**SUPPLEMENTARY MATERIAL**

**Urinary Metals and Metal Mixtures in Midlife Women: the Study of Women’s Health Across the Nation (SWAN)**

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Too few urine vials in repository for metal measurements (n=648)

Urine sample not collected at Chicago (n=368) and Newark (n=278)

Eligible cohort at V03, 1999-2000, n=2,048

Study sites: Boston, Southeast Michigan, Los Angeles, Oakland, Pittsburgh

SWAN cohort at V03, 1999-2000, n=2,694

Study sites: Boston, Southeast Michigan, Los Angeles, Oakland, Pittsburgh, Chicago, Newark

Dropout through V03, 1999-2000

(n=608)

Baseline SWAN cohort, 1996-1997, n=3,302

Study sites: Boston, Southeast Michigan, Los Angeles, Oakland, Pittsburgh, Chicago, Newark

SWAN Multi-Pollutant Study in which metal concentrations were measured, 1999-2000, n=1400

Study sites: Boston, Southeast Michigan, Los Angeles, Oakland, Pittsburgh

Excluded due to missing information on covariates (n=63) and insufficient urine in vials to complete metal measures (n=2)

Final analytical sample size (n=1,335)

Study site and racial/ethnic groups:

Boston: white and black

Southeast Michigan: white and black

Los Angeles: white and Japanese

Oakland: white and Chinese

Pittsburgh: white and black

**Figure S1.** Schematic diagram of the SWAN Multi-Pollutant Study and analytic sample.



**Figure S2**. Determination of optimal number of clusters in k-means clustering. (A) Cubic clustering criterion. This figure contains the cubic clustering criterion values from k=2 to k=10. Note the local maxima at k=2, indicating two is optimal estimate for the number of clusters. (B) Elbow method. This figure plots the total within-cluster sum of square against number of clusters (1 to 10 in our case). The location of a bend (knee) in the plot is generally considered as an indicator of the appropriate number of clusters. (C) Average Silhouette method. This figure shows how well each participants lies within its cluster by average silhouette width. A high average silhouette width indicates a good clustering. The optimal number of clusters is the one that maximizes the average silhouette over a range of possible values (which from 1 to 10 in our case).

**Table S1**. Unadjusted (μg/L) and urinary creatinine adjusted (μg/g) metal concentrations in SWAN participants.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Metals | LODa | % > LODb | GM (GSD)c | Selected percentiles |
|  |  |  |  | 5th  | 25th  | 50th  | 75th  | 90th  | 95th  |
| Arsenic | 0.3 | 100 | 17.11 (3.58) | 2.55 | 6.84 | 15.03 | 38.75 | 94.71 | 151.13 |
|  |  |  | *20.23 (3.39)d* | *3.96* | *8.03* | *16.89* | *43.73* | *107.23* | *184.35* |
| Barium | 0.1 | 99.5 | 1.72 (2.50) | 0.37 | 0.99 | 1.78 | 2.97 | 5.02 | 7.31 |
|  |  |  | *2.04 (2.38)* | *0.53* | *1.16* | *2.00* | *3.47* | *5.79* | *8.51* |
| Beryllium | 0.04 | 16.2 | n.d.e | < LOD | < LOD | < LOD | < LOD | 0.05 | 0.08 |
|  |  |  | *n.d.* | *< LOD* | *< LOD* | *< LOD* | *< LOD* | *0.12* | *0.19* |
| Cadmium | 0.06 | 94.5 | 0.41 (2.81) | < LOD | 0.22 | 0.44 | 0.80 | 1.42 | 1.98 |
|  |  |  | *0.48 (2.34)* | *< LOD* | *0.29* | *0.49* | *0.84* | *1.32* | *1.83* |
| Cobalt | 0.05 | 99.2 | 0.60 (2.28) | 0.15 | 0.37 | 0.62 | 0.95 | 1.70 | 2.27 |
|  |  |  | *0.71 (1.92)* | *0.27* | *0.46* | *0.67* | *1.05* | *1.68* | *2.30* |
| Chromium | 0.4 | 24.3 | n.d. | < LOD | < LOD | < LOD | < LOD | 0.84 | 1.58 |
|  |  |  | *n.d.* | *< LOD* | *< LOD* | *< LOD* | *< LOD* | *1.38* | *2.50* |
| Cesium | 0.01 | 100 | 4.67 (2.02) | 1.51 | 3.03 | 4.73 | 7.32 | 10.44 | 14.06 |
|  |  |  | *5.52 (1.77)* | *2.51* | *3.97* | *5.32* | *7.50* | *11.03* | *14.20* |
| Copper | 2.5 | 96.6 | 9.45 (2.04) | 2.99 | 6.07 | 9.53 | 14.47 | 21.75 | 29.36 |
|  |  |  | *11.18 (1.67)* | *5.96* | *8.35* | *10.45* | *13.54* | *19.12* | *27.01* |
| Mercury | 0.05 | 99.7 | 1.18 (2.57) | 0.25 | 0.66 | 1.23 | 2.37 | 3.71 | 5.22 |
|  |  |  | *1.40 (2.28)* | *0.35* | *0.87* | *1.43* | *2.47* | *3.79* | *5.02* |
| Manganese | 0.08 | 99.7 | 0.96 (2.14) | 0.33 | 0.59 | 0.90 | 1.47 | 2.46 | 3.40 |
|  |  |  | *1.14 (2.22)* | *0.37* | *0.67* | *1.03* | *1.78* | *3.15* | *4.87* |
| Molybdenum | 0.3 | 100 | 41.76 (2.28) | 9.86 | 24.92 | 43.88 | 71.73 | 113.74 | 144.31 |
|  |  |  | *49.39 (1.92)* | *17.83* | *34.18* | *48.65* | *70.75* | *105.28* | *139.33* |
| Nickel | 0.8 | 95.9 | 3.56 (2.11) | 0.89 | 2.35 | 3.77 | 5.85 | 8.49 | 10.66 |
|  |  |  | *4.21 (1.83)* | *1.56* | *2.89* | *4.20* | *6.10* | *8.99* | *11.12* |
| Lead | 0.1 | 97.8 | 0.76 (2.35) | 0.19 | 0.46 | 0.78 | 1.26 | 2.06 | 2.74 |
|  |  |  | *0.90 (2.05)* | *0.32* | *0.57* | *0.87* | *1.33* | *2.14* | *2.85* |
| Platinum | 0.05 | 2.6 | n.d. | < LOD | < LOD | < LOD | < LOD | < LOD | < LOD |
|  |  |  | *n.d.* | *< LOD* | *< LOD* | *< LOD* | *< LOD* | *< LOD* | *< LOD* |
| Antimony | 0.04 | 78.8 | 0.08 (2.20) | < LOD | 0.04 | 0.08 | 0.13 | 0.21 | 0.30 |
|  |  |  | *0.09 (2.05)* | *< LOD* | *0.06* | *0.09* | *0.14* | *0.21* | *0.30* |
| Tin | 0.1 | 96.8 | 0.97 (3.00) | 0.16 | 0.49 | 0.94 | 1.78 | 3.57 | 6.67 |
|  |  |  | *1.14 (2.57)* | *0.32* | *0.63* | *1.00* | *1.83* | *3.74* | *7.06* |
| Thallium | 0.02 | 92.2 | 0.13 (2.57) | < LOD | 0.08 | 0.15 | 0.23 | 0.33 | 0.40 |
|  |  |  | *0.15 (2.32)* | *< LOD* | *0.10* | *0.16* | *0.23* | *0.36* | *0.48* |
| Uranium | 0.01 | 33.0 | 0.01 (1.97) | < LOD | < LOD | < LOD | 0.01 | 0.03 | 0.04 |
|  |  |  | *0.01 (2.44)* | *< LOD* | *< LOD* | *< LOD* | *0.02* | *0.04* | *0.07* |
| Vanadium | 0.6 | 37.2 | 0.69 (2.14) | < LOD | < LOD | < LOD | 1.05 | 2.39 | 3.42 |
|  |  |  | *0.82 (2.56)* | *< LOD* | *< LOD* | *< LOD* | *1.45* | *3.13* | *4.41* |
| Tungsten | 0.2 | 29.6 | n.d. | < LOD | < LOD | < LOD | 0.23 | 0.43 | 0.64 |
|  |  |  | *n.d.* | *< LOD* | *< LOD* | *< LOD* | *0.33* | *0.67* | *1.04* |
| Zinc | 2 | 100 | 283 (2) | 56 | 167 | 308 | 532 | 810 | 1033 |
|  |  |  | 335 (2) | 117 | 228 | 345 | 503 | 714 | 927 |

