CALIFORNIA ENVIRONMENTAL CONTAMINANT

BIOMONITORING PROGRAM

(BIOMONITORING CALIFORNIA)

SCIENTIFIC GUIDANCE PANEL MEETING

CONVENED VIA HYBRID FORMAT BY:

OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

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REPORTED BY: BRANDION IORLANO, CA CER NO. 4221

APPEARANCES

Panel members:

Lara Cushing, PhD, MPH,Acting Chair

Timur S. Durrani, MD, MPH, MBA

Oliver Fiehn, PhD(Remote)

Ulrike Luderer, MD, PhD

Thomas McKone, PhD

Amy Padula, PhD, MSc

Penelope (Jenny) Quintana, PhD, MPH

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Kristina (Kris) Thayer, PhD, Director

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Dina Dobraca, MPH, Research Scientist III, Environmental Health Investigations Branch

Nerissa Wu, PhD, MPH, Supervisor, Exposure Assessment Section, Environmental Health Investigations Branch

Toki Fillman, MS, Research Scientist, Environmental Health Investigations Branch Branch

Jeff Wagner, PhD, Chief, Environmental Health Laboratory Branch

Jianwen She, PhD, Chief, Biochemistry Section, Environmental Health Laboratory Branch

Susan Hurley, MPH, Research Scientist III, Exposure Surveillance and Epidemiology Unit, Environmental Health Investigations Branch

Appearances (continued)

Kathleen Attfield, ScD, Supervisor, Exposure Surveillance and Epidemiology Unit, Environmental Health Investigations Branch

GUEST SPEAKERS:

Kim Anderson, PhD, Professor, Department of Environmental and Molecular Toxicology, Oregon State University

Heather Stapleton, PhD, MS, Professor, Division of Environmental Natural Science and Department of Civil and Environmental Engineering, Duke University

Also Present

Asa Bradman, PhD, University of California, Merced

Ahimsa Porter Sumchai, MD, Hunters Point Community Biomonitoring Program

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PROCEEDINGS

DIRECTOR THAYER: Thank you so much. And thank you to the Panel and to the audience for joining us today at this August meeting of the Scientific Guidance Panel for Biomonitoring California, a program more formally known as California Environmental Contaminant Biomonitoring Program.

Yeah. Is this better?

Okay. So I have a few remarks. I'll start off by introducing myself since I am new-ish to OEHHA. And then we'll recap some of the major discussion points from the March meeting. And then we'll move into introducing the Panel member and including introducing a new member. And then I'll pass it off to Lara Cushing, who has graciously agreed to be our acting Chair for this meeting. So my name is Kris Thayer. I started at OEHHA in middle of May of this year. Before that, I worked at the U.S. Environmental Protection Agency in the Office of Research and Development.

I headed a program called the Chemical and Pollutant Assessment Division. This was a program that did, if you've heard about integrated risk information system or IRIS assessments,

provisional peer review, toxicity value. So we did chemical assessments. I was there for eight years. And then prior to that I was 13 years at NIEHS working in a program that was then called the Division of the National Toxicology Program. I used to head up their assessment groups, but I've always had an interest in biomonitoring.

So when there were opportunities, I engaged in that area, including doing some biomonitoring work to explore exposure to cashiers to BPA and BPS and related compounds and receipt paper. At the time there was a lot of interest in organotins as an endocrine disruptor that from animal studies looked like it had a pretty potent adipogenic effect. And we were interested in exploring the extent of exposure in pregnant women. So there was some methods development and then some biomonitoring on organotins.

And then I also kind of worked on trying to partner existing academic cohort studies. The samples collected with the analytical capability of CDC to see we can get more out of those samples to look at things like diabetes, focusing really on some childhood exposures. So it's great to be back in a program that has an explicit Biomonitoring Program.

So it's great to be here. In terms of the last Panel meeting, it was March 25th, 2025. This summary and this grant transcripts are on our website at biomonitoring.ca.gov. Some of the high points. And so there were updates from the Biomonitoring Program.

There were also presentations on per- and polyfluorinated alkyl substances, or PFAS, in drinking water. So some of the key discussion topics. There was presentation about Biomonitoring California analysis of the CARE, California Regional Exposure Study, in the context of looking at differences in metals that were measured in urine and blood, and participants who were living near wildfire affected areas. There was also the topic of looking at data from STEPS, Studying Trends and Exposure in Prenatal Samples, again, in the context of populations that might have been near these wildfire impacted areas.

There was discussion about the importance of evaluating Biomonitoring Program's report that results reports that were delivered to populations that had participated in the studies. Especially in the context of thinking about the messaging with a culturally and language diverse audience.

The Panel also discussed the analytical

findings of PFAS in drinking water. Some of the topics included suggestions for additional analysis of legacy PFAS and diet and water in California how to account for the impact of socioeconomic status when looking at PFAS levels, California activities compared to other states and federal activities with respect to regulating PFAS, and then also the widespread presence of ultra-short chain PFAS, such as trifluoroacetic acid, that have been detected in wells from the Water Board. So again, the summary and transcript of that meeting is posted on the March meeting on biomonitoring.ca.gov.

So now again want to thank Lara Cushing, who will be acting as our chair today. And then before inviting other Panel members to introduce themselves, I'd like to announce Timur Durrani as he was appointed in June to be a new member of the SGP by the Speaker of the Assembly.

So Dr. Timur Durrani is Professor of Clinical Medicine at University of California in San Francisco, serving as Associate Chief of Occupational and Environmental and Climate Medicine. Board certified in Family Medicine, Preventive Medicine, Occupational Medicine and Medical Toxicology. Timur's clinical practice includes providing

outpatient consulting for medical toxicology and caring for acutely poisoned patients.

He's director of the Western States Pediatric Environmental Health Specialty Unit and is faculty of record for Occupational Toxicology at UCSF, teaches medical, nursing and pharmacy students, as well as a variety of graduate students, volunteered his medical expertise internationally and has served in the U.S. Army in Afghanistan. So now I will administer the Oath of Office and ask you to raise your right hand and repeat after me. I, Timur Durrani, do solemnly swear.

