Supplementary methods

Interview Data

Data are from Wave 1 of the Population Assessment of Tobacco and Health (PATH) Study conducted from September 12, 2013 to December 15, 2014. The PATH Study is a nationally-representative, longitudinal cohort study of approximately 46,000 adults and youth in the U.S., ages 12 years and older. The National Institutes of Health (NIH), through the National Institute on Drug Abuse (NIDA), is partnering with the U.S. Food and Drug Administration’s Center for Tobacco Products (FDA-CTP) to conduct the PATH Study under a contract with Westat. The PATH Study used audio-computer assisted self-interviews (ACASI) available in English and Spanish to collect information on tobacco-use patterns and associated health behaviors. This analysis draws from the 32,320 Adult Interviews (all participants ages 18 years and older). Recruitment employed address-based, area-probability sampling, using an in-person household screener to select youths and adults. Adult tobacco users, young adults ages 18 to 24, and African Americans were oversampled relative to population proportions. The weighting procedures adjusted for oversampling and nonresponse; combined with the use of a probability sample, the weighted data allow the estimates produced by the PATH Study to be representative of the non-institutionalized civilian U.S. population. The weighted response rate for the household screener was 54.0%. Among households that were screened, the overall weighted response rate was 74.0% for the Adult Interview. Further details regarding the PATH Study design and methods are published elsewhere (1, 2). Details on survey interview procedures, questionnaires, sampling, weighting, and information on accessing the data are available online (1). Westat’s Institutional Review Board approved the study design and data collection protocol.

Biospecimen Collection Procedures

All Adult Interview respondents were asked to provide urine and blood biospecimens. Full-void urine specimens were self-collected by 21,801 (67.5%) consenting participants in a 500 mL polypropylene container (PN 6542, Globe Scientific), immediately placed in a Crēdo Cube shipper (Series 4-496, Minnesota Thermal Science) certified to hold contents between 2°C and 8°C for at least 72 hours and shipped overnight to the PATH Study biorepository. Each specimen was divided into aliquots and stored in FluidX® polypropylene cryovials at -80°C. All containers, pipet tips, and vials that came in direct contact with the urine sample were pre-screened by the National Center for Environmental Health (NCEH), Centers for Disease Control and Prevention (CDC) Laboratories and determined not to have amounts of metal contamination that would adversely influence the analytical measurements. For more information on the aliquots created from the urine biospecimens, please see the PATH Study W1 Biospecimen Urine Collection Procedures (1).

Blood was collected by trained phlebotomists from 14,520 (44.9%) participants in 10.0 mL red top serum tubes (BD Vacutainer 367820), and similarly immediately placed in a Crēdo Cube shipper (Series 4-248, Minnesota Thermal Science) and shipped overnight to the PATH Study biorepository. For more information on the processing and aliquots created from the blood biospecimens, please see the PATH Study W1 Biospecimen Blood Collection Procedures (1).

Biomarker Data

Biospecimens collected from a subset of adult respondents were sent to the laboratory for analyses. A stratified probability sample of 11,522 adults who completed the Wave 1 Adult Interview and who provided a urine specimen were selected for analyses. The sample was selected to ensure that respondents represented diverse tobacco product use patterns, including users of multiple tobacco products, and never users of any tobacco product. Of the 11,522 adults who provided urine samples, 7,159 also provided a blood specimen. Urine and blood specimens were shipped overnight on dry ice to the CDC laboratories where they were stored at -80°C until ready for laboratory analysis. All biomarker results reported by CDC met the rigorous accuracy and precision requirements of the quality control/quality assurance program of the CDC National Center for Environmental Health, Division of Laboratory Sciences (3). Given that all respondents did not agree to provide biospecimens, and that, therefore, the resulting biospecimen assay data represent a subsample of adults, specific urine and blood weights are needed to account for potential differences between the full set of Adult Interview respondents in the specified tobacco product user groups and the set of adults with analyzed biospecimens. These weighting procedures are outlined in the Biospecimen Restricted Use Files User Guide (1).

Laboratory Methods

Urinary Biomarkers

Inorganic Arsenic Species

Inorganic arsenic species and their metabolites (arsenate [As(V)], arsenite [As(III)], monomethylarsonic acid (MMA)), and dimethylarsinic acid (DMA)) were measured by high performance liquid chromatography/inductively coupled plasma dynamic reaction cell mass spectrometry (HPLC-ICP-DRC-MS). The limits of detection (LOD) ranged from 0.11 to 1.91 ng/mL, depending upon the analyte (4, 5). Total inorganic arsenic was calculated by taking the sum of the arsenous acid, arsenic acid, dimethylarsinic acid, and monomethylarsonic acid levels in each urine sample.

Metals

Total urine element concentrations of beryllium, cadmium, cobalt, lead, manganese, strontium, thallium, and uranium were measured using inductively coupled plasma mass spectrometry (ICP-MS). The LOD for these elements in urine ranged from 0.002 to 2.34 ng/mL, depending on the analyte (6, 7).

Nicotine Metabolites

Total urinary nicotine metabolites, including the free and glucuronide conjugated forms, were measured by two separate isotope dilution high performance liquid chromatography/tandem mass spectrometric (HPLC-MS/MS) methods based on the cotinine cutoff value of 20 ng/mL. For samples with cotinine levels above or equal to 20 ng/mL, the “Nicotine Metabolites and Analogs in Urine” method was used to measure anatabine, anabasine, and nicotine plus its six major metabolites (cotinine-N-oxide, nicotine-N-oxide, trans-3'-hydroxycotinine, norcotinine, cotinine and nornicotine) (8). The limits of detection ranged from 0.40 to 10.5 ng/mL, depending on the analyte. For samples with cotinine levels less than 20 ng/mL, the “Cotinine and Hydroxycotinine in Urine” method was applied to sensitively measure cotinine and trans-3’-hydroxycotinine using a modified version of the method of Bernert et al. (2005) (9). The limits of detection for both analytes were 0.030 ng/mL. TNE-2 (Total Nicotine Equivalent including two analytes) was calculated for all samples by taking the molar sum of only the two most abundant metabolites of nicotine: cotinine and trans-3'-hydroxycotinine. Furthermore, TNE-7 (Total Nicotine Equivalents including seven nicotine metabolites) was calculated for all samples if cotinine levels were at least 20 ng/mL by taking the molar sum of cotinine, cotinine N-oxide, trans-3'-hydroxycotinine, norcotinine, nicotine, nornicotine, nicotine N-oxide.

Tobacco Specific Nitrosamines (TSNAs)

Total NNAL (4-(methylnitrosamino)-1-(3-pyridyl)-1-butanonol), NNN (N’-nitrosonornicotine), NAB (N’-nitrosoanabasine) and NAT (N’-nitrosoanatabine) were measured by isotope dilution high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry (HPLC-MS/MS) using a modified version of the method of Xia et al. (2014) (10). The LOD for urinary TSNAs ranged from 0.0006 to 0.0042 ng/mL, depending on the analyte.

Polycyclic Aromatic Hydrocarbons (PAHs)

Seven monohydroxylated metabolites of PAHs (1-Naphthol, 2-Naphthol, 3-Hydroxyfluorene, 2-Hydroxyfluorene, 1-Hydroxyphenanthrene, 1-Hydroxypyrene, and 2-Hydroxyphenanthrene and 3-Hydroxyphenanthrene) were measured using an on-line solid phase extraction coupled to isotope dilution HPLC-MS/MS method (11). The LOD ranged from 0.008 to 0.09 ng/mL, depending on the analyte.

Volatile Organic Compounds (VOCs)

Twenty biomarkers of exposure to VOCs were measured, including acrylamide metabolite N-aacetyl-S-(2-carbamoylethyl)-L-cysteine (AAMA) and N-Acetyl-S-(2-carbamoyl-2-hydroxyethyl)-L-cysteine (GAMA); acrylonitrile metabolite N-acetyl-S-(2-cyanoethyl)-L-cysteine (CYMA) and N-Acetyl-S-(1-Cyano-2-hydroxyethyl)-L-cysteine (CYHA); propylene oxide metabolite 2-hydroxypropylmercapturic acid (2HPMA); acrolein metabolites 3-hydroxypropylmercapturic acid (3HPMA) and N-Acetyl-S-(2-carboxyethyl)-L-cysteine (CEMA); crotonaldehyde metabolite 3-hydroxy-1-methyl propylmercapturic acid (HPMMA); isoprene metabolite N-acetyl-S-(4-Hydroxy-2-methyl-2-buten-1-yl)-L-cysteine (IPMA3); styrene metabolite mandelic acid (MADA); butadiene metabolite N-acetyl-S-(4-hydroxy-2-buten-1-yl)-L-cysteine (MHBMA3) and N-Acetyl-S-(3,4-dihydroxybutyl)-L-cysteine (DHBM); xylene metabolites 2-Methylhippuric acid (MHA2) and 3-Methylhippuric acid + 4-Methylhippuric acid (MHA34); N, N-Dimethylformamide metabolite N-Acetyl-S-(N-methylcarbamoyl)-L-cysteine (AMCA); toluene metabolite N-Acetyl-S-(benzyl)-L-cysteine (BMA); metabolites of acrylonitrile, vinyl chloride, ethylene oxide, N-Acetyl-S-(2-hydroxyethyl)-L-cysteine (HEMA); benzene metabolite N-Acetyl-S-(phenyl)-L-cysteine (PMAC); carbon-disulfide metabolite 2-Thioxothiazolidine-4-carboxylic acid (TTCA) and ethylbenzene metabolite phenylglyoxylic acid (PGA) using isotope dilution UPLC-MS/MS as described by Alwis et al. (2012) and modified by Alwis et al. (2016) (12, 13).