a LOD: limit of detection.

b % > LOD: detection rate

c GM: geometric mean; GSD: geometric standard deviation

d Italic type denotes measure in μg/g creatinine

e n.d.: not determined

**Table S2**. Model adjusted least-squares geometric mean concentrationsa (LSGMs, μg/L) and 95% confidence intervals of urinary metals by characteristics of the SWAN participants.

| LSGMsb (μg/L) | As | Ba | Cd | Co | Cs | Cu | Hg | Mn | Mo | Ni | Pb | Sb | Sn | Tl | Zn |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Race/ethnicity |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  White | 12.3(10.9, 13.8) | 1.89(1.73, 2.08) | 0.42(0.38, 0.46) | 0.60(0.55, 0.64) | 4.75(4.50, 5.02) | 9.48(8.96, 10.0) | 1.07(0.98, 1.17) | 1.03(0.95, 1.11) | 38.8(36.2, 41.7) | 3.58(3.36, 3.81) | 0.82(0.76, 0.88) | 0.08(0.07, 0.09) | 1.02(0.92, 1.13) | 0.12(0.11, 0.13) | 272(252, 293) |
|  Black | 11.5(9.79, 13.5) | 1.35(1.19, 1.52) | 0.42(0.38, 0.47) | 0.50(0.45, 0.55) | 3.58(3.32, 3.85) | 8.51(7.88, 9.18) | 0.85(0.75, 0.95) | 0.92(0.83, 1.02) | 30.7(27.9, 33.8) | 2.59(2.38, 2.81) | 0.79(0.71, 0.88) | 0.08(0.07, 0.09) | 1.03(0.90, 1.19) | 0.11(0.10, 0.13) | 342(310, 378) |
|  Chinese | 37.2(28.9, 48.0) | 1.92(1.58, 2.34) | 0.80(0.67, 0.97) | 0.77(0.66, 0.91) | 7.31(6.50, 8.21) | 12.1(10.7, 13.6) | 1.42(1.18, 1.72) | 1.01(0.86, 1.19) | 54.8(47.1, 63.8) | 4.44(3.88, 5.07) | 1.19(1.01, 1.40) | 0.10(0.08, 0.12) | 0.78(0.63, 0.98) | 0.16(0.14, 0.20) | 353(302, 414) |
|  Japanese | 32.1(25.4, 40.5) | 1.92(1.61, 2.30) | 0.87(0.74, 1.03) | 0.62(0.54, 0.71) | 4.38(3.94, 4.88) | 10.7(9.59, 12.0) | 1.42(1.20, 1.68) | 1.04(0.90, 1.21) | 55.1(47.9, 63.3) | 3.93(3.47, 4.40) | 0.92(0.79, 1.07) | 0.08(0.07, 0.09) | 0.96(0.78, 1.17) | 0.15(0.13, 0.18) | 333(288, 385) |
|   *P-value* | *<.0001* | *<.0001* | *<.0001* | *<.0001* | *<.0001* | *<.0001* | *<.0001* | *0.28* | *<.0001* | *<.0001* | *<.0001* | *0.09* | *0.11* | *0.0002* | *<.0001* |
| Education |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  ≤ High school | 18.9(16.2, 22.1) | 1.72(1.53, 1.95) | 0.63(0.56, 0.70) | 0.62(0.56, 0.68) | 4.94(4.60, 5.32) | 10.2(9.48, 11.0) | 1.02(0.91, 1.15) | 1.01(0.92, 1.12) | 43.3(39.4, 47.5) | 3.56(3.28, 3.87) | 0.90(0.82, 1.00) | 0.10(0.08, 0.11) | 0.88(0.77, 1.01) | 0.13(0.11, 0.15) | 340(308, 374) |
|  Some College | 21.7(18.9, 24.9) | 1.87(1.68, 2.08) | 0.62(0.56, 0.69) | 0.61(0.56, 0.66) | 4.75(4.46, 5.06) | 10.1(9.49, 10.8) | 1.22(1.11, 1.35) | 0.98(0.90, 1.07) | 44.5(41.0, 48.3) | 3.61(3.36, 3.88) | 0.91(0.84, 1.00) | 0.09(0.08, 0.10) | 1.02(0.90, 1.15) | 0.14(0.13, 0.16) | 333(305, 362) |
|  ≥ College | 20.2(17.6, 23.3) | 1.66(1.49, 1.86) | 0.53(0.48, 0.59) | 0.61(0.56, 0.67) | 4.80(4.50, 5.12) | 9.96(9.32, 10.7) | 1.26(1.13, 1.40) | 1.00(0.92, 1.10) | 42.9(39.5, 46.7) | 3.52(3.27, 3.79) | 0.93(0.85, 1.02) | 0.08(0.07, 0.09) | 0.93(0.82, 1.05) | 0.13(0.12, 0.15) | 299(274, 327) |
|  *P for trend* | *0.13* | *0.15* | *0.02* | *0.29* | *0.50* | *0.47* | *0.0004* | *0.38* | *0.55* | *0.22* | *0.14* | *0.01* | *0.81* | *0.69* | *0.0006* |
