Implementation of the California Environmental Contaminant Biomonitoring Program: 2018-2019

Sixth Report to the California Legislature

January 2018 – June 2019

BIOMONITORING CALIFORNIA

MEASURING CHEMICALS IN CALIFORNIANS

California Department of Public Health
In collaboration with
California Environmental Protection Agency's
Office of Environmental Health Hazard Assessment and
Department of Toxic Substances Control

DEPARTMENT OF TOXIC SUBSTANCES CONTROL

CDPH

OEHHA

GAVIN NEWSOM
Governor
State of California

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A legislative report describing Biomonitoring California's findings is required every two years (H&SC Section 105459(a)). This is the sixth report, covering Biomonitoring California's activities and findings from January 2018 through June 2019.[1]

To obtain copies of the report:

This report is available online at
biomonitoring.ca.gov/biomonitoring-california-reports.

Copies may also be requested from the Environmental Health Investigations Branch, California Department of Public Health, by calling 510-620-3620, or writing to:

Environmental Health Investigations Branch
850 Marina Bay Parkway, Building P-3
Richmond, CA 94804

[1] The Program is transitioning from calendar year to fiscal year reporting. Future reports will span two fiscal years.

Introduction

Californians experience widespread exposures to environmental chemicals, many of which pose health concerns. Recognizing that preventing exposures to harmful chemicals can reduce the disease burden across the state, the Legislature established the California Environmental Contaminant Biomonitoring Program (also known as Biomonitoring California), which was the first legislatively mandated, ongoing state biomonitoring program in the country. This Sixth Report to the Legislature provides an overview of Program activities from January 2018 through June 2019.

About the Program

Biomonitoring California was established through legislation in 2006 by Senate Bill 1379 (Perata and Ortiz, Chapter 599, Statutes of 2006) and codified in Health and Safety Code Sections 105440 et seq. In passing this law, the California Legislature stated that:

> *"… the establishment of a statewide biomonitoring program will assist in the evaluation of the presence of toxic chemicals in a representative sample of Californians, establish trends in the levels of these chemicals in Californians' bodies over time, and assess effectiveness of public health efforts and regulatory programs to decrease exposures of Californians to specific chemical contaminants. A statewide and community-based biomonitoring program will expand biomedical, epidemiological, and behavioral public health research."*

The Program is a collaborative effort of the California Department of Public Health (CDPH) as the lead, the Office of Environmental Health Hazard Assessment (OEHHA), and the Department of Toxic Substances Control (DTSC). It receives technical advice and peer review from a Scientific Guidance Panel (SGP) and input from the public. Biomonitoring California conducts studies to measure levels of environmental chemicals in Californians that may affect their health and track the levels over time. Biomonitoring data are an essential cornerstone of the State's efforts to reduce exposures to harmful chemicals, and evaluate the effectiveness of those efforts. For more information about Biomonitoring California, visit the Program website at biomonitoring.ca.gov.

What is Biomonitoring?

Biomonitoring is the measurement of chemicals in human biological samples such as blood and urine. It is a tool used to identify *which* chemicals, and *how much* of those chemicals, get into our bodies. Biomonitoring data provide an overall measure of human exposure to potentially

harmful chemicals from all sources, including air, water, food, soil, dust, and consumer products.

Importance of Biomonitoring

People are exposed to harmful chemicals every day through their environment, home, and workplace. Chemical exposures have been linked to many different health impacts, including cancer, respiratory disease, birth defects, and lower fertility. About 30 percent of childhood asthma cases and 10 percent of neurodevelopmental disorders can be attributed to environmental factors.[2]

The health consequences of environmental contaminants are felt across the California population, especially in neighborhoods already impacted by poverty, stress, crime, and other socioeconomic factors. Infants and children are particularly vulnerable to chemical exposures, because they are in a sensitive period of their development, and because of certain behaviors, like frequent hand-to-mouth activity. Reducing chemical exposures is an essential component of disease prevention, and biomonitoring is critical to this effort. Information from biomonitoring studies can:

Identify

- Which chemicals get into people's bodies, and at what levels
- Highly exposed individuals or groups
- Changes in levels of chemicals in people over time
- Differences in chemical levels measured in people across the state
- Emerging chemical exposures that pose health threats

Inform

- Individuals and the public about their chemical exposures, and actions they can take to protect their health
- Policy makers and regulatory managers as they set public and environmental health priorities and develop new laws or programs to address chemical hazards

Evaluate

- Effectiveness of regulatory and public health efforts to reduce harmful chemical exposures

Biomonitoring can be used to assess a wide range of chemical exposures, such as mercury poisonings caused by the use of imported skin care products; exposures to perfluoroalkyl and

[2] California Environmental Health Tracking Program. Costs of Environmental Health Conditions in California Children. https://www.phi.org/uploads/files/2015ROI_CEHTP.pdf. Published June 2015. Accessed May 5, 2021.

polyfluoroalkyl substances (PFASs) from a wide range of sources, including drinking water impacted by airports with fire training areas and municipal solid waste landfills; consumer exposures to brominated flame retardants released from older foam furniture; and air pollutant exposures in disproportionately impacted communities. Biomonitoring is also used to track harmful exposures across the population, including through childhood lead testing and statewide studies of PFASs and metals.

The chemicals measured by Biomonitoring California pose significant potential health concerns, but for most, we lack adequate scientific information to determine the specific health risks associated with levels measured in people. Information from biomonitoring studies, combined with other research, can be used to learn how chemicals affect our health and to support efforts to reduce exposures to harmful substances.

Measuring Harmful Chemical Exposures

Two nationally recognized laboratories are an integral part of Biomonitoring California. The Environmental Health Laboratory (EHL), a branch of CDPH, has a highly advanced and sensitive method for measuring metals in blood and urine, which is an essential public health tool for California's efforts to address exposures to toxic metals, such as lead and mercury. EHL also has extensive capability to measure urinary levels of many non-persistent[3] organic chemicals, including phthalates, phenols, and pesticides.

The Environmental Chemistry Laboratory (ECL), a division of DTSC, has been on the forefront of developing and implementing methods to measure persistent[4] organic chemicals, such as polybrominated diphenyl ether (PBDE) flame retardants, in serum.[5] ECL also analyzes serum for legacy pollutants like polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) and chemicals of emerging national concern, such as PFASs.

During the 18-month period covered by this report (January 1, 2018 through June 30, 2019), Biomonitoring California analyzed 1122 specimens from over 800 individuals for toxic chemicals or their breakdown products. The chemicals measured during this time period are highlighted

[3] Non-persistent chemicals are those that enter the body and are generally metabolized and/or eliminated with urine or stool within hours to weeks.
[4] Persistent chemicals are those that are eliminated from the body very slowly (years to decades) and may accumulate in specific areas of the body (often fat tissue or bone).
[5] Serum is the clear liquid component of blood from which cells, platelets, and clotting proteins have been removed.

below. Appendix C provides the complete list of chemical groups that the Program's laboratories can measure.

