VITALS VAULT

A VITALS VAULT FIELD GUIDE

Understand your blood sugar numbers in 20 minutes

For anyone with a borderline glucose or A1C, a family history, or a wish to spot insulin resistance early.

8

CHAPTERS

20 minutes

Every claim is tied to a named study. References are on the last page.

Educational only. Not medical advice.

THIS GUIDE IS FOR YOU IF

- You have a borderline glucose or A1C and want to know what it does and does not mean.
- You have a family history of diabetes and want to understand the early stages.
- You keep hearing "insulin resistance" and want a plain explanation with real numbers.
- You want to walk into an appointment knowing which questions to ask.

HOW TO USE IT

Read one chapter at a time. Each opens with the one thing to remember. Keep your own lab report beside you and circle the numbers named here. Use the last chapter to record results and prepare questions. Nothing here is a diagnosis.

WHAT IS INSIDE

01 What insulin does, in one picture

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CHAPTER 1

What insulin does, in one picture

THE ONE THING TO REMEMBER

Insulin is the key that lets sugar into your cells, and the body can need far more of it long before blood sugar rises.

Glucose [sugar carried in your blood] rises after a meal. Insulin [hormone that moves sugar into cells] works like a key in a door: it tells muscle, fat and liver cells to take sugar in, and tells the liver to stop making its own. Insulin resistance [cells ignoring insulin's signal] means the lock turns badly, so the pancreas sends more keys.

Early on, the extra insulin keeps blood sugar normal. Over time the beta cells [pancreas cells that make insulin] can tire and fail, and only then does blood sugar climb. High fasting insulin can show up years before blood sugar rises, which is why a normal glucose result alone cannot rule out the problem.

WHAT A STUDY FOUND

Fasting insulin was compared across groups assessed for insulin resistance. Non-obese people averaged 5 to 7 uIU/mL, obese people 16, and people with diabetes 15. Limit: group averages from one study, and labs measure insulin by different methods, so ranges vary.

Katz et al., insulin resistance study, 2000

WHAT A STUDY FOUND

Young, lean, inactive people who were the most insulin resistant ate a carbohydrate milkshake. Their blood sugar looked similar to others, but their insulin ran much higher, they stored far less sugar in muscle and made more fat in the liver. Limit: a controlled lab experiment, not a screening method.

Petersen et al., PNAS, 2007

COMMON BELIEF

"My blood sugar is normal, so my insulin must be fine."

WHAT THE EVIDENCE SAYS

Not necessarily. Insulin can work overtime for years while glucose stays normal. One researcher estimates a quarter to a half of people may be insulin resistant without symptoms. That is an estimate, not a measured count, and experts differ on how to detect it.

5–10

Typical fasting insulin in a healthy person, in uIU/mL. After a meal it rises to about 60. Treat this as a rough guide, not a cut-off.

ASK YOUR CLINICIAN

- **Could my insulin be high even though my glucose is normal?**
- **Which of my numbers show how hard my body is working to keep sugar steady?**
- **Could any medicine I take raise my glucose or insulin?**

CHAPTER 2

The tests and their time windows

THE ONE THING TO REMEMBER

Each test looks at a different window of time, so one normal result does not clear you and one odd result does not convict you.

Think of the tests as cameras with different shutter speeds. Fasting glucose is a snapshot. A1C [your 3-month average blood sugar] is a long exposure. The glucose tolerance test (OGTT [timed sugar drink with blood draws]) is a short film of how you handle a sugar load.

Test	What it shows	Time window
Fasting glucose	Sugar after a fast, mostly the liver's output	One moment
A1C	Share of hemoglobin (oxygen protein) coated with sugar	About 3 months of red cell life
Fasting insulin	How much insulin it takes to hold sugar steady	One moment, after a fast
Glucose tolerance test	Sugar, often with insulin, after a 75 g sugar drink	2 hours, drawn every 30 minutes
Triglycerides	Fats carried in the blood	One moment; rise 20–30% for about 2 hours after eating

The standard lines for prediabetes [blood sugar above normal, below diabetes] and diabetes are below. One criterion is enough for a diagnosis. The lines are somewhat arbitrary: they were set around where diabetic eye disease risk rises. Some groups still use an older fasting line of 110 for prediabetes.