PANEL MEMBER DURRANI: I, Timur Durrani, do solemnly swear.

DIRECTOR THAYER: That I will support and defend the Constitution of the United States.

PANEL MEMBER DURRANI: That I will support and defend the Constitution of the United States.

DIRECTOR THAYER: And the Constitution of the State of California.

PANEL MEMBER DURRANI: And the Constitution of the State of California.

DIRECTOR THAYER: Against all enemies foreign and domestic.

PANEL MEMBER DURRANI: Against all enemies foreign and domestic.

DIRECTOR THAYER: That I will bear true faith and allegiance.

PANEL MEMBER DURRANI: That I will bear true faith and allegiance.

DIRECTOR THAYER: To the Constitution of the United States.

PANEL MEMBER DURRANI: To the Constitution of the United States.

DIRECTOR THAYER: And the Constitution of the State of California.

PANEL MEMBER DURRANI: And the Constitution of the State of California.

DIRECTOR THAYER: That I take this obligation freely.

PANEL MEMBER DURRANI: That I take this obligation freely.

DIRECTOR THAYER: Without any mental reservation or purpose of evasion.

PANEL MEMBER DURRANI: Without any mental reservation or purpose of evasion.

DIRECTOR THAYER: And that I will well and faithfully discharge.

PANEL MEMBER DURRANI: And that I will

well and faithfully discharge.

DIRECTOR THAYER: The duties upon which I am about to enter.

PANEL MEMBER DURRANI: The duties upon which I am about to enter.

DIRECTOR THAYER: Thank you. Congratulations and welcome to the Panel. We're delighted to have you.

PANEL MEMBER DURRANI: Thanks.

DIRECTOR THAYER: Okay. I will now invite the Panel members to introduce themselves. We'll start with Panel member Oliver Fiehn, UC Davis who is attending remotely, although I guess I've actually already introduced Oliver.

PANEL MEMBER FIEHN: Yes. So I'm Oliver Fiehn. I'm analytical chemist and toxicologist for many, many years. And I am at UC Davis.

DIRECTOR THAYER: Thank you. And then we'll start at the table starting with Tom.

PANEL MEMBER MCKONE: Hi. I'm Tom McKone. I am a professor emeritus of Environmental Health Sciences at the University of California Berkeley School of Public Health. I'm also a retired affiliate with the Lawrence Berkeley National Laboratory.

DIRECTOR THAYER: Ulrike.

PANEL MEMBER LUDERER: Hello, I'm Ulrike Luderer. I'm a professor in the Department of Environmental and Occupational Health at UC Irvine, and director of the Center for Occupational Environmental Health. I'm an occupational medicine physician and also my research is in the area mainly of reproductive toxicology.

PANEL MEMBER QUINTANA: Hi everybody. I am Penelope Quintana, nickname Jenny, and I'm a professor of environmental health at the School of Public Health at San Diego State University.

ACTING CHAIR CUSHING: Good morning. Lara Cushing, Associate Professor of Environmental Health Sciences at the University of California Los Angeles.

PANEL MEMBER DURRANI: I'm Tamir. You all just met me.

DIRECTOR THAYER: Nice to meet you.

PANEL MEMBER PADULA: I am Amy Padula, associate professor of Obstetrics, Gynecology and Reproductive Sciences at the University of California San Francisco.

DIRECTOR THAYER: Thank you. Thank you again and welcome. Okay, with that, I'll turn it

over to Lara.

ACTING CHAIR CUSHING: Thank you, Kris. So I'll be acting as chair for this meeting and wanted to start by reminding Panel members to please comply as usual with Bagley-Keene Open Meeting requirements, all discussions and deliberations of the Panel about the subject matters at issue today need to be conducted during the meeting, not on breaks or with individual members of the Panel on or offline, including via phone, e-mail, chats, or text message. How's my volume? Is it too much? Okay.

All right. Panel members who are attending remotely must physically appear on camera during the open portion of the meeting. If you're unable to keep your camera on during the meeting because it's technically impractical, please make an announcement when you turn your camera off. Additionally, if someone older than 18 is in the room with Panelists who are attending remotely, you must disclose the presence of that person and their general relationship to you.

Okay. So we'll begin with an update on program activities including results from the BiomSPHERE study. And then in the afternoon we will have presentations from two guests on silicone

wristbands as an exposure assessment tool. And we will have a fair amount of time for discussion on the use of silicone wristbands as a way to complement biomonitoring studies. There will be time for questions from the Panel and the audience after each presentation. If SGP Panel members wish to speak or ask a question, please raise your hand. I'll call on you at the appropriate time and then you can ask your question or provide your comment.

If online webinar attendees have questions or comments during the question periods after each talk, you can -- you can submit them via the Q and A feature of the Zoom webinar or by e-mail to biomonitoring@oehha.ca.gov. We will not use the chat function during this meeting. So put your questions in the Q and A -- please keep your comments brief and focus on the items under discussion. Relevant comments will be read aloud and paraphrased when necessary.

Oliver and other online attendees, if you wish to speak during the public comment periods and discussion sessions, please use the raise hand feature in Zoom and Rebecca will call on you at the appropriate time. If you are attending in person and wish to comment during the public comment periods and

discussion sessions, please come to the front to raise your hand and I'll call on you at the appropriate time.

For the benefit of the transcriber, please clearly identify yourself before providing comment and write your name and affiliation on the sign-in sheet at the back of the room. At the end of the meeting, there will be time for an open public comment. So with that, I'd like to first introduce Nerissa Wu, who leads the Exposure Assessment Section in the Environmental Health Investigations Branch at the California Department of Public Health and is the overall Lead for BioMonitor in California. Nerissa will provide an update on current Program activities.

DR. NERISSA WU: Thank you, Lara, and welcome to all of our Panelists. Special welcome to our new attendees and Panelists. It's great to have your expertise added to our group. I will be giving a Program update and I believe there's a little bit of a lag here. How long is the lag. Should I keep -- should I keep clicking? Okay, thanks. I'm going to be touching on different components of the Program, including our surveillance and community-focused studies, the laboratory work that's been going -- that's been done in this period, and

outreach and communication activities.