| Financial hardship |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  Severe | 19.014.9, 24.2) | 1.741.44, 2.10) | 0.59(0.50, 0.71) | 0.63(0.54, 0.73) | 4.74(4.24, 5.29) | 10.3(9.18, 11.6) | 1.08(0.91, 1.29) | 1.00(0.86, 1.17) | 44.0(38.1, 50.8) | 3.65(3.21, 4.14) | 0.96(0.83, 1.12) | 0.09(0.08, 0.10) | 0.91(0.73, 1.12) | 0.13(0.11, 0.16) | 338(291, 392) |
|  Moderate | 20.7(18.1, 23.7) | 1.70(1.53, 1.88) | 0.62(0.56, 0.69) | 0.61(0.56, 0.67) | 4.94(4.64, 5.25) | 10.3(9.63, 11.0) | 1.17(1.06, 1.29) | 1.03(0.95, 1.13) | 43.1(39.7, 46.7) | 3.55(3.31, 3.82) | 0.93(0.85, 1.01) | 0.08(0.08, 0.09) | 0.98(0.87, 1.10) | 0.14(0.13, 0.15) | 314(289, 342) |
|  Minor | 21.1(19.0, 23.5) | 1.82(1.68, 2.00) | 0.56(0.52, 0.61) | 0.60(0.56, 0.64) | 4.82(4.59, 5.06) | 9.75(9.27, 10.3) | 1.25(1.16, 1.35) | 0.96(0.90, 1.03) | 43.6(40.9, 46.4) | 3.49(3.30, 3.69) | 0.87(0.81, 0.93) | 0.08(0.08, 0.09) | 0.94(0.86, 1.03) | 0.13(0.12, 0.14) | 319(299, 341) |
|  *P for trend* | *0.59* | *0.23* | *0.09* | *0.59* | *0.65* | *0.16* | *0.09* | *0.16* | *0.89* | *0.55* | *0.07* | *0.29* | *0.83* | *0.26* | *0.87* |
| Smoking |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  Never | 20.5(18.3, 23.0) | 1.68(1.54, 1.83) | 0.46(0.42, 0.50) | 0.66(0.62, 0.71) | 4.74(4.50, 5.00) | 10.2(9.64, 10.7) | 1.24(1.14, 1.35) | 0.96(0.89, 1.03) | 45.9(42.9, 49.1) | 3.81(3.58, 4.04) | 0.82(0.76, 0.88) | 0.08(0.07, 0.09) | 0.96(0.87, 1.06) | 0.14(0.13, 0.15) | 308(287, 331) |
|  Former | 20.6(17.8, 23.8) | 1.73(1.54, 1.93) | 0.55(0.49, 0.61) | 0.61(0.56, 0.67) | 4.93(4.61, 5.28) | 10.2(9.52, 10.9) | 1.12(1.00, 1.24) | 1.03(0.93, 1.13) | 43.6(40.0, 47.6) | 3.58(3.32, 3.87) | 0.89(0.81, 0.98) | 0.09(0.08, 0.10) | 0.83(0.73, 0.94) | 0.13(0.12, 0.15) | 322(294, 353) |
|  Current | 19.7(16.1, 24.1) | 1.86(1.58, 2.17) | 0.83(0.71, 0.96) | 0.57(0.50, 0.64) | 4.82(4.39, 5.29) | 9.93(9.01, 10.9) | 1.14(0.98, 1.32) | 1.01(0.89, 1.15) | 41.3(36.6, 46.6) | 3.32(2.98, 3.70) | 1.06(0.93, 1.21) | 0.09(0.08, 0.10) | 1.06(0.89, 1.27) | 0.13(0.11, 0.15) | 341(300, 387) |
|  *P for trend* | *0.88* | *0.27* | *<.0001* | *0.002* | *0.28* | *0.53* | *0.10* | *0.10* | *0.12* | *0.004* | *<.0001* | *0.12* | *0.67* | *0.46* | *0.09* |
| Secondhand smoking |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  0 hr/wk | 20.8(18.1, 23.8) | 1.69(1.52, 1.88) | 0.62(0.56, 0.68) | 0.60(0.55, 0.65) | 4.82(4.54, 5.13) | 10.1(9.43, 10.7) | 1.14(1.03, 1.26) | 1.05(0.96, 1.14) | 45.6(42.1, 49.5) | 3.49(3.25, 3.75) | 0.88(0.80, 0.95) | 0.09(0.08, 0.10) | 0.94(0.83, 1.06) | 0.14(0.13, 0.16) | 314(289, 341) |
|  <5 hrs/wk | 19.00(16.3, 22.2) | 1.79(1.59, 2.02) | 0.57(0.50, 0.63) | 0.63(0.57, 0.69) | 4.77(4.45, 5.12) | 10.5(9.73, 11.3) | 1.16(1.03, 1.30) | 0.98(0.89, 1.09) | 41.4(37.7, 45.4) | 3.63(3.34, 3.94) | 0.93(0.84, 1.03) | 0.08(0.07, 0.09) | 0.95(0.83, 1.09) | 0.13(0.12, 0.15) | 317(288, 349) |
|  ≥5 hs/wk | 21.1(18.2, 24.4) | 1.77(1.58, 1.99) | 0.60(0.53, 0.66) | 0.61(0.56, 0.67) | 4.89(4.58, 5.24) | 9.79(9.13, 10.5) | 1.19(1.07, 1.33) | 0.96(0.88, 1.06) | 43.8(40.1, 47.8) | 3.57(3.31, 3.86) | 0.95(0.87, 1.04) | 0.09(0.08, 0.10) | 0.94(0.83, 1.07) | 0.13(0.12, 0.15) | 340(311, 373) |
|  *P for trend* | *0.89* | *0.19* | *0.62* | *0.21* | *0.53* | *0.67* | *0.04* | *0.10* | *0.43* | *0.53* | *0.005* | *0.32* | *0.24* | *0.41* | *0.06* |