Test	Prediabetes	Diabetes
Fasting glucose (mg/dL)	100 to 125	126 or more
A1C (%)	5.7 to 6.4	6.5 or more
2-hour tolerance test (mg/dL)	140 to 199	200 or more

WHAT A STUDY FOUND

In more than 5,000 adults, fasting glucose varied about 7.5 mg/dL from day to day. Of those called normal by one fasting reading, a week of sensor data reclassified 40% as prediabetic and 3% as diabetic. Limit: sensors are not diagnostic, and guidelines still accept a single test.

Shilo et al., Nature Medicine, 2024

COMMON BELIEF

"A home fingerstick is as good as a lab test."

WHAT THE EVIDENCE SAYS

Fingersticks suit self-monitoring and screening, but diagnosis needs a lab draw. In people with normal glucose they agreed with lab (venous) results 84.5% of the time, and differed most at 74 mg/dL and below. After meals they can read up to 20% higher.

ASK YOUR CLINICIAN

- **Which of these tests have I had, and when?**
- **Were my samples taken fasting, and for how many hours?**
- **Would a second test help confirm a borderline result?**

CHAPTER 3

What can make A1C misleading

THE ONE THING TO REMEMBER

A1C counts sugar on red blood cells, so anything that changes how long red cells live can move the number without changing your sugar.

Picture red cells as passengers collecting sugar stickers for about 3 months. A1C counts the stickers as a share of hemoglobin [oxygen-carrying protein in red cells]. If passengers ride longer they collect more stickers. If they leave early they collect fewer. The count can move even when your sugar has not.

What changes	Can read too low	Can read too high
Red cell lifespan	Shorter: blood loss, cells breaking early	Longer: iron, B12 or folate shortage
Kidney disease	Kidney failure treated with EPO	Kidney failure with uremia
Blood or pregnancy	Transfusion, pregnancy, high altitude	Thalassemia, other hemoglobin variants
Spleen or sickle cell	Enlarged spleen; sickle cell varies	Spleen removal
Other	Some drugs and conditions	High triglycerides, chronic alcohol use

WHAT A STUDY FOUND

In 87,284 Koreans without anemia or diabetes, lower hemoglobin went with higher A1C, even when fasting glucose was not in the diabetic range. Limit: an association in one population; our source gives no effect size.

Bae et al., 2014

WHAT A STUDY FOUND

In nutritional anemia (shortage of iron, B12 or folate), A1C can read high. Treating an untreated deficiency lowered A1C by 0.3 to 1.0 points with no other change. Limit: applies only to untreated deficiency anemia.

Pilla, Cureus, 2020

COMMON BELIEF

"A1C is my true 3-month average blood sugar."

WHAT THE EVIDENCE SAYS

It is an estimate. It misses post-meal spikes and day-to-day swings. In people with type 2 diabetes called well controlled (A1C under 7%), 2-hour post-meal values were still repeatedly above 160 mg/dL (Bonora, 2006). Another group argues A1C tracks true glucose only weakly in an individual.

Red-cell markers like A1C are worth rechecking in 3 to 6 months, ideally at the same lab. When A1C looks unreliable, clinicians sometimes use fructosamine and glycated albumin [sugar-coated proteins, last 2 to 3 weeks], 1,5-anhydroglucitol [another blood sugar marker], or a sensor. Each has its own confounders, such as kidney failure, pregnancy or albumin changes.

ASK YOUR CLINICIAN

- **Could iron, B12, folate, kidney function or blood loss be changing my A1C?**
- **Does my A1C agree with my fasting glucose, or do they point different ways?**
- **If A1C may be unreliable for me, which backup test fits?**

CHAPTER 4

The years before a diagnosis

THE ONE THING TO REMEMBER

Risk builds quietly over a decade or more, and studies show it rising inside the normal range, long before any diabetes label.