- **Metals**, including arsenic, cadmium, cobalt, lead, and mercury. Exposures to metals are linked to a range of potential health effects, including cancer; cardiovascular disease; toxicity to the respiratory system, nervous system, and kidneys; and harm to the developing infant and child.
- **PFASs**, which are used in a variety of consumer and industrial applications (e.g., fire-fighting foams, non-stick cookware, stain-repellent carpets and clothing, and grease-repellent food containers). PFASs may affect the developing fetus and child, decrease fertility, increase the risk of thyroid disease, interfere with the body's natural hormones and the immune system, and increase cancer risk.
- **Phenols**, a broad class of chemicals that are often used in personal care products, consumer products, and some plastics. Some examples include bisphenol A (BPA), used in hard plastics, fabric adhesives, and some cash register receipts; bisphenol S (BPS) and bisphenol F (BPF), which are used as replacements for BPA in some applications; parabens, added as preservatives to many products; and triclosan, an antibacterial agent that is added to some products. Many phenols affect the endocrine system.
- **1-Nitropyrene (1-NP)**, a marker of exposure to diesel exhaust, which is associated with serious health effects, including asthma and cancer.
- **PBDEs**, which were extensively used as flame retardants in the past. DTSC played a key role in identifying the significant exposures to these chemicals in the state, which prompted the California Legislature to ban most formulations in 2006. PBDEs may interfere with the body's natural hormones; harm the developing fetus; decrease fertility; and increase cancer risk.
- **Organophosphate flame retardants (OPFRs)**, used as replacements for PBDEs in some applications. Some OPFRs may interfere with the body's natural hormones, harm the developing fetus, reduce fertility, and increase cancer risk.

Biomonitoring California Studies

The Biomonitoring California studies described below include:

- Surveillance studies, which provide information about baseline levels of chemicals across the state
- Targeted investigations, which increase understanding of how certain groups may be exposed to chemicals

- Intervention studies, which help evaluate how behavioral, consumer, or policy changes may impact chemical exposures

Biomonitoring California studies generally involve participant recruitment, sample collection, exposure surveys, the return of results to participants, and epidemiologic analyses of results. All studies are approved by the Committee for the Protection of Human Subjects, which is the State's Institutional Review Board (IRB).

Summary results for all Biomonitoring California studies are posted to the Program's interactive online database as they become available. New findings within the reporting period are included below; summary data from the reporting period are available in Appendix E. Information on current and past Biomonitoring California studies is available at the Program website's project archive.

California Regional Exposure (CARE) Study

The CARE Study is Biomonitoring California's statewide surveillance study.[6] The goal is to understand chemical exposures across California's population. Through the CARE Study, Biomonitoring California is generating valuable baseline exposure data that can be used to:

- Identify individuals and communities with higher chemical exposures
- Support communities in reducing their exposures
- Improve public and environmental health policies in California

The Program biomonitored all CARE Study participants for 10 metals and 12 PFASs. Some participants were also biomonitored for 10 phenols and 1-NP. These chemicals were selected based on known or suspected health effects and widespread exposures across the state.

There are eight CARE Study regions. In the current reporting period, the CARE Study reached two regions: Region 1 (Los Angeles [LA] County) and Region 2 (Riverside, San Bernardino, Imperial, Mono, and Inyo counties).

Region 1 Activities (2018-2019)

1. Enrolled 430 participants.
2. Analyzed samples for metals, PFASs, phenols, and 1-NP.
3. Returned results to participants.
4. Provided one-on-one follow-up for participants with results exceeding levels of concern.

Region 2 Activities (2019-)

1. Enrolled 359 participants.
2. Began laboratory analyses for metals, PFASs, phenols, and 1-NP.

[6] Statewide biomonitoring is one of the Program's primary statutory mandates.

CARE Study Findings

Participants in Region 1 (n = 430) reflected the LA County population by age, race, and household income and came from across the county. Thirty-one percent were born outside of the United States. More women (61 percent) participated than men (38 percent), and one percent of study participants did not identify as either male or female.

Results for Region 2 are scheduled to be released to participants as well as the public in 2020. Region 1 (CARE-LA) findings, based on samples collected from January to May in 2018, include:

Metals

- 100 percent of CARE-LA participants had arsenic and lead in their bodies.
- At least seven of the ten metals measured were found in more than 90 percent of participants.
- 8% of participants had levels of mercury, arsenic, or lead that were high enough to be of concern. We contacted these participants to follow up on their results[7]. This included inviting them to participate in a telephone survey to help identify sources of metals exposures, and sharing possible ways to reduce their exposures.
- Asian participants had the highest levels of mercury and arsenic.

PFASs

- 100 percent of participants had at least one PFAS in their bodies.
- Two PFASs (PFOA and PFOS), which are linked with serious health effects, were found in 97 percent of participants.
- Asian participants had the highest levels of certain PFASs.

Phenols

The Program tested 60 female participants from CARE-LA for phenols.

- Of the 60 women tested, 47 percent had BPA, 77 percent had BPS, and 23 percent had BPF in their bodies.
- Triclosan was found in over 80 percent of the women tested.
- Almost all the women tested (95 percent) had methylparaben in their bodies. Levels were highest among Black women.

1-NP (marker of exposure to diesel exhaust)

The Program tested 159 participants from CARE-LA for metabolites of 1-NP, an indicator of exposure to diesel exhaust.

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[7] The Program provides one-on-one follow-up for all study participants with an arsenic, cadmium, lead, or mercury result that exceeds the Program's "levels of concern" (LOC). LOCs are based on guidance from federal and State programs.

- Almost all 159 participants tested (99 percent) had 1-NP metabolites in their bodies.
- Participants who work around diesel equipment had higher levels of 1-NP metabolites in their bodies.
- Participants who provided samples in February generally had higher levels than participants who provided samples later in the study period. This was not surprising, given that diesel-related air pollution is usually worse in the winter than in the spring.

Asian/Pacific Islander Community Exposures (ACE) Project

The ACE Project was conducted in collaboration with two community-based organizations, APA Family Support Services in San Francisco (ACE 1: sample collection in 2016) and the Vietnamese Voluntary Foundation in San Jose (ACE 2: sample collection in 2017).

Findings from earlier studies by Biomonitoring California and the New York City Department of Health and Mental Hygiene have indicated that Asian/Pacific Islanders may have higher levels of certain chemicals compared to people from other ethnic or racial groups. This could be due to a range of factors, such as regular consumption of fish and rice, and the use of traditional remedies, such as some herbal medicines. Given that Asian/Pacific Islanders (API) make up 14 percent of the California population, it was a priority for Biomonitoring California to better understand the levels of chemical exposures in these communities and support exposure reduction. The ACE Project was designed with input from community leaders to measure PFASs and selected metals, and investigate routes of exposure of particular concern in the API population (e.g., consumption of rice and seafood).

The ACE Project measured metals and PFASs in API adults living in the San Francisco Bay Area. Arsenic, cadmium, lead, and mercury were measured in urine and/or blood, and 32 PFASs were measured in serum. Results were returned to the first 100 participants (ACE 1) in 2017. In the current reporting period, Biomonitoring California returned results to the remaining 100 ACE participants (ACE 2).

Results from the ACE Project show that 100 percent of the study population had been exposed to potentially harmful metals and PFASs. In addition, these levels were generally higher than those measured in previous Biomonitoring California studies.

ACE Project Findings

Metals

- Arsenic, lead, and mercury were found in all ACE participants; cadmium was found in more than 97 percent of participants.
- Levels of arsenic, cadmium, and mercury were higher in the ACE population, compared with Asians from the US National Health and Nutrition Examination Survey (NHANES).