a All models were adjusted for age, race/ethnicity, education, financial hardship, smoking, secondhand smoking, study sites and urinary creatinine.

b For values greater than 1, 3 significant figures were shown; for values less than 1, values were shown to 2 decimal places.

**Table S3**. Model adjusted least-squares geometric mean concentrationsa (LSGMs, μg/L) and 95% confidence intervals of urinary metals between white and Chinese women within Oakland site, and between white and Japanese women within Los Angeles site.

| LSGMsb,c (μg/L) | As | Ba | Cd | Co | Cs | Cu | Hg | Mn | Mo | Ni | Pb | Sb | Sn | Tl | Zn |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Oakland (n=300) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  White (n=130) | 13.9(9.52, 20.4) | 1.91(1.38, 2.63) | 0.46(0.34, 0.62) | 0.40(0.31, 0.53) | 5.32(4.10, 6.91) | 7.71(6.27, 9.48) | 1.12(0.84, 1.48) | 0.91(0.68, 1.20) | 31.6(25.0, 39.9) | 3.04(2.49, 3.70) | 0.71(0.56, 0.89) | 0.08(0.07, 0.11) | 0.72(0.50, 1.02) | 0.13(0.11, 0.16) | 219(169, 284) |
|  Chinese (n=170) | 32.0(21.0, 48.7) | 1.89(1.32, 2.70) | 0.81(0.59, 1.12) | 0.46(0.35, 0.62) | 7.72(5.78, 10.30) | 9.32(7.42, 11.7) | 1.34(0.98, 1.84) | 0.83(0.61, 1.14) | 39.0(30.2, 50.5) | 3.84(3.09, 4.78) | 0.94(0.72, 1.21) | 0.09(0.07, 0.11) | 0.52(0.35, 0.77) | 0.17(0.14, 0.22) | 297(223, 396) |
|  *P-value* | *<.0001* | *0.96* | *<.0001* | *0.28* | *0.003* | *0.06* | *0.17* | *0.55* | *0.06* | *0.01* | *0.01* | *0.82* | *0.06* | *0.01* | *0.01* |
| Los Angeles (n=353) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  White (n=154) | 16.0(12.3, 20.8) | 1.90(1.53, 2.35) | 0.31(0.25, 0.38) | 0.61(0.51, 0.73) | 4.66(4.16, 5.21) | 8.24(7.33, 9.25) | 1.05(0.87, 1.28) | 0.86(0.71, 1.05) | 38.8(33.0, 45.7) | 3.67(3.14, 4.28) | 0.67(0.57, 0.80) | 0.08(0.07, 0.09) | 0.88(0.68, 1.13) | 0.10(0.09, 0.12) | 242(203, 288) |
|  Japanese (n=199) | 26.8(20.1, 35.7) | 1.85(1.47, 2.33) | 0.55(0.44, 0.69) | 0.58(0.48, 0.71) | 4.24(3.76, 4.79) | 8.60(7.58, 9.76) | 1.25(1.01, 1.55) | 0.95(0.76, 1.18) | 49.5(41.4, 59.1) | 3.50(2.96, 4.13) | 0.68(0.55, 0.80) | 0.08(0.06, 0.09) | 0.73(0.55, 0.96) | 0.12(0.10, 0.15) | 317(262, 383) |
|   *P-value* | *0.0006* | *0.82* | *<.0001* | *0.64* | *0.15* | *0.51* | *0.12* | *0.40* | *0.009* | *0.59* | *0.93* | *0.42* | *0.19* | *0.07* | *0.007* |

a All models were adjusted for age, education, financial hardship, smoking, secondhand smoking, seafood intake, rice intake, total energy intake, and urinary creatinine.

b Chinese was only sampled in Oakland site and Japanese was only sampled in Los Angeles site by study design.

c For values greater than 1, 3 significant figures were shown; for values less than 1, values were shown to 2 decimal places.