Insulin resistance has been called a long fuse. In one researcher's human work, muscle becomes resistant first, then the liver fills with fat, then diabetes follows. In the CDC's 2020 report, 88 million US adults (34.5%) had prediabetes and 7.3 million had undiagnosed diabetes. An estimate quoted from the CDC says 84% of people with prediabetes did not know it.

10–15 **Years that insulin resistance and loss of glucose control can come before a type 2 diabetes diagnosis, per a medical reference. It is an estimate and varies by person.**

WHAT A STUDY FOUND

In 4,184 people judged not high risk by usual measures, half had early artery buildup (calcium or plaque) on imaging. Their fasting glucose averaged 89 mg/dL versus 86 in those without, and their A1C was also higher. Limit: observational, and the averages differ by only 3 mg/dL.

Fernandez-Friera et al., PESA, 2017

WHAT A STUDY FOUND

In 10,913 adults without diabetes, compared with fasting glucose under 85 mg/dL, readings of 85–89, 90–94 and 95–99 carried 1.34, 1.47 and 1.53 times the risk of heart-related events. All three sit inside the standard normal range. Limit: observational; this shows risk, not a diagnosis.

Shaye et al., CARMA, 2012

WHAT A STUDY FOUND

In 10,232 adults aged 45–79 without diagnosed diabetes, the fewest heart events and deaths occurred at A1C below 5%. Each 1-point rise went with 1.24 to 1.28 times the risk of death, after adjusting for smoking, cholesterol, blood pressure and weight. Limit: an association.

Khaw et al., EPIC-Norfolk, 2004

COMMON BELIEF

“If I do not have diabetes, my blood sugar is not a risk.”

WHAT THE EVIDENCE SAYS

Risk looks like a slope, not a cliff. In about 20,000 UK adults without diagnosed diabetes, crude deaths per 1,000 person-years rose from 5.7 at A1C under 4.5% to 8.7 at 5.0–5.5%, and 24.6 above 6.5% (Pfister, 2011). Observational and confounded; guidelines still use fixed lines.

ASK YOUR CLINICIAN

- Has my fasting glucose or A1C been creeping up over the past few years?
- Does my family history change how often I should be checked?
- Which test would show early changes that my current ones might miss?

CHAPTER 5

The five numbers of metabolic syndrome

THE ONE THING TO REMEMBER

Metabolic syndrome is a cluster of five linked numbers: waist, blood pressure, triglycerides, HDL and fasting glucose.

Think of five smoke alarms in one house. One beeping is worth a look. Several beeping together point to a pattern. Metabolic syndrome [cluster of five linked risk signs] counts a large waist, high blood pressure, high triglycerides [fats carried in your blood], low HDL [a cholesterol-carrying particle] and raised fasting glucose. More than 1 in 3 US adults has it (Liang, Postgrad Med J, 2023).

Number	Line used in a 2020 consensus	Note
Waist	102 cm men, 88 cm women	90 and 80 cm in Asian people; another table uses 94 and 80
Blood pressure	130/85 or higher	Or on treatment
Triglycerides	150 mg/dL or higher	Or on treatment
HDL	Under 40 men, under 50 women	In mg/dL
Fasting glucose	100 to 125 mg/dL	The prediabetes range

187 **mg/dL: fasting triglycerides at or above this carried 4 times the diabetes risk of under 120 in a Manitoba First Nation cohort. One population's cut-off, not a guideline.**

WHAT A STUDY FOUND

In ARIC and Framingham Offspring data, heart events rose even below the 150 mg/dL "normal" line. The lowest quartile (under 83 mg/dL) had the lowest risk and the highest (153 and above) the most. Limit: observational, and quartile cut-offs belong to these groups.

Aberra et al., 2020

WHAT A STUDY FOUND

In 10,196 Japanese adults aged 35–40, a triglyceride-to-HDL ratio (both in mg/dL) of 2.97 in men and 2.23 in women flagged clusters of risk. Other studies found cut-offs from 0.88 to 3.6. Limit: cut-offs differ by sex, age and population.