- 45 percent of ACE participants had at least one result that exceeded the Program's level of concern for arsenic, cadmium, lead, or mercury.
- 26 percent of ACE participants had inorganic arsenic levels that exceeded the level of concern.
- Nearly one in five participants had blood mercury levels that exceeded the level of concern.
- Higher levels of metals were associated with more recent immigration to the United States and consumption of more fish.

PFASs

- Seven PFASs were detected in over 96 percent of the ACE population. Another four PFASs were detected in 51–84 percent of the study population.
- Levels of some PFASs were higher in the ACE population compared with Asians in the NHANES population, most particularly with perfluoroundecanoic acid [PFUA] (72 percent higher).

Measuring Analytes in Maternal Archived Samples (MAMAS)

The MAMAS pilot study analyzes maternal serum samples collected through CDPH's Genetic Disease Screening Program (GDSP). Samples obtained through routine prenatal screening are archived and made available to researchers through the California Biobank Program.

The MAMAS pilot explored the feasibility of using GDSP prenatal screening samples to support statewide biomonitoring surveillance. Biomonitoring California identified a subset of GDSP samples to analyze for levels of specific persistent chemicals (PFASs, PBDEs, PCBs, and OCPs). Samples were selected to equally represent White, Black, Hispanic, and Asian women from across the state.

In the current reporting period, Biomonitoring California analyzed 598 samples for PFASs, PBDEs, PCBs, and OCPs. Samples were collected in 2015 and 2016 and represent women from 40 counties across the state. The Program is evaluating results and summary data; findings will be released to the public as they are finalized.

East Bay Diesel Exposure Project (EBDEP)

EBDEP is a collaboration with the Center for Environmental Research and Children's Health at the University of California, Berkeley, and the University of Washington.

Measuring diesel exhaust exposures has been a key and ongoing priority of the SGP. To address this priority, the Program launched EBDEP in 2017 using one-time funding provided by the Legislature. Sample collection occurred in 2018 and 2019.

EBDEP was designed to directly measure exposures to diesel exhaust within families, and examine how exposures vary between communities and at different time points. Results from EDBEP will help evaluate the effectiveness of California's extensive regulatory efforts to reduce diesel emissions. Participants will be provided with information on exposure sources, possible health concerns, and actions they can take to reduce exposures.

EBDEP is measuring levels of 1-NP metabolites in 40 families with a child aged two to ten living in Alameda and Contra Costa counties. Participants provided information about their home environment and daily activities, parent and child urine samples, and home dust and air samples at two different points in time. The parents and children also carried GPS devices during the two sampling periods. In the current reporting period (January 2018 – June 2019), the project:

1. Recruited 40 parents and 40 children.
2. Collected samples at two time points, usually about four to six months apart. Twenty-five families provided single urine samples, and fifteen families provided daily urine samples for four days during each sampling period.
3. Analyzed urine samples for 1-NP metabolites (University of Washington).
4. Developed results return materials.

Foam Replacement Environmental Exposure Study (FREES)

FREES was an intervention study conducted in collaboration with the University of California, Davis, Environmental Working Group, Green Science Policy Institute, and Silent Spring Institute. Sample collection was conducted from 2016 to 2018.

Biomonitoring studies have measured some of the world's highest levels of PBDEs in California residents.[8] This is due to the state's stringent anti-flammability standard, known as Technical Bulletin 117 (TB 117), which was in effect from 1975 to 2013. In 2006, California implemented a partial ban on PBDEs, leading to the use of alternative flame retardant chemicals such as OPFRs. In 2013, the state updated TB 117 and replaced it with TB 117-2013, which further reduced the use of PBDEs. The purpose of FREES was to determine whether household furnishings continue to be a primary source of flame retardant exposures, and to evaluate how exposures to flame retardants change following replacement or removal of older foam-containing household furnishings.

[8] Zota et al. Elevated House Dust and Serum Concentrations of PBDEs in California: Unintended Consequences of Furniture Flammability Standards? Environmental Science & Technology, 2008; 42 (21): 8158-8164 DOI: 10.1021/es801792z

Biomonitoring California recruited 28 participants who were planning to replace or remove foam-containing furnishings from their homes. PBDE and OPFR flame retardant levels were measured before the intervention and approximately 6, 12, and 18 months after the furniture was replaced or removed. In the current reporting period, the Program completed sample collection and returned 12-month and 18-month results to all participants.

We established a demographically similar comparison group to help examine the decreasing trend in PBDE levels over the same time period, which was expected based on prior published studies. Members of the comparison group did not replace or remove foam-containing household furnishings.

Preliminary FREES Findings

Preliminary findings are drawn from baseline, 6-, 12-, and 18-month results. The Program continues to analyze FREES results and exposure information.

PBDEs

- In FREES participants, levels of the PBDEs commonly found in foam furniture (BDE 47, BDE 99, and BDE 100) showed significant decreases over one year. The comparison group showed less of a decline, consistent with the temporal trend identified in other studies.

OPFRs

- OPFR levels varied widely within FREES participants over time, which was also the case for the comparison group. The variability in OPFR biomonitoring measurements arises in part from the short biological half-lives of these chemicals. It could also be related to the varying sources of OPFR exposures, which can include foam-containing products like furniture and car seats, building materials, plastic parts in electronic equipment, paint, and nail polish.

Additional Activities

Dissemination of Program Findings

Program information is disseminated to the public in several ways. The first priority is to provide results to study participants, including notification of elevated levels of chemicals and health education materials (see section below). Preliminary study findings (such as demographic, geographic, or temporal trends) are then released to stakeholders at public meetings and through the Program website. In coordination with the CDPH Office of Public Affairs, the Program may share study findings through press releases and social media. In-depth

analysis of the study data may result in publications for scientific audiences and informational materials for the general public.

This Report to the Legislature will be posted to the CDPH and Biomonitoring California websites and shared with Program stakeholders via listserv and email.

Notification of Elevated Levels of Chemicals

The Program provides one-on-one follow-up for participants with an arsenic, cadmium, lead, or mercury result that exceeds the respective "level of concern" (LOC).

Biomonitoring California's LOCs are adopted from standards established by State and Federal programs. LOCs for arsenic, cadmium, and mercury are based on guidance from the U.S. Environmental Protection Agency and U.S. Centers for Disease Control and Prevention; the LOC for lead was adopted from CDPH's Occupational Lead Poisoning Prevention Program (OLPPP).

Chemical	**Measured in**	**Level of Concern for Adults**
Arsenic (total)	Urine	≥ 50 micrograms (µg)/liter
Arsenic (inorganic)	Urine	≥ 20 µg/liter
Cadmium	Urine	>3 µg/g creatinine
Cadmium	Blood	≥ 5 µg/liter
Mercury	Urine	≥ 10 µg/liter
Mercury	Blood	≥ 5.8 µg/liter if pregnant or considering becoming pregnant; ≥ 10 µg/liter for all other adults
Lead	Blood	≥ 4.5 µg/deciliter

Of the 550 participants who received their results in the current reporting period, about 16 percent had a result that exceeded the Program's LOC for one or more chemical. Participants whose result(s) exceed the LOC are provided with follow-up support. Follow-up includes a review of the participant's survey responses, and a discussion with the participant about possible exposure sources and ways they might reduce their exposures. Follow-up for adult participants with elevated lead levels is conducted in coordination with OLPPP.