**Table S4**. Ratios of geometric means for urinary metals from linear regression with backward eliminationa.

| Ratio(95% CI) | As | Ba | Cd | Co | Cs | Cu | Hg | Mn | Mo | Ni | Pb | Sb | Sn | Tl | Zn |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Race/ethnicity |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  White | 1.00(Ref) | 1.00(Ref) | 1.00(Ref) | 1.00(Ref) | 1.00(Ref) | 1.00(Ref) | 1.00(Ref) |  | 1.00(Ref) | 1.00(Ref) | 1.00(Ref) |  |  | 1.00(Ref) | 1.00(Ref) |
|  Black | 0.88(0.74, 1.05) | 0.71(0.63, 0.80) | 1.03(0.92, 1.16) | 0.84(0.76, 0.92) | 0.75(0.69, 0.81) | 0.90(0.83, 0.97) | 0.77(0.69, 0.87) |  | 0.79(0.71, 0.87) | 0.72(0.66, 0.78) | 0.97(0.87, 1.08) |  |  | 0.97(0.85, 1.10) | 1.27(1.15, 1.40) |
|  Chinese | 1.93(1.47, 2.55) | 1.00(0.82, 1.21) | 1.93(1.62, 2.31) | 1.30(1.11, 1.52) | 1.38(1.20, 1.58) | 1.17(1.02, 1.35) | 1.17(0.96, 1.43) |  | 1.28(1.09, 1.52) | 1.15(1.00, 1.32) | 1.42(1.21, 1.66) |  |  | 1.43(1.20, 1.71) | 1.27(1.09, 1.48) |
|  Japanese | 1.73(1.34, 2.44) | 1.01(0.85, 1.21) | 2.10(1.79, 2.45) | 1.04(0.91, 1.19) | 0.85(0.76, 0.96) | 1.05(0.93, 1.18) | 1.15(0.96, 1.37) |  | 1.27(1.09, 1.48) | 1.01(0.88, 1.15) | 1.09(0.95, 1.26) |  |  | 1.28(1.08, 1.52) | 1.23(1.08, 1.42) |
| Education |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  ≤ High school |  |  | 1.00(Ref) |  |  |  | 1.00(Ref) |  |  |  |  |  |  |  |  |
|  Some College |  |  | 0.99(0.88, 1.11) |  |  |  | 1.21(1.08, 1.36) |  |  |  |  |  |  |  |  |
|  ≥ College |  |  | 0.83(0.74, 0.93) |  |  |  | 1.26(1.12, 1.42) |  |  |  |  |  |  |  |  |
| Smoking |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  Never |  |  | 1.00(Ref) | 1.00(Ref) |  |  |  |  |  |  | 1.00(Ref) |  | 1.00(Ref) |  |  |
|  Former |  |  | 1.19(1.07, 1.31) | 0.92(0.85, 1.00) |  |  |  |  |  |  | 1.09(1.01, 1.18) |  | 0.90(0.80, 1.01) |  |  |
|  Current |  |  | 1.82(1.59, 2.09) | 0.85(0.76, 0.96) |  |  |  |  |  |  | 1.35(1.19, 1.53) |  | 1.13(0.95, 1.35) |  |  |
| Secondhand smoking |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  0 hr/wk |  |  |  |  |  |  |  |  |  |  |  | 1.00(Ref) |  |  |  |
|  <5 hrs/wk |  |  |  |  |  |  |  |  |  |  |  | 0.92(0.85, 1.01) |  |  |  |
|  ≥5 hs/wk |  |  |  |  |  |  |  |  |  |  |  | 1.09(1.00, 1.20) |  |  |  |
| Seafood intake |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  <1 /wk | 1.00(Ref) |  |  |  | 1.00(Ref) |  | 1.00(Ref) |  |  |  | 1.00(Ref) |  |  |  |  |
|  1-1.9 /wk | 1.17(1.02, 1.35) |  |  |  | 1.09(1.03, 1.16) |  | 1.14(1.03, 1.26) |  |  |  | 1.01(0.92, 1.11) |  |  |  |  |
|  ≥2 /wk | 1.55(1.35, 1.78) |  |  |  | 1.07(1.01, 1.14) |  | 1.21(1.08, 1.36) |  |  |  | 1.13(1.01, 1.23) |  |  |  |  |
| Rice intake |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  <1.5 /wk | 1.00(Ref) |  |  |  | 1.00(Ref) | 1.00(Ref) | 1.00(Ref) |  | 1.00(Ref) | 1.00(Ref) |  |  |  |  |  |
|  1.5-3.4 /wk | 1.02(0.89, 1.17) |  |  |  | 1.00(0.94, 1.06) | 0.97(0.92, 1.03) | 1.06(0.96, 1.17) |  | 1.00(0.92, 1.08) | 0.98(0.91, 1.05) |  |  |  |  |  |
|  ≥3.5 /wk | 1.67(1.37, 2.03) |  |  |  | 1.13(1.02, 1.24) | 1.09(0.99, 1.21) | 1.23(1.05, 1.44) |  | 1.19(1.05, 1.34) | 1.13(1.01, 1.26) |  |  |  |  |  |

a *P* <0.05 for all selected variables in backward elimination. Age, study sites, total energy intake, and urinary creatinine were forced in model selection.

**Table S5**. Geometric mean (GMs, μg/g) of urinary creatinine adjusted metal concentrations by overall exposure patterns.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| GM (GSD)a | As | Ba | Cd | Co | Cs | Cu | Hg | Mn | Mo | Ni | Pb | Sb | Sn | Tl | Zn |
| Low exposure pattern (n=773) | 13.24(2.75) | 1.51(2.19) | 0.36(2.14) | 0.58(1.84) | 4.45(1.65) | 9.17(1.50) | 1.09(2.27) | 0.84(1.88) | 41.35(1.85) | 3.33(1.71) | 0.66(1.80) | 0.08(2.00) | 1.04(2.47) | 0.11(2.16) | 305(1.89) |
| High exposure pattern (n=562) | 36.43(3.46) | 3.10(2.23) | 0.72(2.22) | 0.95(1.81) | 7.45(1.70) | 14.69(1.69) | 1.98(2.01) | 1.73(2.25) | 63.38(1.85) | 5.84(1.70) | 1.39(1.93) | 0.12(1.98) | 1.31(2.67) | 0.22(2.19) | 381(1.89) |

a GM: geometric mean; GSD: geometric standard deviation.

