ELSP elspublishing

OPEN ACCESS
Article

Supplementary data

Seminal plasma trace elements: reliability as biomarkers and associations with sperm quality in male IVF patients

Rooshna Mohsin, Victor Y. Fujimoto, Aubrey L. Galusha, Patrick J. Parsons, Jenna R. Krall, Celeste D. Butts-Jackson, Evelyn Mok-Lin and Michael S. Bloom*

*E-mail: mbloom22@gmu.edu

Received 2 December 2025; Revised 14 February 2026; Accepted 24 February 2026; Published 20 April 2026

https://doi.org/10.55092/ijee20260006

1. Supplementary Tables

Supplementary Table S1. Unadjusted associations between individual seminal plasma trace elements and sperm quality outcomes among male partners of IVF patients across time 1 and time 2 (n = 35).

Element	Total Sperm Count		Sperm Concentration		Motile Concentration		Percent Motility	
	% Change	95% CI	% Change	95% CI	% Change	95% CI	% Change	95% CI
As	21.35	−22.10, 41.28	32.20 *	5.45, 56.95	27.05 *	14.35, 32.40	27.10	−0.55, 31.25
Cd	12.85	−16.35, 34.65	17.50	−3.58, 21.45	−10.25	−15.20, 4.85	18.50	−15.78, 12.50
Cu	31.08	−8.75, 50.33	22.45	−3.25, 25.88	13.50	−2.48, 15.34	16.22	−0.98, 64.58
Se	45.20	−4.38, 50.85	50.12 *	3.12, 89.45	46.15 *	5.12, 90.12	66.05	−4.45, 91.25
Sr	5.78	−3.80, −11.05	2.15	−4.25, 6.50	5.15	−41.22, 73.55	8.20	−60.85, 72.35
Mn	18.75	−15.32, 47.89	32.55	−8.12, 42.75	26.45	-0.98, 15.25	48.32	−10.12, 60.45
Mo	−9.55	−73.10, −60.25	−7.20	−27.20, 5.10	−19.35	−28.25, 35.12	−4.85	−40.50, 35.60
Zn	2.15	−18.24, 21.35	87.60	−18.55, 6.55	−6.85	−21.45, 5.22	−34.75	−40.15, 5.10

Abbreviations: CI, confidence interval.
NOTE: Effect estimate for the difference between the 25th percentile and 75th percentile of seminal plasma trace element concentrations (μg/L); * P-value < 0.10.

Supplementary Table S2. Sensitivity analysis of adjusted associations, with missing smoking values imputed as smokers, between individual seminal plasma trace elements and sperm quality outcomes among male partners of IVF patients (n = 35).

Elements	Total Sperm Count		Sperm Concentration		Motile Concentration		Percent Motility	
	% Change	95% CI	% Change	95% CI	% Change	95% CI	% Change	95% CI
As	19.18	−20.05, 48.41	31.94 *	6.85, 57.03	27.56 *	13.36, 41.76	27.05	−1.02, 50.13
Cd	13.42	−15.07, 41.64	15.45	−3.24, 34.14	−9.92	−22.91, 3.07	17.03	−14.52, 50.86

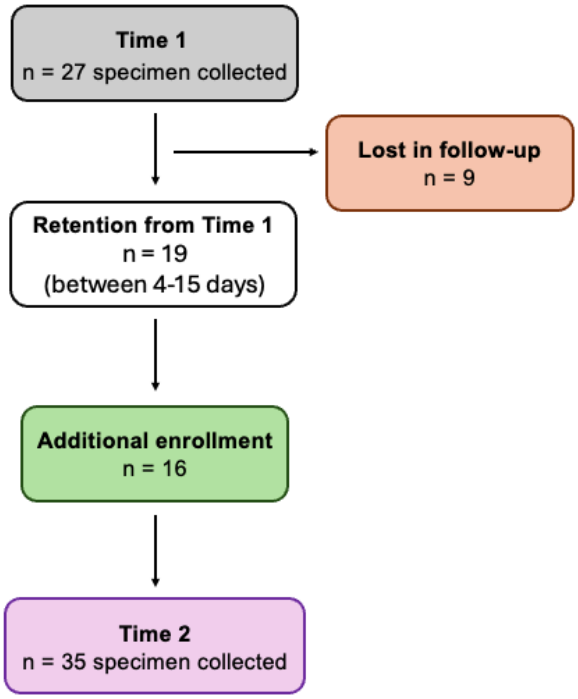
NOTE: Effect estimate for the difference between the 25th percentile and 75th percentile of seminal plasma trace element concentrations (μg/L); [a] adjusted for age (years), days between specimen collections, racial identity (Asian *vs.* non-Asian), and recent seafood consumption (> *vs.* < 1 lb. in the past week); [b] also adjusted for cigarette smoking (ever *vs.* never); * P-value < 0.10.

