm that the person with diabetes has unexpired insulin to treat high glucose levels.
- If the individual uses an insulin pump, consider changing the infusion site or recommending insulin administration via syringe or pen.
- If the individual takes an SGLT inhibitor, consider stopping the medication.

ADA. 2026.

DKA at Home Treatment Comparisons: 2025 Ketone Consensus Statement

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.

DKA at Home Treatment Comparisons: 2026 ADA Ketone Algorithm

Consider general principles for ketone management:

- Confirm that the person with diabetes has unexpired insulin to treat high glucose levels.
- If the individual uses an insulin pump, consider changing the infusion site or recommending insulin administration via syringe or pen.
- If the individual takes an SGLT inhibitor, consider stopping the medication.

Glucose Level	Treatment Recommendations	Emergency Care
If glucose level is <250 mg/dL (<13.9 mmol/L)	• If the person is able to tolerate, increase consumption of glucose-free fluids. • Consider an anti-emetic in the presence of mild to moderate nausea or vomiting. • Adults receiving insulin therapy should eat or drink 15-30 g carbohydrate every 2 hours. Administer insulin with carbohydrate intake. • Youth receiving insulin therapy should eat or drink 0.3g carbohydrate per kg of body weight. Administer insulin with carbohydrate intake.	Consider advising individuals to seek care in a hospital emergency department if they have worsening ketone levels and/or worsening signs or symptoms of ketosis despite self-care
250 mg/dL		
If glucose level is ≥250 mg/dL (≥ 13.9 mmol/L)	• If the person is able to tolerate, increase consumption of glucose-free fluids. • Individuals on insulin therapy should administer a correction dose that is ~10-20% higher than their usual calculated correction dose when ketones are elevated. • Individuals on insulin therapy should correct elevated glucose levels based on a correction factor +10-20%. • Avoid insulin stacking.	

Recommend frequent assessment of ketones until ketone levels are within normal limits (<0.6mmol/L)

- Urine: Recheck every 4 hours
- Capillary: Recheck every 2 hours
- CKM: Recheck every 1-2 ours, with attention to ketone trend arrows

ADA. 2026.

Reflect on What You Have Learned

How will you apply what you have learned to your practice and with your interprofessional and interdisciplinary diabetes care team?