Urinary Creatinine

Creatinine in urine was measured by an enzymatic assay on a commercial automated clinical chemistry analyzer. In this method, creatinine was converted to glycine, formaldehyde and hydrogen peroxide with the aid of creatininase, creatinase, and sarcosine oxidase. Catalyzed by peroxidase, the liberated hydrogen peroxide reacts with 4-aminophenazone and hydroxyl(tosyloxy)iodobenzene (HTIB) to produce a quinone imine chromogen. The intensity of the color produced by the formation of the quinone imine chromogen is directly proportional to the creatinine concentration. The LOD is 1.1 mg/dL.

Blood Biomarkers

Serum Cotinine and trans-3’-Hydroxycotinine

Cotinine and trans-3’-hydroxycotinine were measured by isotope dilution high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry (HPLC-APCI-MS/MS) using a modified version of the method of Bernert et al. (2005) (9). The LOD was 0.015 ng/mL (1.43nmol/L) for both analytes.

**References**

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Supplementary Table 1. List of tobacco exposure biomarkers, PATH Study (2013-2014)

| **Group** | **Parent Compound** | **Biomarker** | **Abbreviation** | **Matrix** |
| --- | --- | --- | --- | --- |
| Tobacco alkaloids | Nicotine | Cotinine |  | Urine |
| Tobacco alkaloids | Anabasine | Anabasine |  | Urine |
| Tobacco alkaloids | Anatabine | Anatabine |  | Urine |
| Tobacco alkaloids | Nicotine | Cotinine n-oxide |  | Urine |
| Tobacco alkaloids | Nicotine | Hydroxycotinine |  | Urine |
| Tobacco alkaloids | Nicotine | Nicotine |  | Urine |
| Tobacco alkaloids | Nicotine | Norcotinine |  | Urine |
| Tobacco alkaloids | Nicotine and nornicotine | Nornicotine |  | Urine |
| Tobacco alkaloids | Nicotine | Nicotine N-Oxide |  | Urine |
| Tobacco alkaloids | Nicotine | Total Nicotine Equivalents -2 | TNE -2 | Urine |
| Tobacco alkaloids | Nicotine | Total Nicotine Equivalents -7 | TNE -7 | Urine |
| Tobacco alkaloids | Nicotine | Serum cotinine |  | Serum |
| Tobacco alkaloids | Nicotine | Serum hydroxycotinine |  | Serum |
| TSNA | N’-nitrosoanabasine | N’-nitrosoanabasine | NAB | Urine |
| TSNA | N’-nitrosoanatabine | N’-nitrosoanatabine | NAT | Urine |
| TSNA | N-Nitrosonornicotine ketone | 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanonol | NNAL | Urine |
| TSNA | N’-nitrosonornicotine | N’-nitrosonornicotine | NNN | Urine |
| Metals | Beryllium | Beryllium |  | Urine |
| Metals | Cadmium | Cadmium |  | Urine |
| Metals | Cobalt | Cobalt |  | Urine |
| Metals | Lead | Lead |  | Urine |
| Metals | Manganese | Manganese |  | Urine |
| Metals | Strontium | Strontium |  | Urine |
| Metals | Thallium | Thallium |  | Urine |
| Metals | Uranium | Uranium |  | Urine |
| Metalloid | Arsenous Acid | Arsenous Acid |  | Urine |
| Metalloid | Arsenic Acid | Arsenic Acid |  | Urine |
| Metalloid | Dimethylarsinic Acid | Dimethylarsinic Acid |  | Urine |
| Metalloid | Monomethylarsonic Acid | Monomethylarsonic Acid |  | Urine |
| Metalloid | Total Inorganic Arsenic | Total Inorganic Arsenic |  | Urine |
| PAH | Naphthalene | 1-Naphthol |  | Urine |
| PAH | Naphthalene | 2-Naphthol |  | Urine |
| PAH | Fluorene | 3-Hydroxyfluorene |  | Urine |
| PAH | Fluorene | 2-Hydroxyfluorene |  | Urine |
| PAH | Phenanthrene | 1-Hydroxyphenanthrene |  | Urine |
| PAH | Pyrene | 1-Hydroxypyrene |  | Urine |
| PAH | Phenanthrene | 2-hydroxyphenanthrene and 3-hydroxyphenanthrene |  | Urine |
| VOC | Xylene | 2-Methylhippuric acid | MHA2 | Urine |
| VOC | Xylene | 3-Methylhippuric acid+4-Methylhippuric acid | MHA34 | Urine |
| VOC | Acrylamide | N-Acetyl-S-(2-carbamoylethyl)-L-cysteine | AAMA | Urine |
| VOC | N,N-dimethylformamide, methyl isocyanate | N-Acetyl-S-(N-methylcarbamoyl)-L-cysteine | AMCA | Urine |
| VOC | Toluene, benzyl alcohol | N-Acetyl-S-(benzyl)-L-cysteine | BMA | Urine |
| VOC | Acrolein | N-Acetyl-S-(2-carboxyethyl)-L-cysteine | CEMA | Urine |
| VOC | Acrylonitrile | N-Acetyl-S-(1-Cyano-2-hydroxyethyl)-L-Cysteine | CYHA | Urine |
| VOC | Acrylonitrile | N-Acetyl-S-(2-cyanoethyl)-L-cysteine | CYMA | Urine |
| VOC | 1,3 butadiene | N-Acetyl-S-(3,4-dihydroxybutyl)-L-cysteine | DHBM | Urine |
| VOC | Acrylamide | N-Acetyl-S-(2-carbamoyl-2-hydroxyethyl)-L-cysteine | GAMA | Urine |
| VOC | Acrylonitrile, vinyl chloride, ethylene oxide | N-Acetyl-S-(2-hydroxyethyl)-L-cysteine | HEMA | Urine |
| VOC | Propylene oxide | 2-hydroxypropylmercapturic acid | 2HPMA | Urine |
| VOC | Acrolein | 3-hydroxypropylmercapturic acid | 3HPMA | Urine |
| VOC | Crotonaldehyde | 3-hydroxy-1-methyl propylmercapturic acid | HPMMA | Urine |
| VOC | Isoprene | N-Acetyl-S-(4-Hydroxy-2-methyl-2-buten-1-yl)-L-Cysteine | IPMA3 | Urine |
| VOC | Styrene | Mandelic acid | MADA | Urine |
| VOC | 1,3 butadiene | N-Acetyl-S-(4-hydroxy-2-buten-1-yl)-L-cysteine | MHBMA3 | Urine |
| VOC | Ethylbenzene, styrene | Phenylglyoxylic acid | PGA | Urine |
| VOC | Benzene | N-Acetyl-S-(phenyl)-L-cysteine | PMA | Urine |
| VOC | Carbon-disulfide | 2-Thioxothiazolidine-4-carboxylic acid | TTCA | Urine |

Supplementary Table 2. Geometric mean biomarker concentrations and 95% CI by tobacco use status, PATH Study (2013-2014)