So let me talk about where we are with various surveillance studies, including CARE, STEPS, Measuring Analytes in Material Archive Samples, MAMAS, and just a few words about our future surveillance plans. So we have presented in recent meetings on CARE, particularly PFAS and drinking water and food as, as we heard from our summary. Emily Pennoyer, who just presented at our last meeting on this -- these associations has just published her manuscript in Environmental Science and Technology and Toki Fillman who also presented her work on CARE participants and drinking water associations has just had her manuscript accepted at the Exposure Science and Environmental Epi Journal. So that will be coming out in the next few weeks and we're very excited about that.

(Inaudible) oh, there we go. We now also have additional data for speciated arsenic and phenols for CARE-LA. So initially in 2018 only a subset of samples collected were analyzed for speciated arsenic and phenols. But the Environmental Health Lab has provided us with results for the remaining samples. So we have gotten the results returned to participants. You can see our staff

packing up those packets right there. And we've weighted the data to the underlying population and that data should be up on the web in the next week or so. And we are diving into the data. So why are we doing this? Well, arsenic is a chemical of concern, of course, and in both CARE-LA and CARE Region 2, the numbers for total arsenic were found to be higher than the national numbers.

We know that organic and inorganic arsenic are generally coming from different exposure sources with organic arsenic, primarily coming from seafood and inorganic arsenic coming from contaminated groundwater, industrial processes, pesticides, rice, and other sources. And inorganic arsenic is more of a concern with regard to health impacts. Through our Program's protocol, we've historically identified participants for individual follow-up who have a total arsenic level that hits a certain threshold, these Levels of Concern threshold. We then speciate the arsenic for those participants only so that we can compare their inorganic levels to our level of concern and then work with the participants who meet that threshold to identify exposure sources and recommend ways to reduce exposure.

So for that subgroup of people with the elevated arsenic levels, we have a lot of data on their inorganic levels and also the ratio between inorganic and organic arsenic. But it's not data that we can extrapolate to the general population because it's an unusual group. So we really wanted population level data to help us understand what the impacts of arsenic exposure are on the general population and to help us identify if there are populations that are disproportionately impacted. We also hope that this data will be helpful information for the Water Boards as they investigate technological and economic feasibility of lowering the MCLs.

So as part of CARE-LA, we measured urinary metals in 428 participants, including total arsenic. Of those, 106 met the threshold to have their arsenic speciated, and those results went back to participants in 2019. So round two, we looked at the remaining 322 samples, excluding 14 participants who did not consent to have additional analyses run. So that gives us 414 participants and only 412 are included up here because two of those didn't have a detectable creatinine. So their creatinine adjusted data couldn't be included.

Of the many arsenic species, our method quantifies six, so Arsenic (III) and Arsenic(V), MMA, DMA, arsenobetaine and arsenocholine. And it's those first four species that are summed as the inorganic related species. And I just want to point out that MMA and dimethyl -- and DMA are summed with the inorganic related species because we conservatively assume that they're biomarkers of exposure to inorganic arsenic.

So this table presents the weighted detection frequencies and geometric means both for individual species and the sums. And then we compare these statistics to the national numbers from the 17-18 NHANES cycle. And just a couple things to note on this table, our lab's limits of detection, our LODs, are lower than the NHANES LOD. So first of all, kudos to the lab. It's really great to be able to have that low LOD. So we have really a nice complete data set to look at the population. We've censored the data based on the NHANES LOD, so we can compare between the populations. And you can see that Los Angeles had higher detection frequencies for all of the species and the sums of those species compared to the national numbers.

We've also compared the geometric means,

and both for the sum of inorganic related species and for DMA individually, Los Angeles had statistically higher geometric means compared with those national numbers. There have been studies in the past, both in California and the U.S., that have shown a sociodemographic and geographic inequity in drinking water, arsenic concentrations and MCL violations. So we'll be looking at demographic patterns in our data. We'll also be using our questionnaire data to look at potential exposure sources. And just a reminder, in our questionnaire to CARE participants, we asked about diet, drinking, water source, occupation, hobbies, smoking habits, et cetera.

We're also interested in identifying opportunities for health education or intervention to reduce exposures. And we're also really interested in identifying partners, invested parties, who might want to work with us on both the work we're doing and also messaging it out. So we look forward to hearing input from this group with respect to recommended next steps for analyses, but also partners we might reach out to. Also, we will be getting data from CARE-2 speciated arsenic later this year. So we'll have more power for these analyses.

For phenols, briefly, we've been

measuring phenols in Biomonitoring California studies since 2010, and our method does include Bisphenol A and two of the analogs, which are used as substitutes, Benzophenone-3, three or 4 parabens, which are used as preservatives, and triclosan and triclocarban, which historically have been used in antibacterial soaps. And these are all of a concern because of their endocrine-disrupting properties. So in CARE-LA, we had 428, again starting with that, but we were only able to measure phenols in 60 participants initially. And we wanted to analyze all the samples again so that we could have population data. And we were able to analyze 346 additional samples for a total of 406.

So this table presents weighted detection frequencies and geometric means for CARE-LA. Four analytes had detection frequencies over 75 percent. So Benzophenone-3, BPA, BPS and methyl paraben were all in a majority of participants. Both of the antibacterial agents, triclocarban and triclosan, had very low detection frequencies, 38 and 16 percent. Maybe not surprising, both were banned from soaps in 2016. And these are samples collected in 2018. We could not finalize data for butylparaben in round two. And so we did not have enough results and it

wasn't representative sampling, so we dropped butylparaben, unfortunately from this weighted sample.

The LODs, the limits of detection, were different between EHL and NHANES. So -- and some were higher for our labs, some were higher for NHANES. So we censored the data to whichever LOD was higher so that we can compare between these populations. And detection frequencies were generally lower in Los Angeles compared to national numbers with the exceptions of Benzophenone-3, that one exception.