**Table S6**. Estimated cumulative odds ratio (95% confidence intervals) of being clustered into the “high” exposure patterna.

|  |  |  |  |
| --- | --- | --- | --- |
| Covariatesb | Odds ratio  | 95% CI | P-value |
| Black vs. white women | 0.38 | 0.26, 0.55 | <.0001 |
| Chinese vs. white women | 2.13 | 1.21, 3.77 | 0.009 |
| Japanese vs. white women | 2.33 | 1.39, 3.92 | 0.001 |
| Some college vs. high school or less | 0.91 | 0.62, 1.31 | 0.60 |
| College and above vs. high school or less | 0.97 | 0.67, 1.40 | 0.86 |
| Financial hardship: moderate vs. severe | 0.68 | 0.39, 1.19 | 0.17 |
| Financial hardship: minor vs. severe | 0.63 | 0.37, 1.07 | 0.09 |
| Former vs. never smoker | 1.03 | 0.77, 1.36 | 0.86 |
| Current vs. never smoker | 2.02 | 1.29, 3.17 | 0.002 |
| Secondhand smoking <5 vs. 0 hrs/wk | 1.29 | 0.96, 1.74 | 0.09 |
| Secondhand smoking ≥5 vs. 0 hrs/wk | 1.33 | 0.94, 1.89 | 0.10 |
| Seafood intake 1-1.9 /wk vs. <1 time/wk | 1.32 | 0.97, 1.80 | 0.08 |
| Seafood intake ≥2 vs. <1 time/wk | 1.82 | 1.33, 2.49 | 0.0002 |
| Rice intake 1.5-3.4 /wk vs. <1.5 times/wk | 1.10 | 0.81, 1.48 | 0.55 |
| Rice intake ≥3.5 vs. <1.5 times/wk | 1.73 | 1.12, 2.67 | 0.01 |
| Boston vs. Michigan | 3.37 | 2.11, 5.34 | <.0001 |
| Oakland vs. Michigan | 2.65 | 1.52, 4.60 | 0.0006 |
| Los Angeles vs. Michigan | 1.84 | 1.07, 3.16 | 0.03 |
| Pittsburgh vs. Michigan | 3.18 | 1.99, 5.07 | <.0001 |

a Participants with “high” vs. “low” exposure patterns were clustered by k-means clustering method.

b Reference groups: race: white women; education: ≤ high school; financial hardship: severe; smoking: never smoker; secondhand smoking: 0 hours/week; seafood intake: <1 time/week; rice intake: <1.5 times/week; study sites: Michigan. Age and total energy intake were adjusted as continuous variables.

**Table S7**. Model adjusted least-squares geometric mean concentrationsa (LSGMs, μg/L) and 95% confidence intervals of urinary metals by characteristics of the SWAN participants, including seafood and rice intake, adjusting for specific gravity.