|  | **Exclusive current cigar smoker** | | **Exclusive current cigarette smoker** | | **Dual cigar/cigarette smokers** | | **Never tobacco use** |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Every day** | **Some day** | **Every day** | **Some day** | **Every day** | **Some day** |  |
| **Urinary Cotinine (µg/g creatinine)** | | |  |  |  |  |  |
| **N** | 61 | 281 | 2218 | 592 | 601 | 181 | 1657 |
|  | 1080.77 (705.75, 1655.05) | 8.57 (5.14, 14.3) | 2994.53 (2808.57, 3192.81) | 149.24 (101.03, 220.45) | 2278.01 (2033.02, 2552.52) | 101.82 (55.5, 186.78) | 0.42 (0.36, 0.49) |
| **Urinary Anabasine (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 124 | 2202 | 468 | 596 | 142 | 90 |
|  | 3.27 (2.04, 5.25) | 0.62 (0.43, 0.88)‡ | 9.71 (9.1, 10.37) | 1.86 (1.57, 2.19) | 7.8 (7.19, 8.47) | 1.61 (1.22, 2.12) | 0.61 (0.35, 1.08)‡ |
| **Urinary Anatabine (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 124 | 2200 | 467 | 596 | 142 | 90 |
|  | 4 (2.29, 6.96) | 0.56 (0.37, 0.85)‡ | 16.72 (15.51, 18.03) | 2.44 (1.96, 3.03) | 13.09 (11.9, 14.4) | 2.07 (1.47, 2.92) | 0.63 (0.31, 1.27)‡ |
| **Urinary Cotinine n-oxide (µg/g creatinine)** | | |  |  |  |  |  |
| **N** | 61 | 124 | 2202 | 468 | 596 | 142 | 90 |
|  | 140.59 (99.6, 198.44) | 20.15 (13.64, 29.75) | 366.51 (346.55, 387.62) | 70.87 (59.12, 84.95) | 324.06 (300.54, 349.42) | 58.35 (44.8, 76.01) | 14.62 (6.77, 31.58) |
| **Urinary Hydroxycotinine (µg/g creatinine)** | | |  |  |  |  |  |
| **N** | 61 | 278 | 2217 | 590 | 601 | 181 | 1654 |
|  | 1986.94 (1337.84, 2950.98) | 15.55 (9.33, 25.89) | 5191.91 (4792.11, 5625.06) | 274.54 (186.87, 403.34) | 4115.36 (3531.09, 4796.3) | 208.52 (108.74, 399.84) | 0.7 (0.6, 0.8) |
| **Urinary Norcotinine (µg/g creatinine)** | |  |  |  |  |  |  |
|  | 61 | 124 | 2202 | 468 | 596 | 142 | 90 |
|  | 45.49 (30.14, 68.67) | 6.05 (4.06, 9.02) | 112.03 (106.76, 117.56) | 21.36 (17.84, 25.58) | 88.69 (82.56, 95.28) | 16.18 (12.46, 21) | 4.42 (2.27, 8.63) |
| **Urinary Nicotine (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 124 | 2200 | 468 | 596 | 142 | 90 |
|  | 337.64 (180.49, 631.62) | 29.87 (18.94, 47.11)‡ | 1435.67 (1319.42, 1562.17) | 150.45 (112.6, 201.02) | 1063.9 (949.22, 1192.43) | 126.26 (83.79, 190.26) | 32.45 (12.4, 84.92) |
| **Urinary Nornicotine (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 124 | 2195 | 467 | 596 | 142 | 90 |
|  | 28.13 (16.94, 46.74) | 4.28 (2.93, 6.26)‡ | 75.79 (71.55, 80.27) | 13.1 (10.78, 15.92) | 63.56 (58.95, 68.54) | 11.49 (8.76, 15.07) | 3.49 (1.86, 6.57)‡ |
| **Urinary Nicotine N-Oxide (µg/g creatinine)** | | |  |  |  |  |  |
| **N** | 61 | 124 | 2202 | 468 | 596 | 142 | 90 |
|  | 120.3 (73.4, 197.17) | 11.33 (6.75, 19.03) | 430.49 (404.52, 458.13) | 52.23 (39.47, 69.11) | 335.11 (305.56, 367.51) | 37.88 (26.17, 54.83) | 12.24 (4.13, 36.27) |
| **Urinary Total Nicotine Equivalents -2 (µmol/g creatinine)** | | |  |  |  |  |  |
| **N** | 61 | 278 | 2217 | 590 | 601 | 181 | 1646 |
|  | 17.4 (11.72, 25.84) | 0.14 (0.08, 0.23) | 46.57 (43.59, 49.75) | 2.43 (1.65, 3.59) | 36.28 (31.78, 41.4) | 1.74 (0.93, 3.25) | 0.01 (0.01, 0.01) |
| **Urinary Total Nicotine Equivalents -7 (µmol/g creatinine)** | | |  |  |  |  |  |
| **N** | 61 | 124 | 2193 | 467 | 596 | 142 | 90 |
|  | 23.15 (15.3, 35.02) | 3.16 (2.11, 4.73)§ | 67.6 (64.16, 71.21) | 12.5 (10.46, 14.93) | 54.12 (50.33, 58.2) | 9.88 (7.57, 12.9) | 2.24 (1.02, 4.9)§ |
| **Serum Cotinine ng/mL** |  |  |  |  |  |  |  |
| **N** | 40† | 172 | 1496 | 364 | 414 | 111 | 978 |
|  | 95.96 (67.96, 135.51) | 0.41 (0.2, 0.86) | 193.74 (173.7, 216.09) | 8.87 (4.54, 17.3) | 199.76 (162.54, 245.52) | 7.98 (4.08, 15.63) | 0.03 (0.02, 0.03)‡ |
| **Serum Hydroxycotinine ng/mL** | |  |  |  |  |  |  |
| **N** | 40† | 172 | 1496 | 364 | 414 | 111 | 978 |
|  | 27.7 (18.91, 40.56) | 0.18 (0.1, 0.33) | 74.03 (65.91, 83.16) | 3.68 (2.03, 6.68) | 70.24 (55.09, 89.56) | 3.29 (1.7, 6.36) | 0.02 (0.02, 0.02)‡ |
| **Urinary NAB (ng/g creatinine)** |  |  |  |  |  |  |  |
| **N** | 61 | 280 | 2210 | 592 | 599 | 181 | 1668 |
|  | 8.49 (4.62, 15.62) | 1.43 (1.22, 1.67)‡ | 21.01 (19.33, 22.83) | 3.25 (2.76, 3.82)‡ | 16.8 (14.97, 18.85) | 2.71 (2.15, 3.41)‡ | 1.07 (1, 1.13)‡ |
| **Urinary NAT (ng/g creatinine)** |  |  |  |  |  |  |  |
| **N** | 61 | 278 | 2192 | 589 | 592 | 181 | 1661 |
|  | 43.26 (22.82, 82) | 4.02 (3.37, 4.8)‡ | 137.74 (126.53, 149.95) | 13.68 (11.08, 16.87)‡ | 100.26 (88.74, 113.28) | 11.57 (8.72, 15.37)‡ | 2.92 (2.74, 3.11)‡ |
| **Urinary NNAL (ng/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2216 | 591 | 598 | 180 | 1666 |
|  | 248.66 (159.85, 386.81) | 7.42 (5.42, 10.15) | 302.15 (281.51, 324.3) | 29.21 (24.13, 35.35) | 285.91 (255.56, 319.85) | 32.48 (22.46, 46.97) | 0.92 (0.82, 1.04)‡ |
| **Urinary NNN (ng/g creatinine)** |  |  |  |  |  |  |  |
| **N** | 60 | 276 | 2104 | 580 | 586 | 179 | 1660 |
|  | 8.67 (4.87, 15.42) | 2.09 (1.85, 2.37)‡ | 14.92 (13.92, 16) | 3.63 (3.24, 4.06)‡ | 12.04 (10.88, 13.31) | 3.22 (2.67, 3.89)‡ | 1.92 (1.81, 2.04)‡ |
| **Urinary Beryllium (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2210 | 592 | 598 | 181 | 1666 |
|  | 0.01 (0.01, 0.01)‡ | 0.01 (0.01, 0.01)‡ | 0.01 (0.01, 0.01)‡ | 0.01 (0.01, 0.01)‡ | 0.01 (0.01, 0.01)‡ | 0.01 (0.01, 0.01)‡ | 0.01 (0.01, 0.01)‡ |
| **Urinary Cadmium (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2210 | 592 | 598 | 181 | 1665 |
|  | 0.21 (0.17, 0.26) | 0.11 (0.1, 0.12) | 0.32 (0.31, 0.34) | 0.15 (0.13, 0.17) | 0.23 (0.19, 0.28) | 0.13 (0.11, 0.16) | 0.15 (0.14, 0.16) |
| **Urinary Cobalt (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2210 | 592 | 598 | 181 | 1666 |
|  | 0.47 (0.39, 0.56) | 0.48 (0.44, 0.51) | 0.54 (0.53, 0.56) | 0.49 (0.46, 0.53) | 0.47 (0.44, 0.5) | 0.42 (0.38, 0.48) | 0.56 (0.54, 0.59) |
| **Urinary Lead (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2210 | 592 | 598 | 181 | 1666 |
|  | 0.49 (0.41, 0.6) | 0.39 (0.34, 0.44) | 0.51 (0.49, 0.52) | 0.4 (0.38, 0.43) | 0.46 (0.38, 0.55) | 0.39 (0.34, 0.45) | 0.35 (0.33, 0.37) |
| **Urinary Manganese (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2209 | 592 | 598 | 181 | 1665 |
|  | 0.12 (0.08, 0.16)‡ | 0.11 (0.1, 0.13)‡ | 0.14 (0.13, 0.15)‡ | 0.12 (0.11, 0.13)‡ | 0.12 (0.11, 0.14)‡ | 0.12 (0.1, 0.14)‡ | 0.13 (0.12, 0.14)‡ |
| **Urinary Strontium (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2208 | 590 | 596 | 179 | 1666 |
|  | 100.07 (79.62, 125.79) | 105.78 (95.97, 116.58) | 112.63 (106.24, 119.39) | 105.01 (95.67, 115.27) | 107.04 (98.99, 115.76) | 106.2 (92.84, 121.47) | 112.47 (106.48, 118.81) |
| **Urinary Thallium (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2210 | 592 | 598 | 181 | 1665 |
|  | 0.15 (0.13, 0.18) | 0.17 (0.16, 0.18) | 0.15 (0.15, 0.16) | 0.15 (0.15, 0.16) | 0.14 (0.13, 0.15) | 0.14 (0.13, 0.16) | 0.17 (0.16, 0.18) |
| **Urinary Uranium (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2210 | 592 | 597 | 181 | 1666 |
|  | 0.01 (0, 0.01) | 0.01 (0, 0.01) | 0.01 (0.01, 0.01) | 0.01 (0.01, 0.01) | 0.01 (0, 0.01) | 0.01 (0.01, 0.01) | 0.01 (0, 0.01) |
| **Urinary Arsenous Acid (µg/g creatinine)** | | |  |  |  |  |  |
| **N** | 61 | 282 | 2217 | 592 | 601 | 181 | 1666 |
|  | 0.31 (0.22, 0.42) | 0.33 (0.29, 0.38) | 0.34 (0.32, 0.36) | 0.35 (0.3, 0.4) | 0.24 (0.22, 0.27) | 0.29 (0.25, 0.33) | 0.33 (0.31, 0.36) |
| **Urinary Arsenic Acid (µg/g creatinine)** | | |  |  |  |  |  |
|  | 61 | 282 | 2217 | 592 | 601 | 181 | 1666 |
|  | 0.31 (0.22, 0.42)‡ | 0.33 (0.29, 0.38)‡ | 0.34 (0.32, 0.36)‡ | 0.35 (0.3, 0.4)‡ | 0.24 (0.22, 0.27)‡ | 0.29 (0.25, 0.33)‡ | 0.33 (0.31, 0.36)‡ |
| **Urinary Dimethylarsinic Acid (µg/g creatinine)** | | |  |  |  |  |  |
| **N** | 61 | 282 | 2217 | 592 | 601 | 181 | 1666 |
|  | 2.83 (2.13, 3.76) | 3.63 (3.22, 4.09) | 3.07 (2.95, 3.2) | 3.4 (3.16, 3.64) | 2.85 (2.66, 3.06) | 3.05 (2.74, 3.41) | 3.68 (3.47, 3.9) |
| **Urinary Monomethylarsonic Acid (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2217 | 592 | 601 | 181 | 1666 |