Wakabayashi et al., 2019

WHAT A STUDY FOUND

In 1,979,509 Korean adults aged 40–60, followed 7.75 years on average, 50.7% had metabolic syndrome. It went with a 24% higher risk of young-onset dementia. Limit: insurance claims data; it cannot show cause.

Korean nationwide insurance cohort, 2009–2020

ASK YOUR CLINICIAN

- Which of the five numbers am I closest to the line on?
- Should my waist, blood pressure and triglycerides be tracked together?
- Was my triglyceride sample fasting, and does that change the reading?

CHAPTER 6

Liver fat and blood sugar

THE ONE THING TO REMEMBER

Fat in the liver and insulin resistance feed each other, and fatty liver often causes no symptoms at all.

Think of the liver as a warehouse: when more fat arrives than it can ship out, it stacks up. Fatty liver [fat in over 5% of liver cells] affects at least 25% of people worldwide. Insulin resistance fills the warehouse three ways: fat released from body fat, fat in food, and fat the liver makes itself. The names have changed from NAFLD to MAFLD to MASLD [fatty liver tied to metabolic problems].

How common it is depends on the group. Among people with diabetes, estimates run from 30–50% in one review to 60–70% in another source. About 80–90% of adults with obesity are affected. Often there are no symptoms; fatigue is the most common complaint.

5%

The share of liver cells holding fat that defines fatty liver. It is found by imaging or scoring, not by a standard blood panel.

WHAT A STUDY FOUND

In 1,181 Framingham Third Generation participants, an ALT-to-AST ratio of 1.33 or more went with 3 times the risk of fatty liver. ALT and AST are liver enzymes [proteins that leak into blood]. At that cut-off the ratio caught only 55% of cases. Limit: a clue, not a diagnosis.

Long et al., Framingham Third Generation, 2016

WHAT A STUDY FOUND

In 206 people with fatty liver (average age 41, BMI 31), average ALT was 65 and AST 64 U/L, triglycerides 215 and fasting glucose 111 mg/dL; 23% had diabetes. Limit: one population, one snapshot, and symptoms were non-specific.

Khoonsari et al., Iran J Pathol, 2017

COMMON BELIEF

"Fatty liver only happens to heavy drinkers."

WHAT THE EVIDENCE SAYS

The metabolic type is defined by metabolic risk, not alcohol. ALT and AST can be normal or only mildly raised, so a normal result does not rule it out. Inflamed fatty liver can progress to advanced scarring within 4 to 6 years in some patients.

ASK YOUR CLINICIAN

- Could fatty liver be behind my liver enzymes or triglycerides?
- Would an ALT-to-AST ratio or an imaging check make sense for me?
- Should my alcohol use be part of this picture?

CHAPTER 7

Everyday things studies link with glucose

THE ONE THING TO REMEMBER

Sleep, light at night, movement and meal order have all been linked with glucose, but mostly through associations or small studies.

Think of these as small weights on a scale: each tips it a little, and none decides it. The findings below are what researchers observed. They are not instructions, and several come from small groups or people who already had diabetes.

WHAT A STUDY FOUND

Wrist sensors tracked light for one week in over 85,000 UK adults, followed about 8 years. The top 10% of night light (about 50 lux) had 53–67% higher type 2 diabetes risk than dark nights, held after adjusting for sleep length and genes. Limit: observational, and one week of light data.

Windred et al., Lancet Reg Health Eur, 2024

WHAT A STUDY FOUND

In the Sleep Heart Health Study, sleeping under 6 or over 9 hours went with higher type 2 diabetes risk. A separate study of 8,000+ adults found disrupted sleep raised new cases over 7.5 years. Limit: observational, and sleep apnea may be a hidden driver.

Sleep Heart Health Study, cited in a 2020s insulin resistance review

WHAT A STUDY FOUND

In overweight or obese adults, walking after meals and breaking up sitting with short bursts of activity improved post-meal glucose and insulin. Limit: short experiments, and our source gives no sample size.