Providing Individual Results and Health Education

Biomonitoring California is committed to the principle of "right to know," and is required by legislation to offer individual results to all study participants, even if the health implications of these results are not yet known. Over 99 percent of participants ask to receive their results; one of the motivating factors for participants to enroll in a biomonitoring study is to learn about their own chemical exposures.

In the current reporting period, Biomonitoring California returned results to over 550 participants. Results materials include a cover letter, study description, individual levels of environmental chemicals with study and NHANES comparison values, text explanations, and chemical-specific fact sheets. Fact sheets include information on the chemical measured, sources of exposure, and guidance to limit exposures. Materials are available in English, Spanish, Chinese, and Vietnamese and are translated into additional languages as needed.

The Program website provides further details on communicating biomonitoring results, including examples of the Program's results return materials.

Scientific Guidance Panel and Chemical Selection

Scientific peer review of Biomonitoring California is provided by the SGP. OEHHA is responsible for convening and staffing the Panel and developing scientific documents and other materials to support the SGP's deliberations. The Panel consists of five members appointed by the Governor, two by the Speaker of the Assembly, and two by the Senate Rules Committee. SGP meetings are open to the public and are accessible via webcast or webinar.

The SGP provides formal recommendations on chemicals or chemical classes that should be biomonitored in California. The Panel also provides input on study design and implementation, laboratory methods, and emerging scientific issues related to biomonitoring. The four SGP meetings held during the current reporting period included routine Program updates, covering items such as CARE Study status and methods, and in-depth discussions of the following topics:

- Community exposures to metals, which included discussion of Biomonitoring California findings on metals to date and perspectives from county health departments on these potentially harmful exposures.
- Exposures to PFASs in California, with review of Program findings to date, presentations by national experts, and engagement with the California State Water Resources Control Board about future biomonitoring work to inform their regulatory efforts on this group of chemicals.
- Community exposures to air pollutants, which included presentations by the California Environmental Protection Agency (CalEPA) Assistant Secretary for Environmental Justice and Tribal Affairs, and a leading expert in biomonitoring of volatile organic compounds (VOCs), as well as engagement with the California Air Resources Board on how biomonitoring can inform implementation of the new Community Air Protection Program established under Assembly Bill 617.

For additional information, visit the SGP meeting page.

Public Involvement

In addition to conducting biomonitoring studies, the Program is mandated to "provide opportunities for public participation and community capacity building" and to allow for "meaningful stakeholder input." The Program has several opportunities for public involvement, as follows:

- **Public access at SGP meetings**. Each SGP meeting is open to the public and includes an open public comment period. Individuals may share comments or ask questions in person or online.
- **Online participation through Program emails, listserv, and website**. Other ongoing public involvement activities include maintenance of an email list with 1016 active subscribers as of June 2019. Notes are sent to subscribers approximately twice each month, informing them of Program activities and new materials, such as biomonitoring results, posted on the website.
- **Outreach to local health departments and community-based organizations**. Biomonitoring California staff routinely reach out to local health departments and organizations during study planning, implementation, and results phases. Outreach may involve education on biomonitoring and environmental health issues; it also provides an opportunity for groups to provide input on local issues and concerns.

More information on the range of public involvement efforts being carried out by Biomonitoring California can be found on the Program website.

Support for Other State Programs

Biomonitoring California is a critical component of the State's innovative regulatory and public health programs designed to reduce or prevent harmful chemical exposures. Chemical exposures are known to have negative impacts on health across the lifespan, and reducing exposures can contribute to disease prevention. Biomonitoring produces valuable data that helps to identify and quantify chemical exposures across the state. Results are shared to help inform and evaluate public health policies. Program findings are being used to support and inform California's efforts in this area, including:

- The **Safer Consumer Products (SCP) program**, operated by DTSC, was established to reduce toxic chemicals in the products that consumers buy and use. Biomonitoring California and SCP regularly collaborate to identify chemicals of emerging concern. The Program's priority chemicals are included in SCP's list of candidate chemicals.
- The **CalEnviroScreen** tool, developed by OEHHA, uses environmental, health, and socioeconomic information to help identify California communities with the highest

pollution burdens and vulnerabilities. Information from Biomonitoring California studies, such as those measuring biomarkers of diesel exhaust exposure, can be used to help evaluate CalEnviroScreen predictions.

- The **California State Water Resources Control Board** (SWRCB) protects the quality of the state's surface, ground, and drinking water. In 2019, SWRCB launched a program requiring measurement of 39 PFASs in water sources near 31 airports and 252 municipal solid waste landfills, and from nearly 1000 community water suppliers. The Program's findings on PFASs have already played a role in motivating this effort. The California Teachers Study, a collaboration with Biomonitoring California's laboratory, demonstrated a link between drinking water PFAS exceedences and biological levels. There has been subsequent interest in examining biomonitoring data collected through the CARE Study in conjunction with drinking water measurements to determine the role that drinking water plays in PFAS exposure.
- **Proposition 65**, formally known as the Safe Drinking Water and Toxic Enforcement Act of 1986, requires Californians to be informed when businesses, through their products or other activities, expose them to chemicals known to cause cancer or reproductive toxicity (including effects on development and male and female reproductive health). Findings from Biomonitoring California studies are being used by researchers to help evaluate the impact of Proposition 65 on selected chemical exposures. OEHHA is the lead agency for implementation of Proposition 65.

Complementary Studies and Support to External Partners

Biomonitoring California staff are involved in complementary studies related to chemical exposures, and also provide support and technical assistance to local agencies and researchers conducting biomonitoring and exposure assessment. Examples within the current reporting period include:

- **EBDEP Air and Dust Studies.** Complementary studies are being conducted in collaboration with UC Berkeley and UW to analyze 1-NP in dust from participants' homes, and monitor indoor air for black carbon (a sooty material released from diesel engines and other sources). The filters from the black carbon monitors are also being analyzed for 1-NP. This information will be used to better understand pathways of exposure.
- **Maternal Cotinine and Autism Study.** The Environmental Health Laboratory (EHL) analyzed 1000 maternal serum samples for cotinine, a metabolite of nicotine. Results will be used by CDPH to study the link between childhood neurological development and exposure to tobacco smoke.

- **Northern California Firefighter Study**. Biomonitoring California provided support to the University of California, Berkeley; Commonweal; and the San Francisco Firefighters Cancer Prevention Foundation in their investigation of chemical exposures in firefighters immediately following response to a wildland-urban interface fire. Program staff assisted with study design, sample management, and results return materials. EHL and ECL conducted the laboratory analyses for metals, PBDEs, and PFASs. Results will be used by partners to inform health-protective measures for future wildfire responders.
- **Phenols and Phthalates Validation Study**. EHL is collaborating with San Jose State University to study food packaging contaminants. EHL analyzed 33 samples for environmental phenols.

Recommendations and Conclusions

At the July 2019 SGP meeting, recommendations for Program improvement were presented by Program leadership and discussed by the Panel. The Panel supported inclusion of the following recommendations in this report:

1. **Maintain core laboratory capabilities and develop innovative and efficient laboratory methods to protect the public's health**
   Laboratory capabilities must include priority chemicals of concern to the state, including heavy metals, PFASs, and other chemicals linked to air and water contamination. It is also essential that the Program further develop methods to efficiently screen for the large numbers of emerging chemicals of concern in California.