Supplementary Table S3. Associations between mixtures of seminal plasma trace elements and sperm quality outcomes using general linear regression models among male partners of IVF patients at time 2 (n = 35).

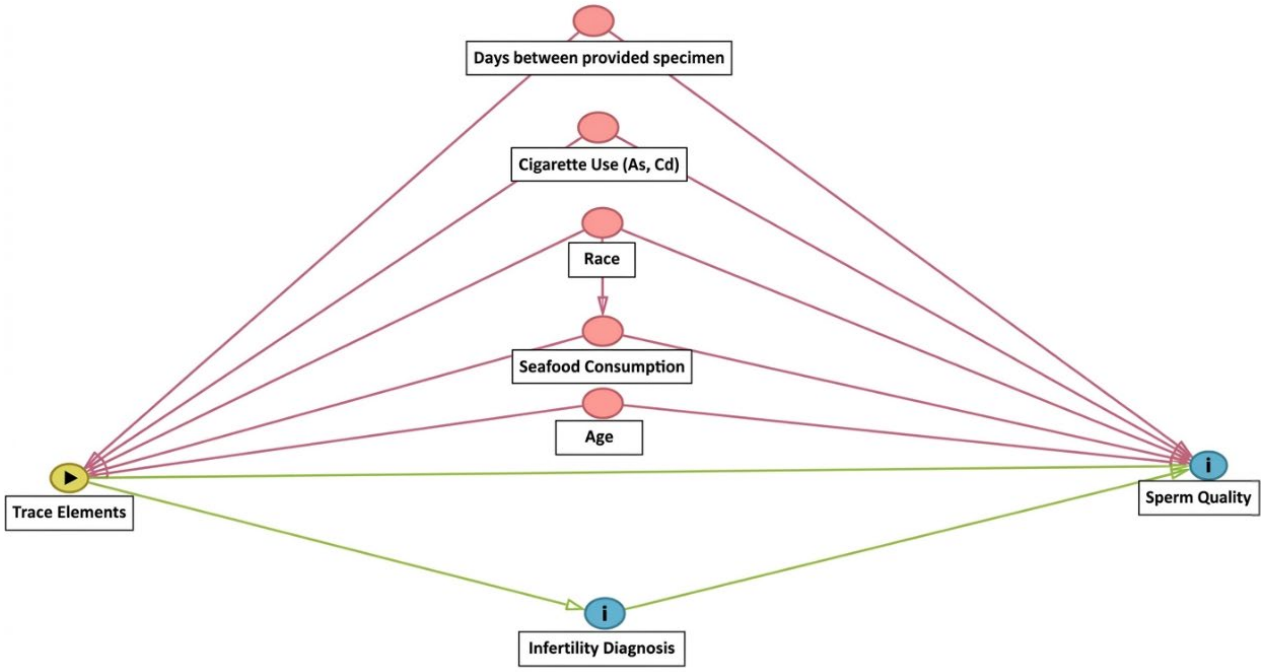
Sperm Quality Outcome	Non-essential Elements (RC1)		Essential Elements (RC2)	
	% Change	95% CI	% Change	95% CI
Total Sperm Count [a]				
Unadjusted	1.54	−3.49, 0.45	−0.34	−3.67, 3.01
Adjusted [b]	−1.48	−4.33, 1.43	0.10	−2.29, 4.25
Sperm Concentration [a]				
Unadjusted	−0.26	−0.87, 0.18	2.73	−1.85, 5.93
Adjusted [b]	−0.34	−1.24, 0.85	2.38	−1.53, 4.35
Motile Sperm Concentration [a]				
Unadjusted	−1.04	−2.71, 0.98	1.07	−0.82, 2.61
Adjusted [b]	−2.17	−3.95, 2.17	2.18	−3.01, 5.17
Percent Motile Sperm [a]				
Unadjusted	−0.84	−5.12, 4.83	−0.37	−4.21, 4.45
Adjusted [b]	−0.79	−2.95, 1.53	0.25	−1.59, 2.15

