Supplementary Data:

Association of urine heavy metals with prevalence of type 1 diabetes and poor glycaemic control

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Table S1. Distribution of urinary metal concentrations categorized by quartiles among T1DM participants and controls.

Variable		Control	T1DM	p-values
Cu	Q1	44 (73.33%)	9 (5.88%)	<0.001
	Q2	10 (16.67%)	44 (28.76%)	
	Q3	2 (3.33%)	51 (33.33%)	
	Q4	4 (6.67%)	49 (32.03%)	
Zn	Q1	38 (63.33%)	15 (9.80%)	<0.001
	Q2	13 (21.67%)	41 (26.80%)	
	Q3	4 (6.67%)	49 (32.03%)	
	Q4	5 (8.33%)	48 (31.37%)	
Cd	Q1	3 (5.00%)	50 (32.68%)	<0.001
	Q2	17 (28.33%)	37 (24.18%)	
	Q3	23 (38.33%)	31 (20.26%)	
	Q4	17 (28.33%)	35 (22.88%)	
As	Q1	27 (45.00%)	26 (16.99%)	<0.001
	Q2	13 (21.67%)	41 (26.80%)	
	Q3	9 (15.00%)	44 (28.76%)	
	Q4	11 (18.33%)	42 (27.45%)	
Ba	Q1	1 (1.67%)	52 (33.99%)	<0.001
	Q2	6 (10.00%)	48 (31.37%)	
	Q3	26 (43.33%)	27 (17.65%)	
	Q4	27 (45.00%)	26 (16.99%)	
Pb	Q1	30 (50.00%)	23 (15.03%)	<0.001
	Q2	13 (21.67%)	41 (26.80%)	
	Q3	14 (23.33%)	40 (26.14%)	
	Q4	3 (5.00%)	49 (32.03%)	

Note: Data are presented as frequency and percentage within each quartile. Differences between groups were tested using the Kruskal–Wallish test; p values < 0.05 were considered statistically significant.

Table S2: Distribution of Urinary Metal Quartiles among T1DM Participants by Glycaemic Control (HbA_{1c} < 8.5% vs. ≥ 8.5%).

Variable		Controlled	Uncontrolled	p-values
Cu	Q1	3 (3.0%)	7 (13.2%)	0.013
	Q2	28 (28.0%)	16 (30.2%)	
	Q3	31 (31.0%)	19 (35.8%)	
	Q4	38 (38.0%)	11 (20.8%)	
Zn	Q1	7 (7.0%)	8 (15.1%)	0.008
	Q2	22 (22.0%)	19 (35.8%)	
	Q3	31 (31.0%)	18 (34.0%)	
	Q4	40 (40.0%)	8 (15.1%)	
Cd	Q1	35 (35.0%)	15 (28.3%)	0.25
	Q2	27 (27.0%)	10 (18.9%)	
	Q3	16 (16.0%)	15 (28.3%)	
	Q4	22 (22.0%)	13 (24.5%)	
As	Q1	10 (10.0%)	16 (30.2%)	0.001
	Q2	24 (24.0%)	17 (32.1%)	
	Q3	25 (25.0%)	11 (20.8%)	
	Q4	41 (41.0%)	9 (17.0%)	
Ba	Q1	14 (14.0%)	9 (17.0%)	0.099
	Q2	21 (21.0%)	20 (37.7%)	
	Q3	30 (30.0%)	10 (18.9%)	
	Q4	35 (35.0%)	14 (26.4%)	
Pb	Q1	35 (35.0%)	17 (32.1%)	0.342
	Q2	33 (33.0%)	15 (28.3%)	
	Q3	19 (19.0%)	8 (15.1%)	
	Q4	13 (13.0%)	13 (24.5%)	

Note: Data are presented as frequency and percentage per quartile. p values are from Kruskal–Wallish tests. Pearson and Spearman correlation coefficients (ρ) are also shown for associations between individual elements and HbA_{1c}. *p ≤ 0.05, **p < 0.01

Table S3. Binomial Logistic Regression Analysis of Uncontrolled glycaemia by Urinary Metal Quartiles in T1DM