|  | 0.34 (0.26, 0.43) | 0.44 (0.4, 0.48) | 0.43 (0.41, 0.45) | 0.4 (0.37, 0.44) | 0.34 (0.31, 0.37) | 0.31 (0.27, 0.36) | 0.48 (0.45, 0.52) |
| **Urinary Total Inorganic Arsenic (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2217 | 592 | 601 | 181 | 1666 |
|  | 4 (3.04, 5.26)§ | 5.04 (4.53, 5.6)§ | 4.43 (4.26, 4.61)§ | 4.78 (4.46, 5.12)§ | 3.91 (3.66, 4.19)§ | 4.16 (3.75, 4.62)§ | 5.1 (4.82, 5.4)§ |
| **Urinary 1-Naphthol (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2218 | 592 | 601 | 181 | 1662 |
|  | 9.21 (6.62, 12.82) | 1.87 (1.54, 2.27) | 14.41 (13.36, 15.54) | 3.09 (2.71, 3.52) | 12.88 (11.88, 13.98) | 3.69 (2.95, 4.62) | 1.4 (1.28, 1.52) |
| **Urinary 2-Naphthol (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2218 | 592 | 600 | 181 | 1665 |
|  | 12.53 (9.85, 15.94) | 4.57 (4.07, 5.12) | 15.89 (15.29, 16.51) | 7.2 (6.66, 7.79) | 14.33 (13.63, 15.08) | 7.45 (6.64, 8.37) | 4.63 (4.35, 4.94) |
| **Urinary 3-Hydroxyfluorene (ng/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2218 | 592 | 601 | 181 | 1668 |
|  | 661.15 (470.17, 929.69) | 97.1 (81.49, 115.69) | 714.87 (682.36, 748.93) | 188.08 (169.06, 209.25) | 740.24 (698.98, 783.94) | 193.61 (163.39, 229.43) | 63.93 (60.27, 67.82) |
| **Urinary 2-Hydroxyfluorene (ng/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2218 | 592 | 601 | 181 | 1668 |
|  | 1153.2 (847.73, 1568.75) | 210.13 (183.96, 240.03) | 1235.29 (1180.67, 1292.44) | 370.09 (341.4, 401.2) | 1214.56 (1152.18, 1280.31) | 406.73 (354.46, 466.7) | 167.08 (157.91, 176.78) |
| **Urinary 1-Hydroxyphenanthrene (ng/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2218 | 592 | 601 | 181 | 1668 |
|  | 191.04 (138.82, 262.9) | 110.11 (98.04, 123.67) | 194.26 (185.96, 202.92) | 118.64 (108.89, 129.27) | 187.38 (175.48, 200.09) | 116.43 (103.05, 131.54) | 105.95 (100.75, 111.41) |
| **Urinary 1-Hydroxypyrene (ng/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 282 | 2218 | 592 | 601 | 181 | 1668 |
|  | 300.14 (221.56, 406.58) | 145.98 (127.65, 166.94) | 336.44 (320.03, 353.7) | 181.17 (167.46, 196.01) | 350.26 (320.09, 383.27) | 198.64 (178.67, 220.85) | 127.93 (120.46, 135.86) |
| **Urinary 2-Hydroxyphenanthrene and 3-Hydroxyphenanthrene (ng/g creatinine)** | | | |  |  |  |  |
| **N** | 61 | 282 | 2218 | 592 | 601 | 181 | 1668 |
|  | 355.77 (266.32, 475.26) | 150.57 (133.13, 170.29) | 340.96 (325.51, 357.15) | 177.34 (165.92, 189.56) | 337.88 (317.6, 359.46) | 182.2 (162.55, 204.22) | 128.83 (122.85, 135.1) |
| **Urinary MHA2 (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 60 | 270 | 2171 | 581 | 580 | 176 | 1600 |
|  | 91.65 (60.97, 137.78) | 26.44 (23.18, 30.14) | 119.95 (113.49, 126.78) | 37.21 (33.1, 41.82) | 114.33 (106.12, 123.16) | 39.19 (32.23, 47.65) | 22.32 (20.73, 24.04) |
| **Urinary MHA34 (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 280 | 2216 | 592 | 598 | 181 | 1664 |
|  | 557.23 (397.67, 780.8) | 168.1 (154.34, 183.1) | 799.75 (757.88, 843.94) | 258.89 (233.64, 286.87) | 791.25 (726.97, 861.22) | 262.92 (219.33, 315.17) | 152.24 (143.79, 161.2) |
| **Urinary AAMA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 277 | 2202 | 587 | 596 | 180 | 1658 |
|  | 121.36 (97.02, 151.81) | 58.89 (54.18, 64.01) | 151.18 (145.66, 156.91) | 80.16 (72.81, 88.26) | 162.27 (150.73, 174.7) | 83.07 (72.82, 94.76) | 45.01 (42.78, 47.36) |
| **Urinary AMCA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 278 | 2186 | 586 | 595 | 180 | 1666 |
|  | 373.42 (277.25, 502.95) | 134.03 (122.61, 146.5) | 570.13 (543.45, 598.12) | 192.79 (178.31, 208.44) | 483.25 (451.58, 517.13) | 176.74 (153.27, 203.81) | 104.12 (98.22, 110.38) |
| **Urinary BMA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 60 | 278 | 2207 | 589 | 597 | 181 | 1666 |
|  | 9.39 (7.21, 12.22) | 6.21 (5.62, 6.86) | 6.64 (6.21, 7.1) | 6.28 (5.53, 7.14) | 6.74 (6.17, 7.37) | 5.61 (4.97, 6.32) | 6.12 (5.78, 6.48) |
| **Urinary CEMA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 60 | 265 | 2087 | 555 | 570 | 178 | 1612 |
|  | 208.98 (167.44, 260.83) | 112.01 (101.08, 124.12) | 310.93 (295.32, 327.37) | 142.98 (129.85, 157.44) | 288.17 (268.84, 308.9) | 133.28 (119.58, 148.54) | 93.83 (89.56, 98.31) |
| **Urinary CYHA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 280 | 2218 | 592 | 599 | 181 | 1666 |
|  | 25.7 (17.95, 36.81) | 2.47 (2.18, 2.81)‡ | 28.86 (27.12, 30.71) | 5.24 (4.55, 6.04)‡ | 29.34 (26.94, 31.95) | 5.11 (4.09, 6.38)‡ | 1.82 (1.71, 1.93)‡ |
| **Urinary CYMA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 280 | 2218 | 592 | 599 | 181 | 1666 |
|  | 167.15 (129.11, 216.4) | 5.94 (4.73, 7.46) | 177.32 (166.71, 188.62) | 21.45 (17.3, 26.6) | 187.26 (168.95, 207.56) | 23.65 (17.08, 32.77) | 1.27 (1.2, 1.36) |
| **Urinary DHBM (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 58 | 246 | 1977 | 530 | 567 | 175 | 1494 |
|  | 439.83 (368.02, 525.65) | 361.01 (341.88, 381.21) | 528.77 (513.17, 544.84) | 381.41 (360.3, 403.75) | 497.7 (480.61, 515.39) | 370.95 (344.33, 399.63) | 347.28 (335.55, 359.42) |
| **Urinary GAMA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 57 | 269 | 2081 | 554 | 565 | 169 | 1593 |
|  | 15.46 (12.12, 19.72) | 9.47 (8.71, 10.3)‡ | 18.8 (18.23, 19.39) | 11.07 (10.08, 12.16) | 18.77 (18.03, 19.54) | 11.34 (10.08, 12.75) | 8.58 (8.1, 9.08)‡ |
| **Urinary HEMA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 55 | 245 | 1908 | 500 | 548 | 162 | 1519 |
|  | 2.21 (1.59, 3.09) | 0.97 (0.87, 1.09) | 3.2 (2.99, 3.43) | 1.41 (1.27, 1.57) | 2.97 (2.64, 3.34) | 1.46 (1.24, 1.72) | 0.96 (0.89, 1.04)‡ |
| **Urinary 2HPMA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 60 | 279 | 2197 | 586 | 595 | 180 | 1617 |
|  | 66.92 (48.22, 92.89) | 29.82 (26.49, 33.57) | 80.39 (76.64, 84.31) | 40.66 (37.78, 43.76) | 82.41 (71.1, 95.51) | 40.47 (35.78, 45.77) | 32.24 (29.24, 35.55) |
| **Urinary 3HPMA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 60 | 273 | 2188 | 580 | 594 | 177 | 1666 |
|  | 717.67 (502.69, 1024.59) | 278.6 (249.94, 310.55) | 1396.05 (1313.86, 1483.37) | 445.31 (399.93, 495.84) | 1207.65 (1122.84, 1298.86) | 438.91 (377.01, 510.99) | 261.12 (246.69, 276.39) |
| **Urinary HPMMA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 280 | 2218 | 592 | 599 | 181 | 1666 |
|  | 1606.43 (1107.01, 2331.17) | 482.43 (439.92, 529.05) | 2902.12 (2734.37, 3080.17) | 813.35 (742.75, 890.65) | 2525.46 (2367.64, 2693.79) | 756.22 (652.49, 876.43) | 440.9 (416.45, 466.79) |
| **Urinary IPM3 (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 279 | 2216 | 589 | 597 | 179 | 1650 |
|  | 24.56 (15.14, 39.85) | 4.47 (3.92, 5.1) | 44.55 (41.71, 47.6) | 8.11 (6.99, 9.42) | 39.41 (36.14, 42.97) | 8.91 (7.23, 10.98) | 3.23 (3.02, 3.46) |
| **Urinary MADA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 54 | 256 | 2021 | 541 | 567 | 173 | 1477 |
|  | 261.31 (214.72, 318.01) | 126.15 (117.13, 135.87) | 306.71 (297.07, 316.65) | 174.01 (165.07, 183.43) | 308.67 (289.63, 328.97) | 167.02 (153.12, 182.18) | 128.15 (122.55, 134) |
| **Urinary MHB3 (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 280 | 2218 | 592 | 599 | 181 | 1666 |
|  | 20.55 (14.47, 29.19) | 5.32 (4.84, 5.86) | 34.55 (32.76, 36.43) | 9.52 (8.29, 10.93) | 29.94 (27.85, 32.18) | 9.08 (7.75, 10.64) | 4.45 (4.24, 4.66) |
| **Urinary PGA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 55 | 266 | 2095 | 556 | 575 | 169 | 1563 |
|  | 365.3 (306.63, 435.18) | 199.5 (187.48, 212.29) | 404.67 (390.69, 419.15) | 244.9 (230.48, 260.23) | 402.62 (380.33, 426.22) | 241.97 (221.17, 264.73) | 202.71 (194.78, 210.97) |
| **Urinary PMAC (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 61 | 280 | 2218 | 592 | 599 | 181 | 1666 |
|  | 0.85 (0.61, 1.18) | 0.91 (0.82, 1) | 1.12 (1.07, 1.17) | 0.92 (0.84, 1) | 0.9 (0.79, 1.02) | 0.89 (0.77, 1.03) | 1 (0.93, 1.08) |
| **Urinary TTCA (µg/g creatinine)** | |  |  |  |  |  |  |
| **N** | 51 | 245 | 1934 | 515 | 560 | 163 | 1381 |
|  | 18.5 (13.37, 25.59) | 22.03 (18.48, 26.25) | 21.99 (20.68, 23.39) | 19.18 (16.84, 21.85) | 20.51 (18.25, 23.05) | 21.12 (16.76, 26.61) | 20.57 (18.25, 23.19) |