2. **Improve the CARE Study, the Program's statewide surveillance project**
   Biomonitoring surveillance provides critical baseline data on chemical exposures in the state. This data is necessary to identify disproportionately impacted groups, to identify trends over time, and to inform health-protective policies. The Panel discussed the importance of having sufficient support for scientifically robust surveillance.

3. **Conduct biomonitoring studies that seek to better understand and mitigate environmental health inequities**
   Environmental exposures vary according to social determinants, such as housing, neighborhoods, education, and industries. Community-based and targeted studies can inform efforts to understand and mitigate environmental health inequities. The Panel highlighted this recommendation as a key avenue for showing the value of biomonitoring.

4. **Expand assistance to local agencies in responding to chemical exposures**

   Local health departments and public agencies are regularly called upon to respond to chemical exposures in the communities they serve. Biomonitoring California should continue to provide support and assistance to local agencies in effectively addressing harmful chemical exposures.

5. **Inform evidence-based decision-making by improving access to biomonitoring data**

   The greatest public health impact of biomonitoring is evidence-based policies that improve environmental health for all Californians. The Panel recommended increasing public access to biomonitoring data in order to assist policymakers as they implement the State's innovative efforts to reduce harmful chemical exposures.

6. **Expand and improve health education for individual participants, health care providers, community organizations, and the general public**

   Health education materials, including fact sheets, newsletters, and web content, are critical to inform the public about harmful chemicals and ways to reduce exposures. Development and dissemination of additional educational tools will increase public understanding of chemical exposures in California.

7. **Conduct biomonitoring studies to evaluate the effectiveness of regulatory programs**

   One of the core goals in the establishing legislation for Biomonitoring California is to help evaluate the effectiveness of regulatory programs. The Panel recommended the Program design studies that can be used to inform public policy and support regulatory programs.

Biomonitoring California is uniquely able to identify, quantify, and report on harmful chemical exposures in our state. The Program's work helps policy makers, regulatory managers, public health leaders, and communities better understand some of the state's most pressing environmental health concerns, including air pollution and water quality. Biomonitoring California studies demonstrate that ongoing exposure to metals remains an issue in California, with serious implications for maternal and child health; the Program's surveillance studies have also illuminated the widespread exposure to PFASs in our state: 100 percent of Californians tested have at least one PFAS in their bodies. Biomonitoring California's core activities are critical to minimizing harmful chemical exposures and disease burden across the state.

Appendix A: Program Structure

Biomonitoring California is a complex, multidisciplinary program developed and implemented collaboratively by the California Department of Public Health (CDPH), Office of Environmental Health Hazard Assessment (OEHHA), and the Department of Toxic Substances Control (DTSC). This multidisciplinary approach contributes to the success of the program by bringing together expertise in analytical chemistry, toxicology, epidemiology, exposure science, and health education. General departmental roles and responsibilities for Biomonitoring California are shown in Figure A1; however, staff members in all three departments frequently collaborate across activities.

Figure A1. Biomonitoring California Departmental Primary Roles and Responsibilities

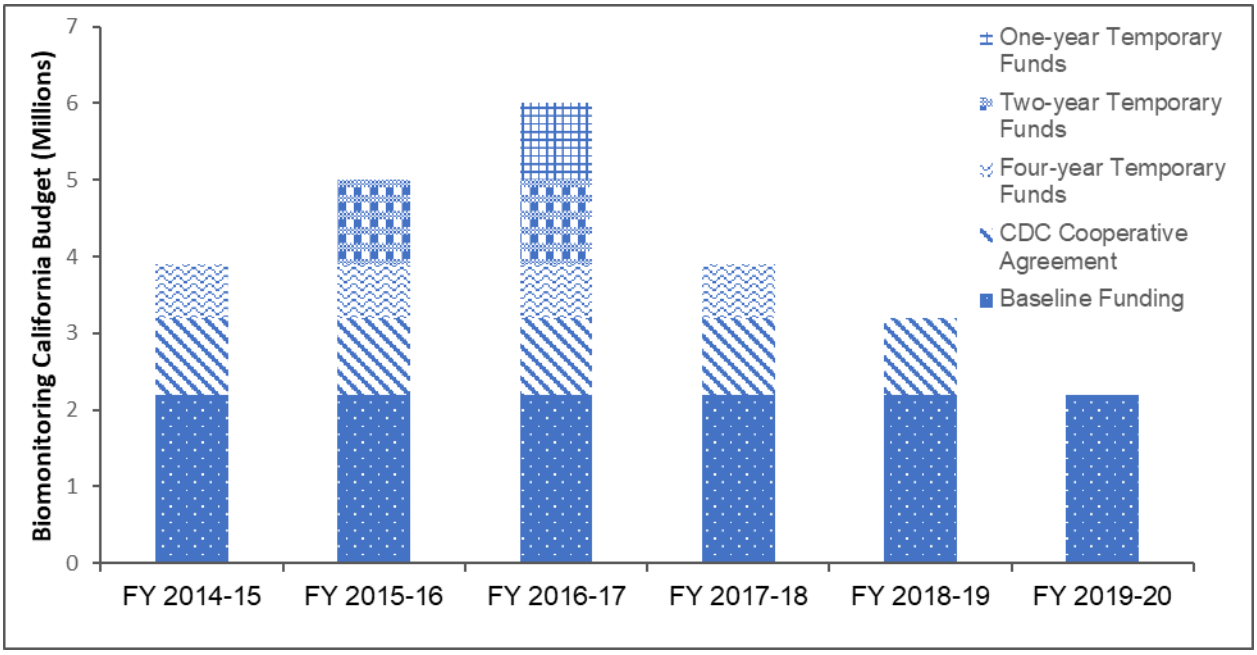
DTSC Environmental Chemistry Laboratory	**CDPH** Environmental Health Laboratory	**CDPH** Environmental Health Investigations Branch	**OEHHA** Reproductive and Cancer Hazard Assessment Branch
• Laboratory analyses of blood samples for *persistent* chemicals that accumulate in people • Quality assurance and interpretation of laboratory data • Non-targeted and semi-targeted screening to identify new chemicals of emerging concern in California	• Laboratory analyses of blood samples for metals and urine samples for metals and *non-persistent* chemicals • Quality assurance and interpretation of laboratory data • Processing, storage, and long-term management of blood and urine samples	• Program lead; responsible for overall coordination of program components and partners • Liaison to National Biomonitoring Network • Design and implementation of statewide biomonitoring study • Management and analysis of epidemiologic data • Dissemination of information to the public • Generation of reports to the Legislature	• Scientific and administrative support of the Scientific Guidance Panel • Evaluation of scientific information for chemical selection, choice of biomarkers, and interpretation of results • Development of chemical fact sheets • Updates and improvements to the Program website • Design and implementation of community-based biomonitoring studies

Appendix B: Program Funding

Biomonitoring California receives $2.2 million in baseline State funding through five special funds, which have been supplemented by temporary State and federal funding[9] (see Figure B1 and Table B1). This funding supported the following projects in the current reporting period (January 2018 – June 2019):

- California Regional Exposure (CARE) Study
- Measuring Analytes in Maternal Archived Samples (MAMAS)
- East Bay Diesel Exposure Project (EBDEP)
- Asian/Pacific Islander Community Exposures (ACE) Project
- Foam Replacement Environmental Exposure Study (FREES)

Figure B1: Biomonitoring California Budget, FY2015-2019 (CDPH, OEHHA, and DTSC)



* Baseline funding consists of five special funds: the Toxic Substances Control Account, the Air Pollution Control Fund, the Department of Pesticide Regulation Fund, the Childhood Lead Poisoning Prevention Fund, and the Birth Defects Monitoring Program Fund. Funding is ongoing.