Metal	Model	Controlled vs Uncontrolled				P_{trend}
		Q1	Q2	Q3	Q4	
Cu	Unadjusted	1	0.191 (0.022–1.644)	0.450 (0.046–4.426)	0.158 (0.014–1.729)	0.310
	Model 1	1	0.227 (0.024–2.111)	0.570 (0.052–6.236)	0.231 (0.018–2.911)	
	Model 2	1	0.156 (0.02 – 2.412)	0.504 (0.04 – 4.345)	0.285 (0.025 – 3.511)	
Zn	Unadjusted	1	1.935 (0.428–8.745)	1.045 (0.203–5.390)	0.238 (0.035–1.632)	**0.015***
	Model 1	1	2.041 (0.428–9.727)	0.824 (0.146–4.644)	**0.116 (0.014–0.952)** *	
	Model 2		2.555 (0.658 – 10.54)	1.254 (0.198 – 4.654)	**0.203 (0.031 – 1.22)***	
As	Unadjusted	1	0.501 (0.133–1.878)	**0.242 (0.060–0.983)** *	0.369 (0.074–1.835)	0.317
	Model 1	1	0.621 (0.133–2.893)	0.256 (0.053–1.247)	0.294 (0.045–1.929)	
	Model 2	1	0.571 (0.156 – 3.156)	0.351 (0.68 – 1.472)	0.322 (0.058 – 1.359)	
Cd	Unadjusted	1	0.810 (0.259–2.534)	1.704 (0.524–5.543)	**3.655 (0.981–13.621)** *	**0.017***
	Model 1	1	0.788 (0.244–2.541)	1.772 (0.516–6.087)	**3.843 (1.008–14.655)** *	
	Model 2		0.852 (0.273 – 2.149)	1.896 (0.482 – 5.910)	**4.023 (0.991 – 12.361)**	
Ba	Unadjusted	1	2.112 (0.537–8.314)	1.228 (0.219–6.901)	2.524 (0.302–21.054)	0.860
	Model 1	1	2.303 (0.563–9.425)	1.495 (0.248–9.018)	3.805 (0.411–35.178)	
	Model 2		2.503 (0.472 – 7.453)	1.589 (0.301- 7.49)	4.015 (0.620 – 14.95)	
Pb	Unadjusted	1	0.501 (0.133–1.878)	0.242 (0.060–0.983)	0.369 (0.074–1.835)	0.232
	Model 1	1	0.621 (0.133–2.893)	0.256 (0.053–1.247)	0.294 (0.045–1.929)	
	Model 2		0.751 (0.235 – 3.055)	0.256 (0.095 – 0.845)	0.336 (0.049 – 2.112)	

Note: ORs and 95% CIs are shown for both unadjusted and adjusted models. Q1 (lowest quartile) is the reference group. Model 1 adjusted for age and sex while model 2 adjusted for age, sex, presence of industries and farmlands near residence and drinking water source.