Abbreviation: CI=confidence interval; † sample size < 50; ‡ greater than 40% of samples tested below the limit of detection (LOD); § 1 or more analytes for this derived variable has greater than 40% below LOD

Supplementary Table 3. Adjusted geometric mean ratios and 95% CI for biomarkers of exposure by tobacco use status, PATH Study (2013-2014)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Exclusive current cigar smoker** | | **Exclusive current cigarette smoker** | | **Dual cigar/cigarette smokers** | | **Never tobacco use (reference)** |
|  | **Every Day** | **Some Day** | **Every Day** | **Some Day** | **Every Day** | **Some Day** |  |
| **Urinary Cotinine** | 2189.22 (1377.22, 3479.98) | 23.94 (13.64, 42) | 5346.68 (4421.91, 6464.86) | 343.37 (230.7, 511.08) | 4214.69 (3462.14, 5130.82) | 223.78 (120.58, 415.29) | 1 |
| **Urinary Hydroxycotinine** | 2196.6 (1352.35, 3567.91) | 26.78 (15.34, 46.77) | 5495.24 (4450.73, 6784.88) | 387.59 (262.28, 572.78) | 4378.96 (3485.98, 5500.67) | 275.2 (140.22, 540.13) | 1 |
| **Urinary Total Nicotine Equivalents -2** | 2185.28 (1370.06, 3485.56) | 26.32 (15.09, 45.89) | 5461.9 (4485.45, 6650.93) | 373.68 (251.79, 554.57) | 4308.42 (3485.09, 5326.24) | 251.52 (132.37, 477.92) | 1 |
| **Serum cotinine** | 2057.73 (1291.07, 3279.65) | 16.68 (7.94, 35.07) | 5498.2 (4406.84, 6859.84) | 282.44 (149.7, 532.9) | 4233.86 (3253.32, 5509.93) | 234.98 (122.17, 451.95) | 1 |
| **Serum hydroxycotinine** | 1140.02 (719.31, 1806.8) | 11.34 (5.96, 21.56) | 3389.88 (2767.75, 4151.85) | 196.75 (110.45, 350.47) | 2781.02 (2104.67, 3674.71) | 182.21 (95.26, 348.52) | 1 |
| **Urinary NAB** | 9.3 (5.7, 15.17) | 1.39 (1.19, 1.63) | 17.3 (15.71, 19.04) | 3.23 (2.77, 3.77) | 16.79 (14.8, 19.05) | 2.85 (2.25, 3.61) | 1 |
| **Urinary NAT** | 16.75 (9.98, 28.12) | 1.42 (1.18, 1.71) | 40.87 (36.99, 45.16) | 4.96 (4.05, 6.07) | 35.6 (30.63, 41.38) | 4.43 (3.3, 5.93) | 1 |
| **Urinary NNAL** | 238.4 (153.32, 370.71) | 9.4 (6.68, 13.24) | 251.15 (214.38, 294.21) | 31.68 (25.99, 38.63) | 259.52 (221.65, 303.87) | 34.65 (23.49, 51.11) | 1 |
| **Urinary NNN** | 4.82 (3.12, 7.45) | 1.13 (1.01, 1.26) | 6.68 (6.23, 7.16) | 1.95 (1.78, 2.14) | 6.36 (5.63, 7.19) | 1.76 (1.53, 2.03) | 1 |
| **Urinary Beryllium** | 1.01 (0.98, 1.05) | 1.02 (0.99, 1.05) | 1.03 (1.02, 1.04) | 1.03 (1.01, 1.06) | 1.03 (1.01, 1.05) | 1.01 (0.99, 1.03) | 1 |
| **Urinary Cadmium** | 1.81 (1.5, 2.18) | 0.95 (0.85, 1.06) | 2.24 (2.07, 2.41) | 1.25 (1.09, 1.44) | 2.05 (1.73, 2.42) | 1.28 (1.12, 1.46) | 1 |
| **Urinary Cobalt** | 1.1 (0.98, 1.24) | 1.02 (0.93, 1.1) | 0.97 (0.91, 1.03) | 0.93 (0.84, 1.02) | 1.02 (0.94, 1.1) | 0.89 (0.79, 1) | 1 |
| **Urinary Lead** | 1.52 (1.29, 1.8) | 1.22 (1.09, 1.37) | 1.41 (1.32, 1.51) | 1.29 (1.2, 1.38) | 1.49 (1.28, 1.74) | 1.33 (1.18, 1.51) | 1 |
| **Urinary Manganese** | 1 (0.85, 1.19) | 0.99 (0.92, 1.07) | 0.97 (0.92, 1.02) | 0.95 (0.89, 1.02) | 1.03 (0.95, 1.12) | 1.01 (0.9, 1.13) | 1 |
| **Urinary Strontium** | 1.08 (0.89, 1.3) | 1.01 (0.91, 1.11) | 1 (0.92, 1.08) | 0.96 (0.87, 1.06) | 1.09 (1.01, 1.17) | 1.05 (0.93, 1.2) | 1 |
| **Urinary Thallium** | 1.04 (0.82, 1.31) | 1.04 (0.96, 1.12) | 0.9 (0.86, 0.95) | 0.96 (0.9, 1.02) | 0.92 (0.86, 0.98) | 0.91 (0.79, 1.04) | 1 |
| **Urinary Uranium** | 1.27 (1, 1.62) | 1.16 (0.96, 1.4) | 1.35 (1.21, 1.51) | 1.17 (0.98, 1.38) | 1.24 (1.01, 1.52) | 1.27 (1.04, 1.54) | 1 |
| **Urinary Arsenous Acid** | 1.01 (0.74, 1.38) | 0.99 (0.83, 1.17) | 1.08 (0.97, 1.2) | 1 (0.86, 1.17) | 0.78 (0.68, 0.89) | 0.8 (0.69, 0.93) | 1 |
| **Urinary Arsenic Acid** | 1.04 (0.99, 1.1) | 1.02 (1, 1.03) | 1.01 (1, 1.02) | 1.02 (1, 1.03) | 1.02 (1.01, 1.04) | 1.02 (0.99, 1.05) | 1 |
| **Urinary Dimethylarsinic Acid** | 0.92 (0.72, 1.17) | 1.09 (0.96, 1.24) | 0.89 (0.83, 0.95) | 0.96 (0.88, 1.04) | 0.9 (0.83, 0.98) | 0.9 (0.8, 1.01) | 1 |
| **Urinary Monomethylarsonic Acid** | 0.78 (0.61, 0.98) | 0.91 (0.81, 1.02) | 0.92 (0.83, 1.02) | 0.84 (0.75, 0.94) | 0.77 (0.69, 0.86) | 0.66 (0.57, 0.77) | 1 |
| **Urinary Total Inorganic Arsenic** | 0.92 (0.75, 1.13) | 1.06 (0.95, 1.18) | 0.92 (0.86, 0.97) | 0.96 (0.89, 1.03) | 0.9 (0.83, 0.96) | 0.88 (0.8, 0.97) | 1 |
| **Urinary 1-Naphthol** | 7.08 (5, 10.03) | 1.55 (1.24, 1.94) | 9.49 (8.43, 10.67) | 2.57 (2.23, 2.96) | 10.12 (8.88, 11.54) | 3.26 (2.54, 4.18) | 1 |
| **Urinary 2-Naphthol** | 2.98 (2.31, 3.85) | 1.22 (1.07, 1.39) | 3.27 (3.01, 3.55) | 1.5 (1.35, 1.68) | 3.21 (2.92, 3.54) | 1.62 (1.45, 1.81) | 1 |
| **Urinary 3-Hydroxyfluorene** | 9.77 (6.9, 13.82) | 1.55 (1.29, 1.87) | 10.43 (9.66, 11.27) | 2.97 (2.66, 3.31) | 11 (10.07, 12.02) | 2.99 (2.5, 3.58) | 1 |
| **Urinary 2-Hydroxyfluorene** | 7.02 (5.13, 9.61) | 1.34 (1.15, 1.55) | 6.93 (6.42, 7.48) | 2.27 (2.07, 2.49) | 7.27 (6.72, 7.88) | 2.54 (2.19, 2.95) | 1 |
| **Urinary 1-Hydroxyphenanthrene** | 2.09 (1.54, 2.84) | 1.14 (1, 1.3) | 1.77 (1.66, 1.89) | 1.2 (1.1, 1.31) | 1.99 (1.83, 2.16) | 1.26 (1.11, 1.43) | 1 |
| **Urinary 1-Hydroxypyrene** | 2.61 (1.94, 3.5) | 1.25 (1.08, 1.44) | 2.48 (2.31, 2.65) | 1.43 (1.32, 1.54) | 2.87 (2.63, 3.13) | 1.59 (1.42, 1.77) | 1 |
| **Urinary 2-Hydroxyphenanthrene and 3-Hydroxyphenanthrene** | 2.82 (2.14, 3.73) | 1.23 (1.07, 1.41) | 2.52 (2.35, 2.69) | 1.42 (1.3, 1.55) | 2.67 (2.47, 2.88) | 1.49 (1.31, 1.69) | 1 |
| **Urinary MHA2** | 4.33 (3.08, 6.08) | 1.21 (1.01, 1.45) | 4.68 (4.28, 5.13) | 1.79 (1.56, 2.05) | 5.06 (4.55, 5.62) | 1.93 (1.6, 2.33) | 1 |
| **Urinary MHA34** | 3.87 (2.83, 5.28) | 1.15 (1.02, 1.29) | 4.66 (4.32, 5.03) | 1.86 (1.66, 2.1) | 5.32 (4.85, 5.83) | 2.01 (1.68, 2.41) | 1 |
| **Urinary AAMA** | 2.87 (2.23, 3.7) | 1.34 (1.2, 1.5) | 3.28 (3.08, 3.49) | 1.82 (1.63, 2.03) | 3.74 (3.32, 4.22) | 1.95 (1.7, 2.23) | 1 |
| **Urinary AMCA** | 4.4 (3.37, 5.74) | 1.43 (1.27, 1.6) | 5.13 (4.77, 5.53) | 2.16 (1.97, 2.36) | 5.56 (4.98, 6.2) | 2.25 (1.96, 2.58) | 1 |
| **Urinary BMA** | 1.68 (1.28, 2.21) | 1.11 (0.97, 1.27) | 1.16 (1.06, 1.26) | 1.14 (1, 1.29) | 1.29 (1.17, 1.42) | 1.04 (0.91, 1.2) | 1 |
| **Urinary CEMA** | 2.26 (1.81, 2.83) | 1.25 (1.11, 1.4) | 3.17 (2.97, 3.39) | 1.62 (1.45, 1.81) | 3.12 (2.85, 3.4) | 1.55 (1.38, 1.75) | 1 |
| **Urinary CYHA** | 15.14 (10.63, 21.58) | 1.43 (1.25, 1.63) | 13.98 (12.97, 15.06) | 3 (2.63, 3.41) | 16.09 (14.44, 17.94) | 3.01 (2.41, 3.75) | 1 |
| **Urinary CYMA** | 123.72 (93.13, 164.36) | 4.98 (3.87, 6.41) | 125.98 (113.91, 139.34) | 17.35 (13.89, 21.69) | 138.75 (120.46, 159.81) | 18.84 (13.36, 26.57) | 1 |
| **Urinary DHBM** | 1.38 (1.19, 1.6) | 1.07 (1, 1.14) | 1.47 (1.41, 1.53) | 1.18 (1.11, 1.25) | 1.55 (1.46, 1.65) | 1.22 (1.14, 1.3) | 1 |
| **Urinary GAMA** | 2.01 (1.48, 2.72) | 1.17 (1.07, 1.28) | 2.06 (1.96, 2.17) | 1.33 (1.2, 1.47) | 2.34 (2.16, 2.53) | 1.4 (1.27, 1.55) | 1 |
| **Urinary HEMA** | 2.77 (2.01, 3.83) | 1.17 (1, 1.35) | 3.27 (2.97, 3.6) | 1.52 (1.38, 1.68) | 3.53 (3.12, 4) | 1.66 (1.42, 1.94) | 1 |
| **Urinary 2HPMA** | 2.38 (1.74, 3.25) | 0.93 (0.78, 1.11) | 2.57 (2.34, 2.84) | 1.4 (1.24, 1.58) | 2.96 (2.48, 3.53) | 1.48 (1.27, 1.71) | 1 |
| **Urinary 3HPMA** | 3.01 (2.24, 4.05) | 1.13 (0.99, 1.29) | 5.19 (4.82, 5.58) | 1.82 (1.6, 2.07) | 4.95 (4.51, 5.44) | 1.9 (1.62, 2.22) | 1 |
| **Urinary HPMM** | 4.03 (2.92, 5.58) | 1.15 (1.01, 1.3) | 6.39 (5.92, 6.9) | 2.05 (1.84, 2.28) | 6.35 (5.75, 7.02) | 2.05 (1.75, 2.4) | 1 |
| **Urinary IPM3** | 8.35 (5.15, 13.53) | 1.48 (1.26, 1.72) | 13.48 (12.26, 14.81) | 2.82 (2.39, 3.33) | 13.54 (11.87, 15.44) | 3.33 (2.66, 4.17) | 1 |
| **Urinary MADA** | 2.24 (1.85, 2.7) | 1.01 (0.92, 1.12) | 2.38 (2.24, 2.53) | 1.46 (1.36, 1.56) | 2.62 (2.38, 2.89) | 1.45 (1.32, 1.59) | 1 |
| **Urinary MHB3** | 4.92 (3.52, 6.88) | 1.24 (1.11, 1.4) | 7.43 (6.93, 7.96) | 2.32 (1.99, 2.7) | 7.13 (6.43, 7.9) | 2.31 (1.95, 2.73) | 1 |
| **Urinary PHGA** | 2 (1.71, 2.35) | 1.01 (0.92, 1.11) | 1.94 (1.84, 2.06) | 1.3 (1.22, 1.39) | 2.17 (2.02, 2.34) | 1.35 (1.23, 1.48) | 1 |
| **Urinary PMAC** | 1.01 (0.78, 1.3) | 0.94 (0.83, 1.07) | 1.07 (0.98, 1.16) | 0.97 (0.89, 1.05) | 1.02 (0.9, 1.14) | 1.01 (0.88, 1.16) | 1 |
| **Urinary TTCA** | 0.99 (0.73, 1.35) | 1.03 (0.83, 1.28) | 1.01 (0.88, 1.16) | 1.02 (0.87, 1.19) | 1.07 (0.9, 1.28) | 1.18 (0.94, 1.48) | 1 |