Abbreviations: CI, confidence interval; RC1, First rotated (principal) component, representing higher non-essential element concentrations and lower essential element concentrations; RC2, Second rotated (principal) component, representing higher essential element concentrations.
NOTE: Effect estimate for the difference between the 25th percentile and 75th percentile of seminal plasma trace element concentrations (µg/L); [a] square root transformed; [b] adjusted for age (years), days between specimen collections, racial identity (Asian *vs.* non-Asian), cigarette smoking (ever *vs.* never), and recent seafood consumption (> *vs.* < 1 lb. in the past week).

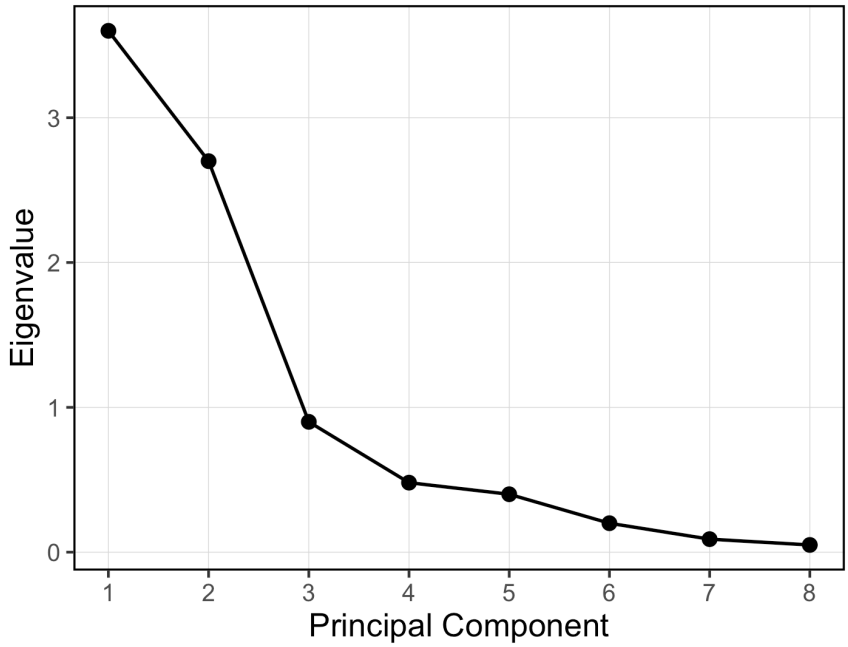
2. Supplementary Figures



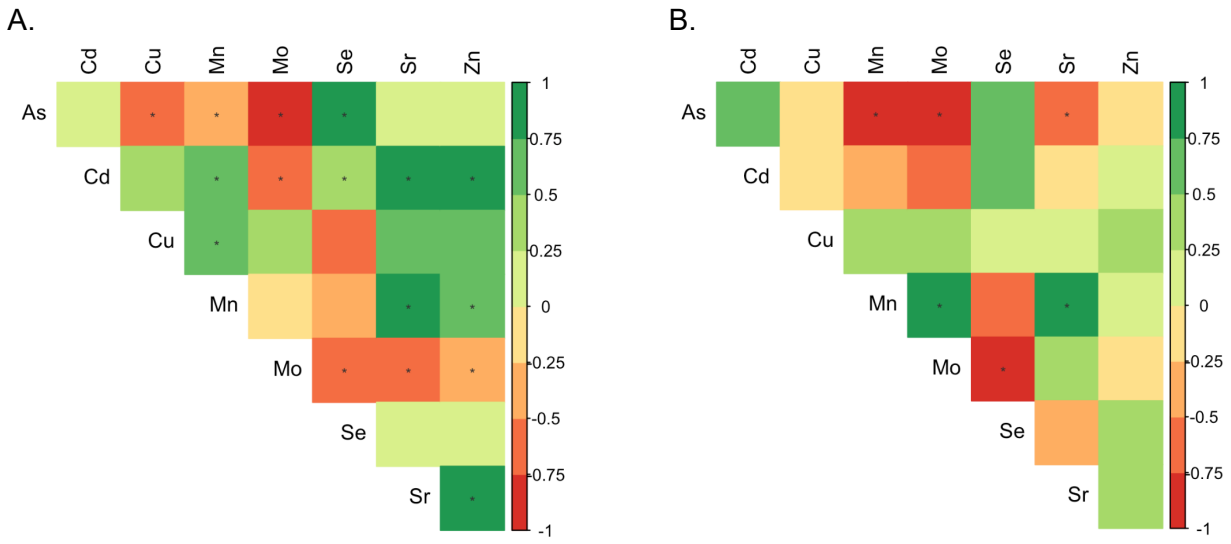
Supplementary Figure S1. Flowchart depicting seminal plasma collection from male study participants at two time points.