[9] Centers for Disease Control and Prevention Cooperative Agreement 5U88EH001148 (grant period: 2014-2019)

Table B1: Biomonitoring California Budget (CDPH, OEHHA, and DTSC)

Funding/Source	Fiscal Year	Note
Baseline State funding: $2.2 million	n/a - baseline	• Split between CDPH, OEHHA, and DTSC • Supports 13.0 full-time positions
CDC Cooperative Agreement: $1.0 million	FFY 14/15 – FFY 18/19	• Funds expired August 2019
State special funds (Four-year[10] augmentation): $700,000	FY 14/15 – FY 17/18	• $350,000 and two 2-year limited-term positions for CDPH • $350,000 and two 2-year limited-term positions for DTSC • Funds expired June 2018
State special funds (2-year augmentation):$1.2 million	FY 15/16 – FY 16/17	• $550,000 and six 2-year limited-term positions for CDPH • $600,000 and two 2-year limited-term positions for DTSC • Funds expired June 2017
Stakeholder bill (1-year augmentation): $1.0 million	FY 16/17	• Intended for environmental justice activities • New activities included the EBDEP, an expansion of the ACE Project, and environmental justice outreach • Funds expired June 2017

[10] Funds were initially approved for two years (FY 14/15 and FY 15/16) and were extended for an additional two years (FY 16/17 and FY 17/18)

Appendix C: Program Analytical Capabilities

Biomonitoring California laboratories can measure over 120 chemicals in blood, urine, and serum. A summary of chemical groups measured by Program laboratories is included in the table below. The Program's website provides additional information on these chemicals.

Chemical group	Description of chemicals in the lab panel
Environmental phenols	Environmental phenols have a wide variety of uses, such as in personal care and other consumer products, and share a common chemical structure. Environmental phenols currently measured by the Program in urine are bisphenol A (BPA); bisphenol F (BPF) and bisphenol S (BPS), which are used as replacements for BPA in some applications; the antimicrobials triclosan and triclocarban; benzophenone-3 (BP-3), a sunscreen chemical; and parabens, which are used as preservatives in personal care products and food. This group of chemicals may interfere with the body's natural hormones.
Herbicides	Biomonitoring California measures the herbicide 2,4-D in urine. 2,4-D is found in some home lawn products designed to kill weeds. There is concern that 2,4-D may interfere with the body's natural hormones and affect the developing fetus, and may increase cancer risk.
Metals	Metals are used in many industries and are found in a variety of products. Biomonitoring California measures antimony, arsenic (total and specific forms), cadmium, cobalt, lead, manganese, mercury, molybdenum, thallium, and uranium. • Some forms of antimony may contribute to respiratory problems, affect the heart, and increase cancer risk. • Some forms of arsenic ("inorganic arsenic") may harm the developing fetus and contribute to cardiovascular disease, and can increase cancer risk. Other forms of arsenic found in seafood are not considered to be a health concern. • Cadmium, lead, and mercury are toxic metals with established levels of concern that can cause a range of health effects, including harm to the developing infant and child, and increased cancer risk. • Cobalt is essential as part of vitamin B12, but in other forms can harm the heart, thyroid, and nervous system, and may increase cancer risk. • Manganese and molybdenum are essential nutrients that can be toxic at higher levels. • Thallium is a highly toxic metal that can harm many important processes in the body. • Uranium can cause kidney damage and increase cancer risk. Biomonitoring California measures metals in urine and/or blood.

Chemical group	Description of chemicals in the lab panel
Organochlorine pesticides (OCPs)	The OCPs measured by Biomonitoring California in serum are no longer used in the United States. Because OCPs last a long time in the environment, they can still be found in high-fat fish, meat, and dairy products. Examples of OCPs include DDT, which is still used in some other countries, and chlordane. OCPs may affect the developing fetus, may interfere with the body's natural hormones, and may increase cancer risk.
Organophosphate flame retardants (OPFRs)	As brominated flame retardants are phased out, organophosphate flame retardants have been entering the market in larger quantities. Some OPFRs may interfere with the body's natural hormones, decrease fertility, affect the developing fetus, and increase cancer risk. Biomonitoring California measures organophosphate flame retardant metabolites in urine.
Organophosphate (OP) pesticides	OP pesticides are used in commercial agriculture to control pests on fruit and vegetable crops. They are also used in home gardens, for flea control on pets, and in some no-pest strips. OP pesticides may affect the nervous system and may harm the developing fetus, possibly affecting later learning and behavior. Biomonitoring California measures OP pesticide metabolites in urine.
Perfluoroalkyl and polyfluoroalkyl substances (PFASs)	PFASs are used to make various products resistant to oil, stains, grease, and water. Some example products that use PFASs include non-stick cookware, stain-repellent carpets and clothing, and grease-repellent food containers. PFASs may affect the developing fetus and child, decrease fertility, interfere with the body's natural hormones and the immune system, and increase cancer risk. Biomonitoring California measures PFASs in serum.
Polybrominated diphenyl ethers (PBDEs)	PBDE flame retardants were commonly added to polyurethane foam used in upholstered furniture and in some infant products. PBDEs were also used in electronics and insulation for cables and wires. US production of penta- and octa-PBDEs ended by 2006. PBDEs have spread through the environment and break down slowly. Research studies have measured the world's highest levels of PBDEs in California residents. PBDEs may interfere with the body's natural hormones, may harm the developing fetus, and may decrease fertility. Biomonitoring California measures PBDEs in serum.

Chemical group	Description of chemicals in the lab panel
Polychlorinated biphenyls (PCBs)	PCBs were widely used to insulate electrical equipment and as plasticizers. PCBs were banned in the late 1970s but are still in some old equipment and products. They have spread through the environment and take a long time to break down. They are found in some high-fat fish and high-fat animal products, and in old caulk and old fluorescent light fixtures. Exposure to PCBs can affect the developing fetus and interfere with the body's natural hormones, and may increase cancer risk. Biomonitoring California measures PCBs in serum.
Polycyclic aromatic hydrocarbons (PAHs)	PAHs occur naturally in petroleum products, such as gasoline and diesel, and are formed when these products are burned. PAHs are found in tobacco and wood smoke. They also form when foods are grilled, barbecued, or roasted. PAHs may contribute to respiratory problems, affect the developing fetus and the body's natural hormones, and increase cancer risk. Biomonitoring California measures PAH metabolites in urine.
Pyrethroid pesticides	Pyrethroid pesticides are common ingredients in pest control products for the home and garden. They are also used to control insects on commercial agricultural crops and livestock. Some pyrethroid pesticides may affect the developing fetus, interfere with the body's natural hormones, and increase cancer risk. Biomonitoring California measures pyrethroid pesticide metabolites in urine.