Abbreviation: CI=confidence interval; † sample size < 50; ‡ greater than 40% of samples tested below the limit of detection

Supplementary Table 4. Characteristics of Wave 1 PATH Study adult every day and some day cigar smokers by cigar typea with urinary biomarker data: United States, 2013-2014b

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Traditional cigar smoker** | | **Cigarillo smoker** | | **Filtered cigar smoker** | |
| **Every day (n = 12)** | **Some day (n = 100)** | **Every day (n = 24)** | **Some day (n = 94)** | **Every day (n = 7)** | **Some day (n = 8)** |
|  | **Percent, 95% CI** | **Percent, 95% CI** | **Percent, 95% CI** | **Percent, 95% CI** | **Percent, 95% CI** | **Percent, 95% CI** |
| **Sex** |  |  |  |  |  |  |
| Male | 100 \* | 95.1 (84, 98.6) \* | 71.8 (48.4, 87.4) \* | 38.3 (26.6, 51.6) | † | 43.6 (17.3, 74) \* |
| Female | 0 \* | 4.9 (1.4, 16) \* | 28.2 (12.6, 51.6) \* | 61.7 (48.4, 73.4) | † | 56.4 (26, 82.7) \* |
| **Median age (years), 95% CI** | 56.6 (49.0, 64.1) | 54.4 (50.2, 58.6) | 36.3 (28.8, 43.9) | 25.3 (21.0, 29.5) | 49.7 (42.7, 56.6) | 19.7 (16.1, 23.3) |
| **Age group (years)** |  |  |  |  |  |  |
| 18-24 | † | 6.2 (2.9, 12.8) \* | 24.6 (10.9, 46.7) \* | 45.7 (34.2, 57.8) | 0 \* | † |
| 25-34 | † | 13.1 (7.4, 22.3) | † | † | 0 \* | † |
| 35-54 | 31.2 (11.5, 61.2) \* | 28.8 (20.8, 38.3) | 51 (26.2, 75.4) \* | 29.0 (16.6, 45.6) | 67.0 (32.3, 89.6) \* | 0 \* |
| 55+ | 55.5 (29.3, 79) \* | 51.9 (41.8, 61.8) | † | † | 33.0 (10.4, 67.7) \* | 0 \* |
| **Race/ethnicity** |  |  |  |  |  |  |
| White, Non-Hispanic | † | 86.2 (77, 92.1) | † | 34 (22, 48.5) | † | 54.9 (24.4, 82.2) \* |
| Black/AA, Non-Hispanic | 0 \* | 3.9 (1.4, 10.4) \* | 75.1 (50.7, 89.9) \* | 39.1 (28.1, 51.3) | † | † |
| Other or Multi-Race, Non-Hispanic | 0 \* | 3.7 (1.2, 10.8) \* | † | 4.3 (1.3, 13.3) \* | 0 \* | 0 \* |
| Hispanic | † | 6.2 (2.7, 13.5) \* | 14.3 (4.2, 39) \* | 22.7 (13.5, 35.5) | 0 \* | † |
| **Education** |  |  |  |  |  |  |
| Less than high school diploma | 17.2 (4.9, 45.3) \* | 3.5 (1.2, 9.7) \* | 39.4 (16.4, 68.4) \* | 13.2 (7.7, 21.9) | † | 0 \* |
| High school diploma / GED | 29.6 (11.5, 57.5) \* | 11.7 (6.1, 21.5) \* | 27.4 (11.7, 51.8) \* | 25.3 (17.6, 34.9) | 54.9 (23.5, 82.8) \* | 47.1 (18.6, 77.6) \* |
| Some college/associate's degree | 29 (10.5, 58.8) \* | 34.2 (24.8, 45.1) | 33.2 (14.3, 59.6) \* | 46.2 (35.2, 57.5) | † | † |
| Completed college or more | 24.3 (8.5, 52.5) \* | 50.5 (39.6, 61.4) | 0 \* | 15.4 (6.1, 33.7) \* | † | † |
| **Median cigars smoked per day, 95% CI** | 1.42 (-0.17, 3.01) | 0.06 (0.04, 0.07) | 4.05 (2.5, 5.61) | 0.08 (0.05, 0.11) | 7.68 (2.66, 12.69) | 0.09 (-0.13, 0.3) |

Abbreviation: CI=confidence interval; aEvery day smokers of a cigar type cannot be current every day or established smokers of another cigar type, and some day smokers cannot be current established or experimental smokers of another type; b Estimates are for participants with urinary biomarker weights and creatinine concentrations >= 10 and <= 370 mg/dL;\* Flagged based on criteria for proportions: if the relative standard error (RSE) of a proportion or the inverse of the proportion is greater than 30; † Suppressed due to confidentiality concerns (n < 3 or the estimate would allow for calculation of an estimate where n < 3).