| LSGMsb (μg/L) | As | Ba | Cd | Co | Cs | Cu | Hg | Mn | Mo | Ni | Pb | Sb | Sn | Tl | Zn |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Race/ethnicity |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  White | 13.5(11.9, 15.3) | 1.86(1.69, 2.05) | 0.41(0.37, 0.45) | 0.59(0.54, 0.64) | 4.71(4.44, 5.01) | 9.24(8.69, 9.84) | 1.09(0.99, 1.20) | 1.00(0.92, 1.09) | 38.9(36.0, 42.1) | 3.53(3.31, 3.76) | 0.80(0.73, 0.86) | 0.08(0.08, 0.09) | 1.02(0.91, 1.14) | 0.12(0.11, 0.13) | 256(237, 278) |
|  Black | 14.0(12.0, 16.4) | 1.47(1.30, 1.66) | 0.49(0.44, 0.56) | 0.56(0.51, 0.62) | 4.10(3.80, 4.42) | 9.73(9.00, 10.5) | 1.00(0.88, 1.12) | 0.98(0.88, 1.08) | 35.8(32.5, 39.5) | 2.95(2.72, 3.20) | 0.89(0.81, 0.99) | 0.09(0.08, 0.10) | 1.21(1.05, 1.40) | 0.13(0.11, 0.14) | 390(353, 431) |
|  Chinese | 26.4(20.4, 34.2) | 1.77(1.45, 2.16) | 0.71(0.58, 0.87) | 0.70(0.60, 0.83) | 6.58(5.81, 7.44) | 10.9(9.56, 12.3) | 1.23(1.01, 1.51) | 0.97(0.82, 1.15) | 48.3(41.2, 56.6) | 3.99(3.50, 4.54) | 1.09(0.92, 1.29) | 0.09(0.08, 0.11) | 0.70(0.55, 0.88) | 0.15(0.12, 0.18) | 342(290, 403) |
|  Japanese | 24.0(19.0, 30.3) | 1.82(1.52, 2.18) | 0.80(0.66, 0.96) | 0.58(0.50, 0.67) | 4.09(3.65, 4.58) | 9.94(8.84, 11.2) | 1.28(1.07, 1.54) | 1.01(0.87, 1.19) | 50.5(43.7, 58.4) | 3.65(3.24, 4.12) | 0.86(0.74, 1.01) | 0.07(0.06, 0.08) | 0.89(0.72, 1.11) | 0.14(0.12, 0.17) | 334(287, 388) |
|   *P-value* | *<.0001* | *0.004* | *<.0001* | *0.15* | *<.0001* | *0.08* | *0.13* | *0.94* | *0.0007* | *<.0001* | *0.002* | *0.02* | *0.002* | *0.04* | *<.0001* |
| Education |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  ≤ High school | 17.1(14.7, 19.9) | 1.68(1.49, 1.89) | 0.60(0.53, 0.68) | 0.60(0.55, 0.66) | 4.76(4.43, 5.13) | 9.77(9.07, 10.5) | 0.98(0.87, 1.11) | 1.00(0.90, 1.10) | 41.6(37.9, 45.7) | 3.41(3.16, 3.69) | 0.87(0.79, 0.96) | 0.08(0.08, 0.09) | 0.86(0.75, 0.98) | 0.12(0.11, 0.14) | 333(303, 367) |
|  Some College | 20.0(17.5, 22.9) | 1.84(1.66, 2.04) | 0.62(0.55, 0.69) | 0.60(0.55, 0.66) | 4.73(4.43, 5.04) | 10.0(9.36, 10.7) | 1.21(1.09, 1.35) | 0.97(0.89, 1.06) | 44.1(40.6, 47.9) | 3.57(3.33, 3.82) | 0.91(0.83, 0.99) | 0.09(0.08, 0.10) | 1.02(0.90, 1.15) | 0.14(0.13, 0.16) | 339(311, 369) |
|  ≥ College | 18.8(16.4, 21.6) | 1.66(1.49, 1.85) | 0.53(0.48, 0.59) | 0.61(0.56, 0.67) | 4.83(4.52, 5.16) | 10.0(9.34, 10.7) | 1.26(1.13, 1.40) | 1.00(0.91, 1.10) | 43.2(39.7, 47.1) | 3.55(3.31, 3.80) | 0.94(0.85, 1.02) | 0.08(0.07, 0.09) | 0.94(0.83, 1.07) | 0.13(0.12, 0.15) | 309(283, 338) |
|  *P for trend* | *0.72* | *0.49* | *0.01* | *0.67* | *0.70* | *0.69* | *0.0008* | *0.84* | *0.77* | *0.54* | *0.21* | *0.27* | *0.53* | *0.86* | *0.10* |
| Financial hardship |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  Severe | 17.0(13.5, 21.5) | 1.69(1.41, 2.02) | 0.57(0.47, 0.69) | 0.62(0.53, 0.72) | 4.70(4.20, 5.26) | 10.0(8.90, 11.2) | 1.07(0.90, 1.29) | 0.99(0.85, 1.16) | 43.6(37.7, 50.4) | 3.56(3.16, 4.01) | 0.94(0.80, 1.10) | 0.09(0.08, 0.10) | 0.91(0.73, 1.13) | 0.13(0.11, 0.16) | 343(296, 399) |
|  Moderate | 19.1(16.8, 21.8) | 1.68(1.52, 1.86) | 0.62(0.56, 0.69) | 0.61(0.56, 0.66) | 4.89(4.59, 5.21) | 10.2(9.6, 10.9) | 1.15(1.04, 1.28) | 1.03(0.94, 1.13) | 42.5(39.2, 46.2) | 3.53(3.30, 3.77) | 0.92(0.84, 1.01) | 0.08(0.08, 0.09) | 0.97(0.86, 1.10) | 0.14(0.12, 0.15) | 320(294, 348) |
|  Minor | 19.7(17.8, 21.8) | 1.81(1.67, 1.95) | 0.55(0.51, 0.60) | 0.59(0.55, 0.63) | 4.73(4.50, 4.97) | 9.58(9.11, 10.1) | 1.21(1.12, 1.32) | 0.95(0.89, 1.02) | 42.7(40.1, 45.5) | 3.44(3.26, 3.62) | 0.85(0.79, 0.91) | 0.08(0.07, 0.09) | 0.93(0.85, 1.02) | 0.13(0.12, 0.14) | 318(298, 339) |
|  *P for trend* | *0.35* | *0.21* | *0.08* | *0.39* | *0.58* | *0.09* | *0.17* | *0.16* | *0.81* | *0.35* | *0.05* | *0.20* | *0.62* | *0.21* | *0.47* |
| Smoking |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  Never | 18.3(16.3, 20.4) | 1.63(1.49, 1.78) | 0.45(0.41, 0.49) | 0.65(0.60, 0.69) | 4.61(4.37, 4.87) | 9.87(9.34, 10.4) | 1.20(1.10, 1.31) | 0.94(0.87, 1.01) | 44.4(41.4, 47.5) | 3.69(3.48, 3.90) | 0.79(0.73, 0.85) | 0.08(0.07, 0.09) | 0.93(0.84, 1.03) | 0.13(0.12, 0.15) | 306(285, 329) |