Appendix D: Publications

The Program has collaborated on the following papers, January 2018 – June 2019:

- Berger KP, Kogut KR, Bradman A, She J, Gavin Q, Zahedi R, Parra KL, Harley KG (2018). Personal care product use as a predictor of urinary concentrations of certain phthalates, parabens, and phenols in the HERMOSA study. J Expo Sci & Environ Epi. Epub: Jan 9, 2018. doi:10.1038/s41370-017-0003-z.
- Hurley S, Goldberg D, Park JS, Petreas M, Bernstein L, Anton-Culver H, Neuhausen SL, Nelson DO, Reynolds P (2019). A breast cancer case-control study of polybrominated diphenyl ether (PBDE) serum levels among California women. Cancer Causes & Control. Environment International. 127:412-419.
- Hurley S, Goldberg D, Wang M, Park JS, Petreas M, Bernstein L, Anto-Culver H, Nelson DO, Reynolds P (2018). Time trends in per- and polyfluoroalkyl substances (PFASs) in California women: Declining serum levels, 2011-2015. Epub: Dec. 3, 2017. Environ Sci Technol 2018, 52(1): 277–287.
- Hurley S, Goldberg D, Wang M, Park JS, Petreas M, Bernstein L, Anton-Culver H, Nelson DO, Reynolds P (2018). Breast cancer risk and serum levels of per- and poly-fluoroalkyl substances: a case-control study nested in the California Teachers Study. Environmental Health. 17(1):83.
- Parry E, Zota AR, Park JS, Woodruff TJ (2018). Polybrominated diphenyl ethers (PBDEs) and hydroxylated PBDE metabolites (OH-PBDEs): A six-year temporal trend in Northern California pregnant women. Chemosphere 2018 Mar;195:777-783. doi: 10.1016/j.chemosphere.2017.12.065. Epub: Dec 11, 2017.
- Zota AR, Mitro SD, Robinson JF, Hamilton EG, Parry E, Park JS, Zoeller RT, Woodruff TJ (2018). Polybrominated diphenyl ethers (PBDEs) and hydroxylated PBDE metabolites (OH-PBDEs) in maternal and fetal tissues, and associations with fetal cytochrome P450 gene expression. Environ Int 112:269-278. doi: 10.1016/j.envint.2017.12.030. Epub: Jan 6, 2018.

Information on all Biomonitoring California publications can be found on the Program website.

Appendix E: Summary Data from CARE and ACE

Summary data are provided below for two of the five studies described in the Sixth Report to the Legislature (January 2018 – June 2019): the California Regional Exposure Study – Region 1 (CARE-LA) and the Asian/Pacific Islander Community Exposures (ACE) Project. These data are also available online. Summary results include:

- **Geometric Mean**: The middle value of a set of numbers. This is different than the average, also called the "arithmetic mean". A geometric mean is sometimes calculated when the set of numbers contains some extreme values. An asterisk (*) means the geometric mean was not calculated because the chemical was found in less than 65% of the study group.
- **Percentiles**: Four percentiles (25th, 50th, 75th, and 90th or 95th) describe chemical levels across the study populations.
- **Detection Frequency:** The percentage of study participants with a measurable level of a chemical in their blood or urine sample.

In some tables, the total number of samples does not match the number of total participants in the study since not all participants were able to provide both urine and blood samples.

Data for the other studies described in the Sixth Report (Measuring Analytes in Maternal Archived Samples, East Bay Diesel Exposure Project, and Foam Replacement Environmental Exposure Study) are not included because they were not available at the time this report was written.

Metals Measured in Urine

Data are reported in micrograms per liter (µg/L) with the exception of cadmium (micrograms per gram creatinine).

California Regional Exposure Study – Region 1 (CARE-LA)

Summary results for levels of metals in urine (see units above) from 428 samples collected in 2018.

Chemical	Geometric mean	25th percentile	50th percentile	75th percentile	95th percentile	Detection frequency
Antimony	*	<0.03	<0.03	<0.03	0.10	25%
Arsenic	8.2	3.6	8.4	19.4	66.0	100%
Cadmium	0.25	0.14	0.24	0.43	0.83	100%
Cobalt	0.21	0.11	0.23	0.42	1.4	100%
Manganese	*	<0.10	<0.10	<0.10	0.21	15%
Mercury	0.18	0.08	0.22	0.46	1.5	98%
Molybdenum	29.1	14.6	34.0	59.2	152	100%
Thallium	0.16	0.08	0.18	0.32	0.59	99.8%
Uranium	*	<0.01	<0.01	0.02	0.10	49%

*This value cannot be calculated because the metal was not found in enough people (<65%).

Asian/Pacific Islander Community Exposures (ACE) Project – ACE 1

Summary results for levels of metals in urine (see units above) from 100 samples collected in 2016.

Chemical	Geometric mean	25th percentile	50th percentile	75th percentile	95th percentile	Detection frequency
Arsenic	22.2	12.6	22.1	44.0	131	100%
Cadmium	0.45	0.22	0.46	0.91	1.8	97%
Mercury	0.30	0.14	0.30	0.60	1.7	99%

ACE 2

Summary results for levels of metals in urine (see units above) from 100 samples collected in 2017.

Chemical	Geometric mean	25th percentile	50th percentile	75th percentile	95th percentile	Detection frequency
Arsenic	34.0	18.0	35.4	70.5	121	100%
Cadmium	0.63	0.35	0.71	1.1	2.2	99%
Mercury	0.43	0.22	0.42	0.82	2.1	97%

Metals Measured in Blood

Data are reported in µg/L with the exception of lead (µg/deciliter).

CARE-LA

Summary results for levels of metals in blood (see units above) from 428 samples collected in 2018.

Chemical	Geometric mean	25th percentile	50th percentile	75th percentile	95th percentile	Detection Frequency
Cadmium	0.30	0.20	0.29	0.45	0.88	99%
Lead	0.78	0.52	0.76	1.2	2.2	100%
Manganese	10.3	8.2	9.9	12.7	18.7	100%
Mercury	1.05	0.44	1.1	2.4	6.2	95%

ACE 1

Summary results for levels of metals in blood (see units above) from 96 samples collected in 2016.

Chemical	Geometric mean	25th percentile	50th percentile	75th percentile	90th percentile	Detection Frequency
Cadmium	0.52	0.34	0.52	0.80	1.2	99%
Lead	1.2	0.84	1.2	1.9	2.4	100%
Mercury	3.6	2.5	4.1	7.1	9.2	100%

ACE 2

Summary results for levels of metals in blood (see units above) from 99 samples collected in 2017.

Chemical	Geometric mean	25th percentile	50th percentile	75th percentile	90th percentile	Detection Frequency
Cadmium	0.59	0.37	0.61	0.89	1.3	100%
Lead	1.1	0.86	1.1	1.4	2.1	100%
Mercury	4.8	3.2	5.2	8.0	10	100%

Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs) Measured in Serum

Data are reported in nanogram per microliter (ng/mL).

CARE-LA

Summary results for levels of PFASs in serum (ng/mL) from 425 samples collected in 2018.