Supplementary Table 5. Geometric mean biomarker concentrations and 95% CI in every day and some day cigar smokers by type, PATH Study (2013-2014)

|  | **Exclusive current traditional cigar smoker** | | **Exclusive current cigarillo smoker** | | **Exclusive current filtered cigar smoker** | |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Every day** | **Some day** | **Every day** | **Some day** | **Every day** | **Some day** |
| **Urinary Cotinine (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 1711.76 (848.07, 3455.06) | 9.22 (4.37, 19.42) | 505.14 (252.88, 1009.04) | 10.39 (5.85, 18.46) | 3057.66 (1684.73, 5549.45) | 13.2 (0.27, 643.85) |
| **Urinary Anabasine (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 40† | 24† | 50 | 7† | 3† |
|  | 4.66 (2.18, 9.96) | 0.74 (0.41, 1.34)‡ | 1.53 (0.67, 3.46) | 0.35 (0.27, 0.47)‡ | 11.69 (7.24, 18.87) | 1.82 (0.3, 11.2) |
| **Urinary Anatabine (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12 | 40† | 24† | 50 | 7† | 3† |
|  | 6.79 (2.82, 16.34) | 0.73 (0.36, 1.51)‡ | 1.32 (0.54, 3.2) | 0.3 (0.21, 0.42)‡ | 18.78 (10.27, 34.36) | 1.77 (0.24, 12.92) |
| **Urinary Cotinine n-oxide (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 40† | 24† | 50 | 7† | 3† |
|  | 171.39 (94.37, 311.28) | 25.54 (14.78, 44.16) | 79.94 (41.1, 155.47) | 9.51 (5.79, 15.62) | 328.85 (189.34, 571.15) | 72.53 (8.36, 629.43) |
| **Urinary Hydroxycotinine (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 97 | 24† | 94 | 7† | 8† |
|  | 2669.9 (1489.41, 4786.02) | 17.24 (8.29, 35.84) | 1032.67 (506.01, 2107.49) | 18.59 (10.1, 34.19) | 6908.78 (3349.5, 14250.26) | 19.25 (0.53, 695.02) |
| **Urinary Norcotinine (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 40† | 24† | 50 | 7† | 3† |
|  | 57.55 (32.25, 102.69) | 7.71 (4.4, 13.52) | 22.08 (10.13, 48.14) | 2.95 (1.96, 4.47) | 140.77 (83.59, 237.06) | 20.58 (2.53, 167.56) |
| **Urinary Nicotine (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 40† | 24† | 50 | 7† | 3† |
|  | 576.22 (189.15, 1755.37) | 39.69 (18.25, 86.34) | 109.27 (38.2, 312.54) | 16.02 (9.26, 27.72)‡ | 1335.07 (679.32, 2623.8) | 186.73 (14.67, 2377.45) |
| **Urinary Nornicotine (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 40† | 24† | 50 | 7† | 3† |
|  | 44.14 (21.27, 91.59) | 5.5 (2.95, 10.24)‡ | 11.34 (4.5, 28.61) | 2.29 (1.63, 3.22)‡ | 94.33 (61.74, 144.11) | 14.61 (1.72, 124.45) |
| **Urinary Nicotine N-Oxide (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 40† | 24† | 50 | 7† | 3† |
|  | 163.39 (59.12, 451.59) | 14.45 (6.22, 33.61) | 51.18 (21.57, 121.41) | 5.82 (3.32, 10.23) | 441.92 (270.32, 722.48) | 53.5 (2.8, 1020.96) |
| **Urinary TNE -2 (µmol/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 97 | 24† | 94 | 7† | 8† |
|  | 24.05 (12.85, 45.01) | 0.16 (0.07, 0.33) | 8.47 (4.17, 17.19) | 0.17 (0.1, 0.31) | 58.8 (33.79, 102.32) | 0.18 (0, 7.58) |
| **Urinary TNE -7 (µmol/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 40† | 24† | 50 | 7† | 3† |
|  | 33.01 (17.37, 62.74) | 4.16 (2.35, 7.38)§ | 10.66 (5.08, 22.37) | 1.42 (0.93, 2.16)\§ | 76.07 (46.66, 124.01) | 10.7 (1.08, 105.86) |
| **Serum Cotinine ng/mL** |  |  |  |  |  |  |
| **N** | 5† | 64 | 18† | 57 | 6† | 5† |
|  | 54.66 (32.48, 92) | 0.33 (0.11, 0.96) | 90.64 (50.09, 163.99) | 0.43 (0.14, 1.28) | 194.25 (99.65, 378.68) | 13.38 (0.13, 1361.9) |
| **Serum Hydroxycotinine ng/mL** |  |  |  |  |  |  |
| **N** | 5† | 64 | 18† | 57 | 6† | 5† |
|  | 17.64 (10.19, 30.56) | 0.16 (0.06, 0.42) | 24.24 (14.86, 39.56) | 0.15 (0.06, 0.35) | 80.82 (37.88, 172.46) | 2.18 (0.03, 176.73) |
| **Urinary NAB (ng/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 93 | 7† | 8† |
|  | 11.66 (3.2, 42.45) | 1.61 (1.27, 2.05)‡ | 3.22 (1.45, 7.16) | 1.07 (0.88, 1.31)‡ | 39.02 (14.94, 101.92) | 1.46 (0.41, 5.14)‡ |
| **Urinary NAT (ng/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 99 | 24† | 93 | 7† | 8† |
|  | 57 (13.62, 238.53) | 4.79 (3.5, 6.55)‡ | 15.32 (6.45, 36.41) | 2.76 (2.27, 3.36)‡ | 223.35 (77.09, 647.09) | 4.3 (0.99, 18.67)‡ |
| **Urinary NNAL (ng/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 250.73 (99.64, 630.91) | 8.68 (5.23, 14.41) | 118.15 (61.17, 228.23) | 7.01 (5.16, 9.51) | 979.54 (648.2, 1480.24) | 9.83 (0.95, 102.12) |
| **Urinary NNN (ng/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 95 | 24† | 94 | 6† | 8† |
|  | 10.47 (3.87, 28.35) | 2.4 (1.9, 3.02)‡ | 4.15 (1.7, 10.12) | 1.56 (1.34, 1.81)‡ | 29.72 (7.6, 116.19) | 2.37 (0.88, 6.33)‡ |
| **Urinary Beryllium (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 0.01 (0.01, 0.01)‡ | 0.01 (0.01, 0.01)‡ | 0.01 (0, 0.01)‡ | 0.01 (0.01, 0.01)‡ | 0.02 (0.01, 0.06)‡ | 0.01 (0, 0.03)‡ |
| **Urinary Cadmium (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 0.21 (0.14, 0.32) | 0.12 (0.1, 0.15) | 0.17 (0.13, 0.23) | 0.08 (0.07, 0.1) | 0.48 (0.35, 0.65) | 0.08 (0.06, 0.12) |
| **Urinary Cobalt (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 0.54 (0.43, 0.67) | 0.48 (0.43, 0.53) | 0.39 (0.27, 0.57) | 0.48 (0.42, 0.55) | 0.73 (0.58, 0.91) | 0.56 (0.39, 0.8) |
| **Urinary Lead (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 0.69 (0.47, 1.01) | 0.53 (0.45, 0.63) | 0.34 (0.26, 0.45) | 0.22 (0.18, 0.26) | 0.83 (0.59, 1.15) | 0.21 (0.16, 0.28) |
| **Urinary Manganese (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 0.11 (0.07, 0.2)‡ | 0.12 (0.1, 0.14)‡ | 0.08 (0.05, 0.12)‡ | 0.1 (0.08, 0.12)‡ | 0.34 (0.16, 0.7) | 0.13 (0.06, 0.28)‡ |
| **Urinary Strontium (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 133.43 (99.54, 178.85) | 115.5 (98.42, 135.54) | 88.65 (61.88, 127.01) | 86 (70.59, 104.79) | 137.08 (85.46, 219.87) | 137.62 (89.42, 211.8) |
| **Urinary Thallium (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 0.14 (0.1, 0.2) | 0.19 (0.17, 0.21) | 0.16 (0.11, 0.25) | 0.14 (0.13, 0.15) | 0.13 (0.1, 0.18) | 0.17 (0.09, 0.32) |
| **Urinary Uranium (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 0 (0, 0.01) | 0 (0, 0.01) | 0.01 (0, 0.01) | 0.01 (0, 0.01) | 0.01 (0.01, 0.01) | 0.01 (0, 0.01) |
| **Urinary Arsenous Acid (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 0.4 (0.27, 0.59) | 0.34 (0.28, 0.42) | 0.21 (0.13, 0.36) | 0.33 (0.26, 0.42) | 0.43 (0.26, 0.72) | 0.35 (0.19, 0.62) |
| **Urinary Arsenic Acid (µg/g creatinine)** |  |  |  |  |  |  |
|  | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 0.4 (0.27, 0.59)‡ | 0.34 (0.28, 0.42)‡ | 0.21 (0.13, 0.36) | 0.33 (0.26, 0.42)‡ | 0.43 (0.26, 0.72) | 0.35 (0.19, 0.62)‡ |
| **Urinary Dimethylarsinic Acid (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 4.47 (2.89, 6.9) | 4.07 (3.45, 4.8) | 1.61 (1.06, 2.44) | 2.78 (2.23, 3.47) | 4.99 (2.6, 9.6) | 3.42 (1.66, 7.07) |
| **Urinary Monomethylarsonic Acid (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 0.46 (0.3, 0.68) | 0.48 (0.42, 0.55) | 0.24 (0.16, 0.36) | 0.38 (0.31, 0.45) | 0.57 (0.29, 1.13) | 0.47 (0.24, 0.92) |