In a comparison of geometric means between Los Angeles and national numbers, Benzophenone-3 was significantly higher in Los Angeles, as was bisphenol S, and then methyl paraben and BPA were significantly lower. So, you know, still thinking about what the significance and what source might be of these differences. We did see elevated BP3 levels in the FOX study. And this is a UV stabilizer used as an ingredient in sunscreens. And at the time we hypothesized that this was due to, it was in a southern California climate, people were wearing more sunscreen. As far as BPA goes, BPA was added to Prop 65 in 2015. So maybe there's a

difference in product formulation or utilization by state, something we'll continue to watch.

And we'll continue exploring the data. We'll be looking at distributions in the population, which we hope will be helpful to groups like the Safer Consumer Products Program as they consider alternatives for parabens. There's also Senate Bill 1226, which will ban bisphenols in juvenile products like teething rings starting in 2026. So we're always thinking about how our data might be used to look at what impact those legislation have.

We do have exposure questionnaires, but unfortunately the part of the questionnaire that focused on very recent exposures did not center around phenols until CARE-2. But we are hoping to have CARE-2 phenols data in the next year and then we will be able to explore those exposure sources further.

So moving on from CARE, we also have the STEPS study, which will look at PFAS levels among pregnant Californians over time in three counties. The lab has conducted analysis in all of the Orange County samples from 2015 to 2021. They're now completing QA on all that data and we hope to have that later this year. They're also making a lot of

progress. More than half of the Fresno samples have been run. And we are waiting for the 2024 birth records for Los Angeles County so that we can select the samples from LA County that fit our eligibility criteria.

And STEPS was built on the success of the MAMAS study, which demonstrated the utility of Biobank samples. And MAMAS data analysis, which you heard a little bit about last summer, was just presented in two different presentations at the ISES-ISEE conference, as part of the poster: "Trends of PFASs and Persistent Organic Pollutants and Pregnant Californians" by Dina Dobraca and persistent organic pollutant levels in Californians shouldn't hexachlorobenzene be Decreasing?" That was presented by Ian Tang.

There is still a lot of analysis to be done with CARE, MAMAS and STEPS data, but we're also in the early stages of designing our next surveillance efforts, which we hope will involve field collection of samples. So of course the big goal is to develop a methodology that can be sustained into the future to generate the kind of reliable generalizable data that we can use to look at trends. But there are always choices to make

since we can't cover everything we would like to.

So we're thinking about what analytes to prioritize. Are there particular subpopulations to prioritize? Where in California should we be focused because we just can't get to the entire state all at once? And while we ponder these questions, we're also thinking about ways to make our lab methods and our field work more efficient.

So one of the things we're doing is evaluating these micro-sampling devices, which would be less expensive and less invasive and give us much more flexibility in the field. And they basically clip onto your arm. You can see a picture here of it clipped on and it collects 4-500 microliters of blood. You can also use serum separator tubes and spin that down for a serum sample. You can see how happy I am to have collected 500 microliters of my blood here. So that's something we're really looking at because it would really change our field work.

So I just want to shift a little bit to now provide some updates on four of our community focused studies. And I'm starting to go faster because I know my time's running out. So our work has largely been focused on getting results and program findings out in BiomSPHERE. The team has

completed returning biomonitoring results, most recently for urinary metabolites of PAHs and VOCs. You'll be hearing about that from Aalekhya in just a minute.

We also have an evaluation of results return materials for BiomSPHERE, which you heard a little bit about last November. And that's ongoing including assessing participant experiences with Silent Spring's electronic results return platform. So that's a really exciting development for the Program.

FRESSCA, the team has also completed running -- returning biomonitoring results, which included metabolites of PAHs, VOCs and metals. And the team also just held a community meeting in July, which was very well attended.

For the Asian/Pacific Islander Community Exposures, or ACE, Project, you heard recently about the associations between seafood consumption and serum PFASs levels. Kelly Chen has submitted her manuscript for publication. It's in review and we expect to have that out in press in the fall as well.

For SAPEP, we have submitted a short communication to a journal for review highlighting the PAH and VOC findings, particularly the high

levels of naphthalene that were measured in SAPEP. And as we release these publications, we're also thinking about how to disseminate findings to a wider audience. So there's a lot of social media, fact sheets, lay audience-friendly ways of getting information out that are also in production.

So quickly on the lab side, I've already mentioned the progress that the labs are making, analyzing samples collected for various studies. This is just a summary of the progress ECL has made on STEPS. We're also continuing to explore different PFASs. We're about to send aliquots off as part of our pilot study to have ultra-short PFASs measured and everyone is very curious to see how that's going to go. The lab is also about to demonstrate their new serum methods, cyclosiloxanes and PAHs, which will help us understand impacts of personal care products, wildfires and other exposure sources.

Over in the Environmental Health Lab, staff continue to provide data on the CARE study. We've talked about arsenic and phenols data that have been reported. They've now moved on to CARE-2 and we'll have that data out in the next year. They are also working on non-targeted screening to improve targeted methods and potentially identify additional

chemicals of concern. So for example, they're working to identify new biomarkers of PAH exposure, particularly for naphthalene and phenanthrene. And they're exploring the use of AI in non-targeted screening to enhance staff efforts to identify chemicals.

We've talked about non-targeted screening here before. It has this huge potential to help expand our universe of chemicals that we can identify and quantify, but it's super data intensive. So making this process more efficient would be extremely helpful.

And as I alluded to, with all the findings coming out of the Program, our communications team is working on different ways to broadcast the message. We've been developing fact sheets that are devoted to summarize scientific publications. Staff are working on social media campaigns. And this is not the updated slide because we actually just got social media out on PFASs yesterday, which is very exciting. And we have some short videos in production that will also be posted online.

Can't get any of it done without this extraordinary team. So thank you to all of you and I

will now pause for questions.

ACTING CHAIR CUSHING: Thanks Nerissa for that great update. So we'll now invite short clarifying questions to start either from Panel members or the audience. Please hold the more substantive questions for the open discussion period that we'll have shortly. But are there any questions, clarifying questions, at this point? Yeah, Tom.