Chemical	Geometric mean	25th percentile	50th percentile	75th percentile	95th percentile	Detection Frequency
2-(N-Ethyl-perfluorooctane sulfonamido) acetic acid [Et-PFOSA-AcOH]	*	<0.01	<0.01	0.01	0.05	31%
2-(N-Methyl-perfluorooctane sulfonamido) acetic acid [Me-PFOSA-AcOH]	0.07	0.04	0.06	0.09	0.34	100%
Perfluorobutane sulfonic acid (PFBuS)	*	<0.03	<0.03	<0.03	<0.03	5%
Perfluorodecanoic acid (PFDeA)	0.10	<0.06	0.09	0.16	0.39	69%
Perfluorododecanoic acid (PFDoA)	*	<0.11	<0.11	<0.11	<0.11	2%
Perfluoroheptanoic acid (PFHpA)	*	<0.03	0.03	0.05	0.10	53%
Perfluorohexane sulfonic acid (PFHxS)	0.61	0.37	0.68	1.1	2.3	99%
Perfluorononanoic acid (PFNA)	0.30	0.21	0.32	0.49	0.92	97%
Perfluorooctane sulfonamide (PFOSA)	*	<0.01	<0.01	0.01	0.05	25%
Perfluorooctane sulfonic acid (PFOS)	2.1	1.3	2.4	4.0	8.3	98%
Perfluorooctanoic acid (PFOA)	1.0	0.73	1.1	1.6	3.1	99%
Perfluoroundecanoic acid (PFUA)	0.08	0.04	0.08	0.16	0.38	82%

*This value cannot be calculated because the PFAS was not found in enough people (<65%).

ACE 1

Summary results for levels of PFASs in serum (ng/mL) from 96 samples collected in 2016.

Chemical†	Geometric mean	25th percentile	50th percentile	75th percentile	90th percentile	Detection Frequency
Et-PFOSA-AcOH	*	<0.05	<0.05	<0.05	<0.05	5%
Me-PFOSA-AcOH	0.05	0.03	0.05	0.10	0.23	96%
Perfluorobutanoic acid (PFBA)	*	<0.05	0.06	0.08	0.14	63%
Perfluorodecane sulfonic acid (PFDS)	*	<0.01	0.01	0.02	0.05	53%
Perfluorohexanoic acid (PFHxA)	0.18	0.15	0.18	0.21	0.28	98%
PFDeA	0.48	0.28	0.45	0.74	1.5	80%
PFDoA	*	<0.05	0.05	0.08	0.13	56%
PFHpA	*	<0.05	<0.05	0.06	0.09	30%
PFHxS	0.77	0.43	0.79	1.4	1.8	100%
PFNA	0.99	0.65	0.95	1.3	2.2	99%
PFOA	1.4	1.0	1.4	2.2	2.9	100%
PFOS	6.5	3.3	6.1	11.7	19.3	100%
PFUA	0.40	0.30	0.43	0.60	0.82	100%
6:2 Fluorotelomer phosphate diester (6:2 diPAP)	*	<0.05	<0.05	<0.05	<0.05	7%

*This value cannot be calculated because the PFAS was not found in enough people (<65%).

†18 PFAS were not detected in any participants: 4:2 Fluorotelomer sulfonic acid (4:2 FTS), 5:3 Fluorotelomer carboxylic acid (5:3 FTCA), 6:2 Fluorotelomer carboxylic acid (6:2 FTCA), 6:2 Fluorotelomer sulfonic acid (6:2 FTS), 6:2 Fluorotelomer unsaturated carboxylic acid (6:2 FTUCA), 7:3 Fluorotelomer carboxylic acid (7:3 FTCA), 8:2 Fluorotelomer carboxylic acid (8:2 FTCA), 8:2 Fluorotelomer phosphate diester (8:2 diPAP), 8:2 Fluorotelomer phosphate monoester (8:2 PAP), 8:2 Fluorotelomer sulfonic acid (8:2 FTS), 8:2 Fluorotelomer unsaturated carboxylic acid (8:2 FTUCA), Bis(perfluorohexyl)phosphinic acid (6:6 PFPi), Perfluorobutane sulfonic acid (PFBuS), Perfluorohexylperfluorooctyl phosphinic acid (6:8 PFPi), Perfluorohexylphosphonic acid (PFHxPA), Perfluorooctane sulfonamide (PFOSA), Perfluorooctylphosphonic acid (PFOPA), Perfluoropentanoic acid (PFPeA).

ACE 2

Summary results for levels of PFASs in serum (ng/mL) from 99 samples collected in 2017.

Chemical†	Geometric mean	25th percentile	50th percentile	75th percentile	90th percentile	Detection Frequency
Et-PFOSA-AcOH	*	<0.05	<0.05	<0.05	<0.05	3%
Me-PFOSA-AcOH	0.03	0.02	0.03	0.05	0.11	97%
PFBA	0.06	<0.05	0.06	0.07	0.10	68%
PFBuS	*	<0.04	<0.04	<0.04	<0.04	3%
PFDeA	0.56	0.39	0.54	0.82	1.3	88%
PFDoA	*	<0.05	0.01	0.02	0.04	53%
PFDS	*	<0.01	0.05	0.08	0.13	60%
PFHpA	*	<0.05	<0.05	<0.05	0.07	20%
PFHxA	0.19	0.12	0.17	0.27	0.45	98%
PFHxS	1.3	0.79	1.2	1.8	3.1	100%
PFNA	1.1	0.84	1.1	1.5	2.2	99%
PFOA	1.7	1.2	1.6	2.3	3.1	100%
PFOS	7.5	4.2	7.0	11.5	22.9	100%
PFOSA	*	<0.01	<0.01	<0.01	<0.01	3%
PFUA	0.45	0.31	0.44	0.74	1.1	98%
5:3 FTCA	*	<0.05	<0.05	<0.05	<0.05	2%
6:2 diPAP	*	<0.05	<0.05	<0.05	<0.05	2%
6:2 FTS	*	<0.05	<0.05	<0.05	<0.05	3%
7:3 FTCA	*	<0.05	<0.05	<0.05	<0.05	5%

*This value cannot be calculated because the PFAS was not found in enough people (<65%).

†13 PFAS were not detected in any participants: 4:2 FTS, 6:2 FTCA, 6:2 FTUCA, 8:2 FTCA, 8:2 diPAP, 8:2 PAP, 8:2 FTS, 8:2 FTUCA, 6:6 PFPi, 6:8 PFPi, PFHxPA, PFOPA, PFPeA.

Phenols Measured in Urine

Data are reported in micrograms per liter (µg/L).

California Regional Exposure Study – Region 1 (CARE-LA)

Summary results for levels of phenols in urine (µg/L) from samples collected from 60 female participants in 2018.

Chemical	Geometric mean	25th percentile	50th percentile	75th percentile	90th percentile	Detection Frequency
Benzophenone-3	31.6	7.5	22.3	152	513	95%
Bisphenol A (BPA)	*	<0.1	<0.1	0.76	2.0	47%
Bisphenol F (BPF)	*	<0.2	<0.2	<0.2	0.86	23%
Bisphenol S (BPS)	0.38	0.11	0.34	1.3	2.4	77%
Butyl paraben	*	<0.1	<0.1	<0.1	0.89	17%
Ethyl paraben	*	<0.5	<0.5	3.5	71.4	35%
Methyl paraben	15.7	4.2	12.7	60.1	291	95%
Propyl paraben	2.1	<0.2	2.6	9.3	81.3	67%
Triclocarban	*	<0.1	<0.1	<0.1	0.21	17%
Triclosan	1.7	0.24	0.91	8.3	103	82%

*This value cannot be calculated because the phenol was not found in enough people (<65%).