|  Former | 18.5(16.0, 21.3) | 1.67(1.49, 1.86) | 0.52(0.47, 0.59) | 0.59(0.54, 0.65) | 4.77(4.45, 5.11) | 9.82(9.15, 10.5) | 1.07(0.96, 1.20) | 1.01(0.91, 1.11) | 41.9(38.4, 45.8) | 3.45(3.21, 3.71) | 0.86(0.78, 0.95) | 0.08(0.07, 0.09) | 0.80(0.70, 0.91) | 0.13(0.11, 0.14) | 318(290, 348) |
|  Current | 19.0(15.6, 23.2) | 1.88(1.62, 2.19) | 0.84(0.72, 0.98) | 0.58(0.51, 0.66) | 4.94(4.49, 5.43) | 10.1(9.16, 11.1) | 1.17(1.00, 1.36) | 1.03(0.90, 1.17) | 42.6(37.7, 48.1) | 3.39(3.07, 3.75) | 1.08(0.95, 1.23) | 0.09(0.08, 0.10) | 1.10(0.92, 1.32) | 0.13(0.12, 0.16) | 358(316, 406) |
|  *P for trend* | *0.62* | *0.13* | *<.0001* | *0.01* | *0.13* | *0.90* | *0.21* | *0.08* | *0.35* | *0.02* | *<.0001* | *0.06* | *0.98* | *0.70* | *0.02* |
| Secondhand smoking |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  0 hr/wk | 19.3(16.9, 22.0) | 1.68(1.52, 1.86) | 0.61(0.55, 0.68) | 0.60(0.55, 0.65) | 4.80(4.51, 5.11) | 9.99(9.36, 10.7) | 1.13(1.02, 1.25) | 1.05(0.96, 1.15) | 45.3(41.8, 49.2) | 3.46(3.24, 3.70) | 0.87(0.80, 0.95) | 0.09(0.08, 0.09) | 0.94(0.83, 1.06) | 0.14(0.13, 0.15) | 320(295, 348) |
|  <5 hrs/wk | 17.8(15.3, 20.6) | 1.78(1.59, 2.00) | 0.56(0.50, 0.63) | 0.63(0.57, 0.69) | 4.76(4.43, 5.12) | 10.4(9.65, 11.2) | 1.15(1.02, 1.29) | 0.98(0.89, 1.08) | 41.2(37.6, 45.2) | 3.61(3.35, 3.90) | 0.92(0.84, 1.02) | 0.08(0.07, 0.09) | 0.96(0.84, 1.10) | 0.13(0.12, 0.14) | 322(293, 355) |
|  ≥5 hs/wk | 18.8(16.3, 21.6) | 1.71(1.53, 1.91) | 0.57(0.51, 0.64) | 0.59(0.54, 0.64) | 4.76(4.44, 5.09) | 9.43(8.78, 10.1) | 1.16(1.04, 1.29) | 0.94(0.86, 1.04) | 42.4(38.8, 46.3) | 3.45(3.21, 3.71) | 0.92(0.83, 1.01) | 0.09(0.08, 0.10) | 0.91(0.80, 1.04) | 0.13(0.11, 0.14) | 339(309, 371) |
|  *P for trend* | *0.62* | *0.45* | *0.40* | *0.96* | *0.74* | *0.35* | *0.43* | *0.02* | *0.11* | *0.75* | *0.17* | *0.79* | *0.75* | *0.17* | *0.23* |
| Seafood intake |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  <1 /wk | 15.6(13.5, 18.0) | 1.73(1.55, 1.93) | 0.58(0.52, 0.65) | 0.62(0.57, 0.68) | 4.65(4.34, 4.98) | 10.1(9.39, 10.8) | 1.06(0.95, 1.19) | 0.97(0.88, 1.07) | 41.9(38.4, 45.8) | 3.53(3.28, 3.79) | 0.89(0.81, 0.98) | 0.09(0.08, 0.10) | 0.94(0.82, 1.07) | 0.13(0.11, 0.14) | 336(306, 367) |
|  1-1.9 /wk | 17.7(15.5, 20.3) | 1.63(1.47, 1.81) | 0.56(0.50, 0.62) | 0.60(0.55, 0.65) | 4.89(4.58, 5.21) | 9.64(9.02, 10.3) | 1.16(1.05, 1.29) | 0.96(0.88, 1.05) | 43.2(39.8, 47.0) | 3.45(3.22, 3.70) | 0.87(0.80, 0.95) | 0.08(0.07, 0.09) | 0.99(0.88, 1.12) | 0.13(0.12, 0.14) | 326(299, 355) |
|  ≥2 /wk | 23.2(20.4, 26.4) | 1.81(1.64, 2.00) | 0.60(0.54, 0.67) | 0.60(0.55, 0.65) | 4.78(4.49, 5.09) | 10.1(9.43, 10.7) | 1.22(1.10, 1.35) | 1.04(0.95, 1.13) | 43.7(40.3, 47.4) | 3.55(3.32, 3.79) | 0.95(0.87, 1.03) | 0.08(0.08, 0.09) | 0.88(0.78, 1.00) | 0.14(0.12, 0.15) | 319(294, 347) |
|  *P for trend* | *<.0001* | *0.39* | *0.57* | *0.55* | *0.48* | *0.98* | *0.02* | *0.18* | *0.41* | *0.86* | *0.21* | *0.66* | *0.29* | *0.23* | *0.30* |
| Rice intake |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  <1.5 /wk | 16.0(13.7, 18.7) | 1.72(1.53, 1.94) | 0.58(0.51, 0.65) | 0.61(0.55, 0.67) | 4.70(4.37, 5.06) | 10.0(9.29, 10.8) | 1.07(0.95, 1.21) | 1.01(0.91, 1.11) | 42.2(38.4, 46.4) | 3.50(3.24, 3.79) | 0.90(0.81, 0.99) | 0.09(0.08, 0.09) | 0.90(0.78, 1.03) | 0.13(0.11, 0.14) | 334(303, 368) |
|  1.5-3.4 /wk | 16.1(13.9, 18.6) | 1.71(1.52, 1.91) | 0.57(0.51, 0.65) | 0.59(0.53, 0.64) | 4.67(4.36, 5.01) | 9.61(8.94, 10.3) | 1.13(1.01, 1.27) | 1.00(0.91, 1.10) | 41.1(37.6, 45.0) | 3.38(3.14, 3.64) | 0.90(0.82, 1.00) | 0.08(0.08, 0.09) | 0.92(0.81, 1.05) | 0.13(0.12, 0.15) | 344(314, 377) |
|  ≥3.5 /wk | 24.9(21.4, 29.0) | 1.74(1.55, 1.96) | 0.59(0.52, 0.67) | 0.62(0.57, 0.69) | 4.95(4.60, 5.32) | 10.2(9.42, 11.0) | 1.24(1.10, 1.40) | 0.97(0.87, 1.07) | 45.6(41.5, 50.1) | 3.65(3.38, 3.94) | 0.91(0.82, 1.00) | 0.08(0.07, 0.09) | 0.99(0.86, 1.14) | 0.14(0.12, 0.15) | 304(276, 355) |
|  *P for trend* | *0.0004* | *0.91* | *0.63* | *0.99* | *0.48* | *0.83* | *0.05* | *0.69* | *0.41* | *0.79* | *0.82* | *0.96* | *0.37* | *0.42* | *0.39* |

a All models were adjusted for age, race/ethnicity, education, financial hardship, smoking, secondhand smoking, seafood intake, rice intake, total energy intake, study sites and specific gravity.

b For values greater than 1, 3 significant figures were shown; for values less than 1, values were shown to 2 decimal places.