PANEL MEMBER MCKONE: Yes on the slides on arsenic comparing CARE, I guess or yeah, the CARE study to NHANES. I think you mentioned a little later there was one where you next one.

DR. NERISSA WU: Was it detection frequency or geometric mean.

PANEL MEMBER MCKONE: The ones where with the arrow showing that two -- there. So those are significantly higher, right? Inorganic species in CARE. I think you mentioned it, but I -- is there some operating ideas about why it's higher in CARE-LA.

DR. NERISSA WU: I am going to call on Toki Fillman who's the analyst doing this work. I don't know if you've an answer.

PANEL MEMBER MCKONE: And if this is a

lengthy discussion, we can hold it.

TOKI FILLMAN: Thank you for this question. So I don't think we have to know -- we don't know the exact reasons why, but of course it could be due to some of the major exposure sources for inorganic arsenic, which include diets such as rice consumption or drinking water. As we know, in California, we have higher a proportion of the population who are Asian or Hispanic, which may -- are known to eat more rice.

And also in terms of drinking water, there have been some recent studies that have shown that drink -- public water system drinking water in the southwest states, which include California, also Arizona and Nevada, can have higher drinking water arsenic concentrations as well. So it may be due to these exposure sources, but we do look forward to exploring this data further to get some better ideas about this.

PANEL MEMBER QUINTANA: Hi, Jenny Quintana. Just a clarifying question on the next slide, I think. So you're talking about arsenic, this little blue box on the right hand side at the bottom.

TOKI FILLMAN: Yes.

PANEL MEMBER QUINTANA: About other things you're exploring. And you mentioned smoking at the end. I'm just curious if your questions also ask about secondhand smoke because tobacco smoke is a source of arsenic and other metals.

DR. NERISSA WU: I don't remember. Do you guys remember?

AUDIENCE: It does.

DR. NERISSA WU: It does.

PANEL MEMBER QUINTANA: Okay, great. Thank you.

DR. NERISSA WU: These are -- none of these are questions for me, I guess, but yes, we ask about secondhand smoke.

ACTING CHAIR CUSHING: Rebecca, have there been any questions on the Zoom Q and A? Where is Rebecca.

REBECCA BELLOSO: We have not received any questions from online.

ACTING CHAIR CUSHING: Okay. So why don't we go ahead and move into the open discussion period for more substantive questions and comments. We have 15 minutes for this.

PANEL MEMBER QUINTANA: I have a question, which is maybe getting into a bit of a

different topic, but I mean, obviously some of the -- many of the chemicals that you've -- that talked about today have to do with, you know, are in plastics, found in plastics. And there's also, I think, recently just been a lot of awareness of microplastics and nanoplastics. And I was wondering if that is something that you are thinking about as a Program. It's a little bit off a -- on a tangent, but I'm curious.

DR. NERISSA WU: It is definitely a topic that gets raised to us all the time. And maybe you remember in 2023, we did a round of Program evaluation interviews and microplastics came up from most of the interviewees. We're actually starting a new round of that and I expect microplastics to come up again. It's obviously super important, the methods -- we're following the methods.

If Jeff Wagner's online, maybe he could speak to this a little bit, but there are a number of different methods that are being used in fish tissue and some -- and human. There been a number of papers coming out on human tissue, but I don't know that we have a method that we could use on a large scale yet for biomonitoring. But yeah, it's obviously something super important for us to keep in mind.

(Inaudible). And we have a lot of plasticizer-type chemicals and we'll continue to measure those.

STEPHANIE JARMUL: This is Stephanie Jarmul, just a quick reminder to please identify yourself when you're providing public comment.

REBECCA BELLOSO: Oh, and Jeff is actually online if he wants to weigh in.

ACTING CHAIR CUSHING: Yes, Jeff. Please unmute.

DR. JEFF WAGNER: Yeah, thank you. This is Jeff Wagner. Yeah, following up on Nerissa's comments. I agree. The issue -- some of the issue -- analytical issues with microplastics include you've got a number of polymers at minimum, say, most studies look at maybe six different polymers up to maybe 20 different polymers. And then like Nerissa mentioned, there's all the plasticizers and flame retardants that are associated with them.

So you've actually -- and then if you throw in particle size, which is I think a very key aspect of even defining what your analyte is, whether you're talking about five millimeters, five micrometers, or five nanometers you've got a pretty complex matrix of analytes. And then you add to that what the target organs are and what you would expect

them to be and whether or not they would show up in traditional matrices like blood or urine. So yeah, it's complicated.

DIRECTOR THAYER: Hi, this is Kris Thayer. And also microplastics are on OEHHA's radar, so we're monitoring the exposure space as well as thinking about sort of health outcome comparison. I do have a quick question. When you were talking about the micro-samplers, which are very exciting, do you have like a range of how many chemicals that use sort of a blood-based matrix you might be able to get from a micro-sample.

DR. NERISSA WU: Well, the limit is probably -- I mean, we can get whole blood or serum. So anything that we're looking for in a traditional blood or serum sample, we could look at. The limiting factor will be our volume because with a 400 microliter sample, about 200 is of serum. So we might be only able to do -- run one Panel on that.

Right now, our focus has been PFASs in our most recent studies, but especially with the hexachlorobenzene work that Ian's been doing, I mean, the thought of not measuring our legacy pollutants to track trends in there, that's a loss as well.

So this is the kind of -- there are all

these considerations we need to look at as we plan our study. And I'll say that the Micros-samplers appeal to us, it -- the logistics of getting into the field and handling so many participants and gathering their samples, it's just very difficult logistically.

So if something where we could use a micro-sampler without phlebotomy really opens up a lot of possibilities for us. And can I say one more thing about microplastics? We also have to keep in mind our designated list, what we are enabled to measure in a biomonitoring study.

ACTING CHAIR CUSHING: I also just wanted to follow up on the these micro-samplers. I was also wondering which study populations you're employing them in. And then also if you're looking for additional study populations where that could be expanded. And also if you have a sense of the cost yet per sampler. I mean, of course the analysis is a whole other story, but --

DR. NERISSA WU: Well, we are not using them in a study just yet. We would -- we're -- our lab is actually looking at them and screening them for PFASs and metals. There is a metal blade that kind of sticks into the arm. And so we have to make sure that it's not contaminating our samples before

we use them for anything.