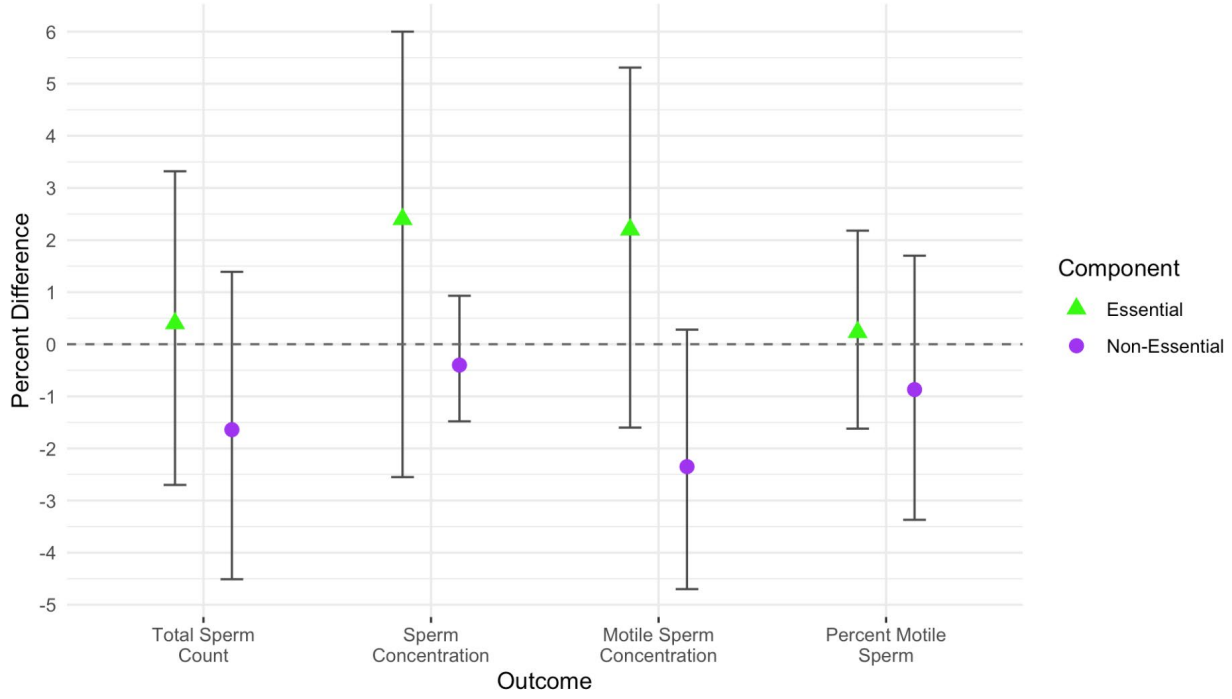
Supplementary Figure S2. Directed acyclic graph (DAG) describing the conceptual model of hypothesized causal associations between seminal plasma trace element concentrations and sperm quality outcome measurements.



Supplementary Figure S3. Scree plot of seminal plasma trace element concentrations at time 2 semen collection, from principal component analysis.



Supplementary Figure S4. Pairwise correlations between seminal plasma trace element concentrations at **(A)** Time 1 (n = 27) and **(B)** Time 2 (n = 35) among male partners of IVF patients. NOTE: * P-value < 0.10.



Supplementary Figure S5. Sensitivity analysis of adjusted associations, with missing smoking values imputed as smokers, between multiple seminal plasma trace elements and sperm quality outcomes among male partners of IVF patients (n = 35). NOTE: Relative difference in sperm quality outcome for the difference between the 25th percentile and the 75th percentile of seminal plasma trace element concentrations (µg/L), adjusted for age (years), days abstinent before providing specimen, race (Asian *vs.* Other), and seafood consumption (> 1 lb. in the past week).