Dunstan et al., 2012

WHAT A STUDY FOUND

In 11 people with type 2 diabetes eating the same meal (68 g carbohydrate), eating carbohydrate last instead of first lowered 1-hour glucose from 199.4 to 125.6 mg/dL and 2-hour glucose from 169.2 to 140.8. Limit: only 11 people, all with diabetes.

Shukla et al., 2015

COMMON BELIEF

"A glucose spike after eating means something is wrong."

WHAT THE EVIDENCE SAYS

Everyone's glucose rises after eating. A common rule of thumb is back near the pre-meal level within 2 hours, with a peak under 140 mg/dL. One physician says a spike alone tells little unless it is very high (over 160 to 180). Repeated 2-hour readings above 140 deserve a clinician's look.

ASK YOUR CLINICIAN

- Are my sleep, shift work or night light worth mentioning?
- Would a sensor or tolerance test show how I respond after meals?
- Does any of this change given my medicines or conditions?

CHAPTER 8

Your tracking page and questions

THE ONE THING TO REMEMBER

Numbers mean the most as a trend from the same lab, so write each result down with its date and what was going on that week.

Treat results like a bank balance: one deposit means little, the pattern over months tells the story. Use the same lab and conditions when you can. Recheck red-cell markers like A1C in 3 to 6 months. ALT is lowest around 4 am and highest around 4 pm, so note the time. Avoid testing so often that every blip causes worry, fingersticks included.

WHAT A STUDY FOUND

In 7,412 US adults, fasting glucose, A1C and the glucose tolerance test showed limited agreement on who had abnormal results. That is one reason no single number settles the question. Limit: one US sample; our source gives no agreement figures.

Tucker, J Clin Med, 2020

BEFORE THE APPOINTMENT

- [ ] Bring my last 2 or 3 lab reports, from the same lab if possible
- [ ] Note whether each draw was fasting, and the time of day
- [ ] List every medicine and supplement I take
- [ ] Write down family history of diabetes, fatty liver or heart disease
- [ ] Note my sleep, shift work and night light this month

MY NUMBERS (ADD THE DATE TO EACH)

Fasting glucose (mg/dL) _____

A1C (%) _____

Fasting insulin (uIU/mL) _____

Triglycerides (mg/dL) _____

HDL (mg/dL) _____

Waist (cm or inches) _____

Blood pressure _____

ALT and AST (U/L) _____

ASK YOUR CLINICIAN

- Given my history, which tests besides fasting glucose make sense for me?
- How often should I repeat each one, and at which lab?
- Which of my numbers should I watch most closely?
- What would make you want to look further?

THE WHOLE GUIDE ON ONE PAGE

If you remember nothing else

1. Insulin is a key that lets sugar into cells; resistance means the lock turns badly and insulin climbs first.
2. Fasting glucose is a snapshot, A1C a 3-month average, the tolerance test a 2-hour film, each with blind spots.
3. A1C can mislead when red cells live longer or shorter, for example with an iron, B12 or folate shortage.
4. Risk starts rising inside the normal range, and insulin resistance can precede diabetes by 10 to 15 years.
5. Watch five numbers together: waist, blood pressure, triglycerides, HDL and fasting glucose.
6. Fatty liver is common, often silent, and tied to insulin resistance; ALT and AST give only a clue.
7. Sleep, night light, movement and meal order are linked with glucose, mostly in observational or small studies.
8. Track results from the same lab with dates, and bring your questions to a clinician.

WHAT THIS GUIDE CANNOT DO

This guide cannot tell you whether your own numbers are a problem, what is causing them, or what to do about them. It cannot diagnose diabetes or prediabetes, and one result is never enough. Most studies here show associations in particular groups. What is missing is your own set of results, from the same lab, tracked over time and read with a clinician who knows your history.

A FREE NEXT STEP

A short free page on the Vitals Vault site explains the blood markers behind metabolism and energy, so you can see how the numbers in this guide fit together.

vitalsvault.com/lab-check

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This guide is educational. It is not medical advice and not a diagnosis, and it does not replace a clinician who knows your history. Study findings describe groups of people and may not apply to you.