We'll then use them as part of our pilot study so we can do venipuncture versus micros-samplers and see if there are differences. And we're also assessing the usability. How long does it take? Are they acceptable by participants, et cetera. So it's a little ways down the road. We're eyeing them for our surveillance in the future.

Again, the big payoff is when we have to do many of these samples and need to have people out in the field. But I think there's a huge application for like emergency response. So if we can get these approved by our labs for use for say, metals, and there's a fire where we want to assess blood metals, then we -- somebody else could use these.

Maybe not Biomonitoring California, but we other -- have other environmental health investigations teams that do go in after emergency responses. And we ourselves have worked with firefighters to capture samples after a response. And this would just enable a much easier field presence. There was a lot of talk at ISES about them. I don't know if Ian, you have anything to add to the use of micros-samplers by other researchers? Sorry to put you on the spot, but --

DR. IAN TANG: Ian Tang, Biomonitoring California. Yes. There's a -- there are fair amounts of researchers now using these micros-samplers or at least testing them. They've mostly been used to look at antibodies or proteins and things like that. So not really looking, excuse me, at chemical exposure. Some people that I've talked to, they've been successful. Others, they've said they've had issues, especially with populations such as young kids. It's supposed to be painless. But I've heard that they've been running into issues as well.

ACTING CHAIR CUSHING: Thanks.

Jenny, did you have a comment?

PANEL MEMBER QUINTANA: Hi Jenny Quintana, I want to talk or ask you about your results return. The more I've been involved with this Program, the more impressed I am with how pioneering California biomonitoring has been in returning complex chemicals to communities. And I think you're really leading the way here. And I'm curious if -- how much evaluation do you do. Do you routinely do evaluation on your results returns? And are you thinking of publishing kind of like best practices from all your years of experience? Or

maybe you haven't, I'm sorry if I missed that, but thank you.

DR. NERISSA WU: We have done a number of results return evaluation rounds. I wouldn't say it's routine because there's always sort of a different angle on it. So for example, for CARE, we sent out a postcard with a results return -- whoops, packet. And we asked participants to be part of a -- as -- of an interview afterwards and collected their information. We've done pre-results return evaluation, both with staff and community members. If there's a particular community we're trying to reach and want to make sure that our language are culturally and linguistically appropriate.

For this round, Rebecca presented on last November, this is in the BiomSPHERE community. So again, a particular community that we want to be cognizant of the language we use and if our materials are appropriately accessible. So we are gathering a lot of information. There's been a lot of work done with UC Merced and CCAC, the California Asthma Coalition, working with those participants to get their feedback and we're always trying to make them better.

I mean, it's really complicated

information to get into just the right language. One of the things we're really excited about is the electronic platform, which we're assessing both from a staff perspective. The results are very staff-intensive to get the packets out, the way they look, to make sure they're error free. But also to make sure participants can access them. We've heard back from a lot of people that the thick packet of papers that you have to thumb through to find your results is actually kind of hard to get through, that people are not really used to getting so much data in that way.

So an electric platform where you can kind of dig down through links might be more accessible, but it's something we want to collect more data on. Silent Spring has done a lot of their own assessment, which we -- which we follow their example. And they do excellent work, but we want to try this out with a California population as well.

STEPHANIE JARMUL: And then just to add, this is Stephanie Jarmul. We have actually already even started implementing some incremental changes to our materials such as trying to reduce some of the amount of text. Even though as scientists, I think we want to reiterate all the facts multiple times.

We started introducing more graphics into our materials and I guess we haven't really shown them to the Panel yet.

So that's something that maybe we can do at our next meeting just to showcase some of the things that we've been working on across CDPH and at OEHHA.

DR. NERISSA WU: We have published a couple of articles on results return generally, and actually through National biomonitoring Network, we gave an extensive workshop on results return and evaluation.

PANEL MEMBER QUINTANA: Thank you.

STEPHANIE JARMUL: We do have a comment from a participant, Dr. Sumchai if you wanted to unmute and ask your comment, your question.

DR. AHIMSA PORTER SUMCHAI: Good morning. My name is Dr. Ahimsa Porter Sumchai. I'm the principal investigator, founder of the Hunters Point Community Biomonitoring Program. I have a comment about the role of arsenic detections in human biomonitoring and the impact of geospatial mapping and detecting other chemicals in aggregate, how that impacts interpretation of the significance of an arsenic exposure, even if you don't know whether it

is speciated to be inorganic versus organic.

One of our early mappings, I call the South Basin Cluster and that's where we were detecting the same four chemicals in people living and working in an industrialized region adjacent to a system of federal Superfund sites in South San Francisco. The South Basin Cluster consisted of manganese and vanadium, which we were detecting early on almost a hundred percent of the time, and then arsenic and gadolinium. And we are not able to speciate the arsenic. We can send people we've tested to the San Francisco General Hospital. But it's a very, very lengthy and cumbersome process for them.

But with our geospatial mapping by just putting a pinhead with an assigned color. And for the arsenic, it was red, along with blue for gadolinium, yellow for manganese and white for vanadium. In a map of this region called South Central Bayview, we were able to detect neighbors. We had three neighbors who had four of the chemicals or three of the chemicals. And unlike what you're doing, we only map detections that are above allowable levels so that the significance is baked in when we're mapping these detections.

We also had an unusual detection of two sisters in the same household who had all four chemicals detected above referenced range. And the older sister, a registered nurse who'd been in the house longer, had higher concentrations of the same for chemicals.

So I'm -- you know, just offering that in addition to speciating -- you know, arsenic when it's detected in high concentrations, looking at the pattern of its association, you know, with other toxic chemicals. Vanadium is on the Proposition 65 list. And manganese, we have, you know, a detection frequency that, you know, has approached a hundred percent. And shipyard soils have a detection frequency a hundred percent. And shipyard ear monitoring detects manganese in concentrations that exceed the World Health Organization's limits for safe human exposure. Thank you so much.