| **Urinary Total Inorganic Arsenic (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 5.95 (4, 8.84)§ | 5.62 (4.89, 6.46)§ | 2.43 (1.61, 3.66)§ | 4 (3.26, 4.91)§ | 6.53 (3.49, 12.2)§ | 4.74 (2.44, 9.23)§ |
| **Urinary 1-Naphthol (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 4.69 (2.38, 9.24) | 1.87 (1.35, 2.59) | 6.65 (3.97, 11.13) | 1.98 (1.46, 2.67) | 25.5 (16.38, 39.68) | 2.19 (0.83, 5.8) |
| **Urinary 2-Naphthol (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 7.1 (4.12, 12.23) | 3.89 (3.24, 4.67) | 10.55 (7.66, 14.52) | 5.98 (5.02, 7.13) | 26.46 (18.04, 38.81) | 8.53 (4.67, 15.57) |
| **Urinary 3-Hydroxyfluorene (ng/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 269.03 (129.24, 560.03) | 78 (61.78, 98.47) | 601.25 (359.34, 1006.02) | 136.18 (97.03, 191.11) | 1276 (873.05, 1864.92) | 173.83 (63.08, 479) |
| **Urinary 2-Hydroxyfluorene (ng/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 571.66 (293.15, 1114.81) | 177.81 (148.99, 212.2) | 990.82 (685.04, 1433.09) | 268.65 (207.89, 347.16) | 2383.64 (1466.82, 3873.53) | 356.25 (144.18, 880.22) |
| **Urinary 1-Hydroxyphenanthrene (ng/g creatinine)** | | | | | | |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 144.87 (98.02, 214.11) | 111.47 (94.38, 131.66) | 120.1 (78.01, 184.92) | 101.47 (78.81, 130.65) | 338.08 (256.22, 446.09) | 135.96 (85.39, 216.48) |
| **Urinary 1-Hydroxypyrene (ng/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 177.78 (117.63, 268.69) | 133.65 (112.18, 159.24) | 220.78 (136.1, 358.14) | 161.46 (121.87, 213.89) | 625.14 (402.27, 971.5) | 203.36 (100.7, 410.69) |
| **Urinary 2-Hydroxyphenanthrene and 3-Hydroxyphenanthrene (ng/g creatinine)** | | | | | | |
| **N** | 12† | 100 | 24† | 94 | 7† | 8† |
|  | 249.67 (174.54, 357.14) | 144.87 (121.03, 173.41) | 247.8 (164.42, 373.47) | 159.5 (122.69, 207.37) | 592.22 (469.98, 746.25) | 196.34 (108.05, 356.77) |
| **Urinary MHA2 (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 11† | 95 | 24† | 92 | 7† | 8† |
|  | 69.87 (40.49, 120.56) | 25.46 (21.34, 30.39) | 55.54 (24.27, 127.08) | 21.64 (15.97, 29.32) | 300.18 (202.28, 445.45) | 51.17 (14.35, 182.52) |
| **Urinary MHA34 (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 93 | 7† | 8† |
|  | 463.93 (268.43, 801.84) | 155.59 (138.35, 174.97) | 343.82 (183.84, 643.01) | 156.08 (124.18, 196.18) | 1670.11 (1111.55, 2509.36) | 223.18 (121.24, 410.84) |
| **Urinary AAMA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 98 | 24† | 92 | 7† | 8† |
|  | 67.9 (46.08, 100.05) | 55.4 (49.03, 62.6) | 149.53 (106.63, 209.69) | 68.81 (59.83, 79.13) | 159.11 (63.03, 401.63) | 50.36 (26.91, 94.22) |
| **Urinary AMCA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 99 | 24† | 93 | 7† | 8† |
|  | 325.33 (188.15, 562.52) | 147.34 (128.83, 168.51) | 235.71 (146.99, 377.98) | 97.86 (84.02, 113.97) | 1219.31 (945.72, 1572.04) | 121.53 (53.22, 277.52) |
| **Urinary BMA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 92 | 7† | 8† |
|  | 16.93 (9.16, 31.26) | 6.45 (5.52, 7.54) | 7.9 (5.5, 11.33) | 5.75 (4.97, 6.65) | 7.9 (5.29, 11.8) | 4.53 (2.44, 8.42) |
| **Urinary CEMA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 90 | 24† | 90 | 6† | 8† |
|  | 144.03 (103.04, 201.34) | 120.02 (101.43, 142.03) | 175.31 (112.41, 273.42) | 93.96 (79.53, 111) | 454.99 (301.57, 686.47) | 119.93 (59.97, 239.86) |
| **Urinary CYHA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 93 | 7† | 8† |
|  | 19.27 (6.69, 55.48) | 2.3 (1.94, 2.73)‡ | 17.72 (11.69, 26.84) | 2.53 (1.9, 3.36)‡ | 77.57 (42.45, 141.74) | 2.95 (1.08, 8.04)‡ |
| **Urinary CYMA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 93 | 7† | 8† |
|  | 151.31 (81.87, 279.66) | 5.31 (3.89, 7.26) | 94.83 (70, 128.48) | 9.15 (5.82, 14.38) | 473.3 (274.53, 816.02) | 10.82 (1.79, 65.58) |
| **Urinary DHBM (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 11† | 87 | 24† | 83 | 6† | 8† |
|  | 523.4 (392.76, 697.5) | 390.85 (363.46, 420.3) | 326.02 (241.87, 439.46) | 307.36 (272.1, 347.19) | 632.12 (515.91, 774.52) | 296.26 (237.49, 369.57) |
| **Urinary GAMA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 96 | 21† | 89 | 6† | 8† |
|  | 10.86 (8.13, 14.5) | 9.09 (7.84, 10.52)‡ | 19.24 (12.23, 30.27) | 10.2 (8.86, 11.74) | 20.39 (8.24, 50.47)‡ | 11.54 (4.64, 28.71)‡ |
| **Urinary HEMA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 10† | 89 | 22† | 78 | 7† | 7† |
|  | 1.89 (1.25, 2.85) | 0.89 (0.77, 1.04)‡ | 1.27 (0.79, 2.03) | 1.1 (0.84, 1.44) | 6.7 (3.51, 12.76) | 1.25 (0.38, 4.12) |
| **Urinary 2HPMA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 23† | 92 | 7† | 8† |
|  | 53.07 (34.05, 82.72) | 32.81 (25.83, 41.69) | 47.73 (26.48, 86.02) | 26.61 (22.82, 31.02) | 155.35 (99.6, 242.31) | 31.19 (18.33, 53.07) |
| **Urinary 3HPMA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 97 | 23† | 91 | 7† | 8† |
|  | 666.62 (455.34, 975.92) | 294.21 (241.87, 357.89) | 396.88 (195.98, 803.74) | 255.47 (207.5, 314.53) | 2018.59 (1249.51, 3261.04) | 267.48 (157.28, 454.88) |
| **Urinary HPMMA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 93 | 7† | 8† |
|  | 1965.36 (1444.79, 2673.51) | 511.02 (449.72, 580.67) | 784.95 (384.69, 1601.64) | 404.07 (335.86, 486.14) | 4982.09 (3248.02, 7641.93) | 569.01 (306.78, 1055.38) |
| **Urinary IPM3 (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 93 | 7† | 8† |
|  | 20.58 (8.77, 48.27) | 4.57 (3.76, 5.55) | 12.85 (5.11, 32.31) | 4.69 (3.68, 5.98) | 77.83 (44.9, 134.93) | 6.48 (2.61, 16.12) |
| **Urinary MADA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 9† | 94 | 22† | 83 | 6† | 7† |
|  | 222.23 (162.47, 303.96) | 122.24 (108.71, 137.47) | 196.33 (145.92, 264.15) | 125.37 (106.33, 147.82) | 513.38 (298.94, 881.65) | 124.73 (69.93, 222.48) |
| **Urinary MHB3 (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 93 | 7† | 8† |
|  | 15.93 (9.5, 26.7) | 5.32 (4.59, 6.16) | 12.7 (6.53, 24.73) | 5.05 (4.17, 6.12) | 57.74 (38.94, 85.61) | 7.5 (3.58, 15.73) |
| **Urinary PGA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 10† | 93 | 22† | 89 | 5† | 8† |
|  | 434.39 (317.4, 594.5) | 201.01 (181.54, 222.58) | 279.19 (216.22, 360.5) | 173.06 (151.28, 197.99) | 597.65 (387.78, 921.09) | 255.47 (146.63, 445.1) |
| **Urinary PMAC (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 12† | 100 | 24† | 93 | 7† | 8† |
|  | 0.98 (0.58, 1.67) | 1.01 (0.85, 1.2) | 0.56 (0.31, 1) | 0.74 (0.6, 0.9) | 1.77 (0.9, 3.47) | 0.82 (0.4, 1.67) |
| **Urinary TTCA (µg/g creatinine)** |  |  |  |  |  |  |
| **N** | 11† | 89 | 19† | 79 | 6† | 8† |
|  | 14.52 (8.24, 25.6) | 28.85 (21.34, 39) | 14.03 (10.58, 18.61) | 13.81 (11.21, 17.01) | 45.36 (32.21, 63.87) | 25.78 (18.55, 35.83) |

Abbreviation: CI=confidence interval; † sample size < 50; ‡ greater than 40% of samples tested below the limit of detection (LOD); § 1 or more analytes for this derived variable has greater than 40% below LOD