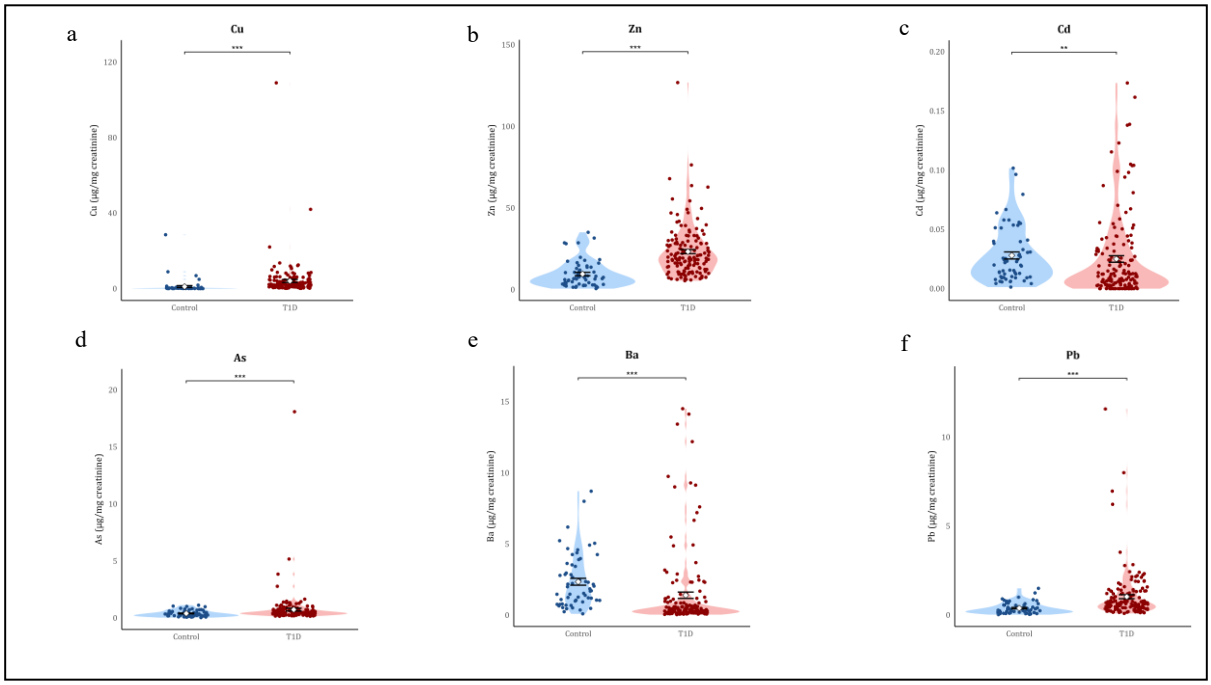

Figure S1. Urinary elemental concentrations in children with Type 1 Diabetes (T1D) and healthy controls. (a–f) Violin and dot plots showing urinary concentrations (µg/mg creatinine) of Cu, Zn, Cd, As, Ba and Pb in T1D patients (n = 153) and healthy controls (n = 60). Data are presented as mean ± standard error (SE). White diamonds represent group means; error bars indicate SE. Group comparisons were performed using the Wilcoxon rank-sum test. ***p < 0.0005, **p < 0.005, *p < 0.05.

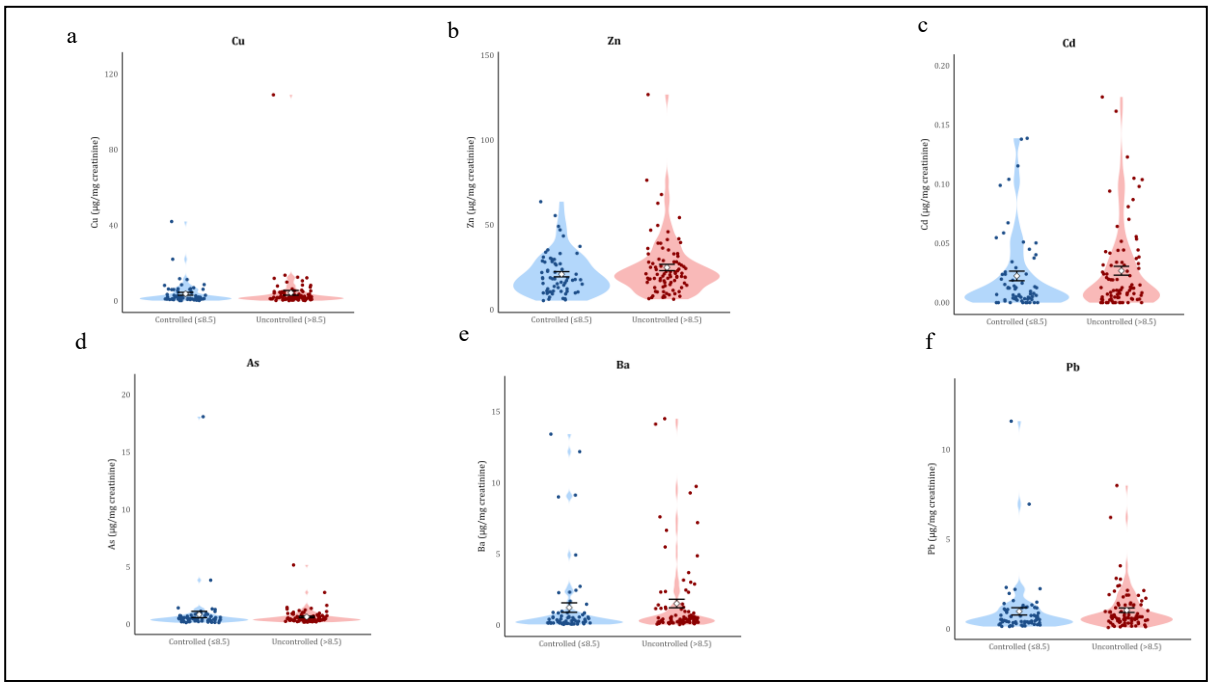

Figure S2 Urinary elemental concentrations in children with controlled and uncontrolled Type 1 Diabetes (T1D). (a–f) Violin and dot plots showing concentrations (µg/mg creatinine) of Cu, Zn, Cd, As, Ba and Pb in children with controlled glycaemia (HbA1c ≤ 8.5%; n = 61) and uncontrolled glycaemia (HbA1c > 8.5%; n = 92). Data are represented as mean ± SE. White diamonds denote group means, and black error bars show SE. Wilcoxon rank-sum test was used for group comparisons. *p < 0.05, **p < 0.005, ***p < 0.0005.