ACTING CHAIR CUSHING: Thank you, Dr. Sumchai.

Are there any other public comments in person or via the web?

REBECCA BELLOSO: We do not have any additional comments online.

ACTING CHAIR CUSHING: Any other comments

from the Panel members? Oops. All right. Then I think we can wrap up this section just a little bit early and move on to the next agenda item. We will be hearing from Aalekhya Reddam next. She is Research Scientist in the Safer Alternatives Assessment and Biomonitoring Section at OEHHA and will give a presentation on preliminary findings from the BiomSPHERE study.

DR. AALEKHYA REDDAM: Thank you. Is this okay volume-wise? Perfect. Good morning everyone. So today I will be presenting some of our preliminary work on our study titled the Biomonitoring component of the San Joaquin Valley Pollution Health Environmental Research Study, or BiomSPHERE.

As many of you know, the San Joaquin Valley is heavily burdened by high levels of air pollution and it contains four AB617 communities. And those are the yellow dots that we see on the map. And these are communities that are selected by the California Air Resource Board, or CARB, as being disproportionately impacted by pollution. I should also mention that there are many other communities that are impacted by air pollution in the Central Valley that have not yet been designated under AB617.

Several of our recent community

biomonitoring studies have attempted to characterize exposure to air pollutants in this area. So these projects are the Stockton Air Pollution Exposure Project, or SAPEP, FRESSCA-Murejes, and BiomSPHERE, which is the study that I will be talking about today. Researchers from UC Merced, and Berkeley received funding from CARB to initiate the San Joaquin Valley Pollution and Health Environmental Research study, or SPHERE. And the goal of the study was to assess exposures to air pollutants and noise among families that live in Fresno and Stockton.

BiomSPHERE added an additional biomonitoring component to this project, and its goals were similar. First, we really wanted to evaluate the air pollution exposures in families, but by analyzing urine samples for biomarkers of air pollution. And then we also wanted to examine differences in exposures between individuals -- within individuals, over time and across the two different communities in Stockton and Fresno.

And lastly, as I mentioned before, we had a few studies in the San Joaquin Valley and BiomSPHERE is providing additional comparative data to those studies. For BiomSPHERE, we recruited 64 families, and these included a parent or

grandparent-child pair. The participants either spoke English or Spanish and the majority were non-smoking. We had 12 households in Stockton and 52 in Fresno. And the study activities mainly occurred between February to November of 2023.

For the participant demographics, our adults were on average 42 years old and the range was between 28 to 66 years old. And our children were on average nine years old with a range of three to 13 years old. Most of our adults were female, although our children were more evenly split. And while a majority being female adults is common when recruiting parent-child pairs, moving forward, we really hope to more intentionally recruit more adult males.

For race/ethnicity, our participants were mostly Hispanic/Latino. For household income, more than 50 percent of our participants had a household income of less than $30,000. And a majority of our participants rented their homes.

As I mentioned before, the goal of our project was to assess exposure to air pollutants. Two major class of air pollutants are polycyclic aromatic hydrocarbons, or PAHs, and volatile organic compounds, or VOCs. And these are both known to be

major components of indoor and outdoor air pollution. Exposure to these chemicals have known to cause cancer, as well as respiratory and cardio health effects -- cardiovascular health effects among others. And here in the slide, we have a few potential sources of PAHs and VOCs.

And as we can see, there are a lot of overlapping sources. Both PAHs and VOCs are formed when materials such as tobacco or fuel, such as gasoline and oil are burned. And they're also known to be in consumer products such as paints, cleaning products, and air fresheners. PAHs can also be formed when food is grilled, barbecued, smoked, fried, or roasted. And some VOCs are also tied to gas appliance use. So today I will be talking about the air and biomonitoring results of our PAHs and VOCs in BiomSPHERE.

In our study, air monitoring was conducted for 24 hours. We collected one indoor and one outdoor sample at each home. In the picture on the right, the arrows are pointing towards the different air monitors that we use to collect air concentrations for a range of air pollutants. We measured 36 PAHs. We also measured criteria air pollutants such as PM 2.5, ozone, NO2 and carbon

monoxide. And Kimberly valle actually presented on these criteria air pollutants at our November 2024 SGP.

We also measured black carbon and we tried to measure VOCs. However, there were some -- there were some issues with the overssaturation of sorbent tubes and therefore we were only able to collect VOCs in a small subset of our population. So today I will be focusing on PAHs in this presentation and we'll focus on the four that overlapped with urinary metabolites or the metabolites that we can measure in urine. And these were naphthalene, fluorene, phenanthrene and pyrene.

For our biomonitoring samples, participants were asked to provide the first morning void the day after the air monitoring started. So this was designed to characterize exposure to air pollutants during the same time period that the air monitoring equipment was at the residence.

For a subset of our -- for population, which was eight families, daily samples were collected over four consecutive days. And in the urine samples we measured metabolites of PAHs, VOCs. We also measured biomarkers of oxidative stress and inflammation, and also cotinine, which is a

metabolite of nicotine, to account for any potential smoke exposure or tobacco-related exposure.

Now moving on to the data analysis that we did. For the air monitoring data analysis, if there were values that were below the limit of detection, or LOD, they were imputed by LOD divided by squared root of two. We also calculated the indoor and outdoor ratio for air samples when there was at least one indoor or outdoor sample that was detected in a household. And if a detected sample didn't have a corresponding pair, so for example, if we had an indoor sample that was detected and it didn't have a corresponding outdoor sample, we use imputed values. And then we used univariate linear models to examine associations between the PAHs in air and their respective metabolites in urine.

For our biomonitoring data analysis, similarly, the values below LOD were imputed. We used creatinine adjusted values when comparing our concentrations to NHANES just to keep it consistent with what NHANES does. But for our data analysis, we chose to use specific gravity adjusted values. And this is because specific gravity is a direct measure of dilution and is shown to be better, especially for children's samples.

We also log transformed the values for normality. And then since eight families gave multiple urine samples in those families, we selected the one that was closest to the air monitoring and then used linear models to -- and then we used linear models to examine associations between the biomarkers of exposure and questionnaire data.

So we will first talk about the PAH results. Before I talk about PAHs in air, I would specifically like to acknowledge Marley Zalay from UC Berkeley for all her work on the air data analysis. It was an immense amount of work. So truly, thank you so much to Marley. As I mentioned before, we measured PAH in both indoor and outdoor air at each home. And in this table we have the sample size and detection frequencies for both indoor air on top and outdoor air below. And the Ns represent the sample that had a valid detection.

Pyrene unfortunately had fewer quantifiable samples compared to the other PAHs due to an instrument error. And that's why we have a lower sample size for pyrene. When looking at the detection frequencies of the PAHs in air, we see that naphthalene is the most frequently detected PAH. And this is consistent with what we see in other studies.

And then when we calculated the indoor/outdoor ratio here, the Ns represent the total number of matched pairs that were used to calculate this ratio. And we see something similar where naphthalene had the highest indoor to outdoor ratio, suggesting that the indoor concentrations are higher than the outdoor concentrations for naphthalene.

For our PAH metabolites in urine, we measured nine PAH metabolites for fluorene, naphthalene, phenanthrene and pyrene. In this table we have the detection frequency as well as the medians for adults and children separately. Only 2-hydroxynaphthalene, or 2-naphthol, as I'll be referring to it from now on, was detected in all the samples in both children and adults.

We also had high detection rates for 2-hydroxy fluorene, 1-hydroxyphenanthrene and 1-hydroxypyrene. And for the most part we see that children had lower or similar levels of PAHs to their adults. For our data analysis, we only selected metabolites with detection frequency of 65 percent and above, which is similar to what the Program has done as Nerissa also mentioned. And those are the ones that we have highlighted here on this slide.

We then compared the PAH metabolites in

BiomSPHERE to NHANES. So in each of these graphs, we have the geometric means and the 95 percent conference intervals. The dark blue represents the BiomSPHERE concentrations and the light blue represents the NHANES concentrations. And we have a pair of graphs for adults and children except for 3- and 4-hydroxyphenanthrene because there were low detection frequencies in adults.

We compared our BiomSPHERE adults to the 20 years and older population in NHANES and then compared our BiomSPHERE children to the children's -- children age six to 11 years in NHANES just because that was the closest age range to our BiomSPHERE children. And overall in these graphs we see that most of the geometric means of the PAHs for adults and children in BiomSPHERE are lower than those of NHANES, that is other than 2-naphthol, where the concentrations are significantly higher in BiomSPHERE compared to NHANES in both adults and children. So we have much higher levels of 2-naphthol in our population.

As you might remember, we had a similar finding in SAPEP, which was in 2021. So I've put the values of NHANES, SAPEP, and BiomSPHERE in this graph to show the difference of the geometric means. In

SAPEP, we only recruited children and 1- and 2-naphthol were measured together. So we did the same comparison with children from NHANES and BiomSPHERE.

And once again, in this graph, the light blue bar is NHANES. The dark blue bar are the BiomSPHERE concentrations, and the green bar is SAPEP. And really what we see is that SAPEP and BiomSPHERE are significantly higher than NHANES levels. SAPEP, while is higher than BiomSPHERE, it's not a significant difference, but both are significantly higher than what we see in NHANES.

We then looked at correlations between PAH metabolites and adults compared to children in BiomSPHERE. Each of these graphs show the correlations between the log transformed metabolites in children, which are on the X-axis and adults on the Y-axis and r in each of these graphs are the Pearson correlation coefficients. And what we see is that out of all the PAH metabolites, only two levels of 2-naphthol were strongly correlated between adults and children. And this we think is suggesting a common exposure source. And therefore we think that exposures are likely either happening at home or common activities rather than school or at work.

We then examined the repeatability of PAHs in urine, and we used intraclass correlation coefficients for these. As a reminder, we had families that gave urine samples for multiple consecutive days. We had seven families that gave samples for four days, and one family that gave urine sample for three days leading to a total sample size of 31 for the multiple samples.

And in this table, the different colors represent the interpretation of the different interclass correlation coefficients that are seen in the lower table and the light green and the dark green represent good and excellent repeatability, respectively. So those are the ones that we'll really be focusing on.

What we see is that 2-naphthol had excellent repeatability and 2-hydroxyfluorene and 1-hydroxyphenanthrene had good repeatability in adults. And 2-naphthol was the only metabolite that had good repeatability in children. So this really suggests that there is relatively consistent exposure for fluorene and pyrene in our adult participants and naphthalene in both our adult and child participants.

We then looked at associations between PAHs and indoor air and their respective metabolites.

So since the detection frequencies were lower than 65 percent for all of our PAHs in air, we looked to see if the concentration of the metabolites were significantly different between participants that had any detections in their indoor air or not.

So in these graphs we see the concentration of metabolites, and that's on the Y-axis. And the white dots here represent households that didn't have any PAHs detected in there, so they were not detected. But the green dots represent PAHs -- households that had PAHs detected in air. And the black bars are the geometric means. And really what we see was that there were no significant differences between the PAH metabolites in participants that had PAHs detected in air or not.

And we also didn't see any positive associations between PAHs metabolites, and ones detected in outdoor air suggesting that neither indoor nor outdoor air are significant contributor to the metabolite levels.

BiomSPHERE study also had two questionnaires. There was one that was below -- before the air sampling data and one that was after the air sampling data. So the post-sampling questionnaire was used for demographic and housing

variables and the post sampling questionnaire asked questions about habit and product use over the past two days. We had a wide range of -- range of questions in both the questionnaires, and these are the ones that we focused on for our analysis.

For the pre-sampling questionnaire, we asked questions about race/ethnicity, sex, household income, home ownership, the presence of an attached garage and the city of residence. And for our post-sampling questionnaires, we selected questions on cleaning product, air freshener, gas stove, and personal care product use, as well as grilled food consumption.

Among the pre-sampling questionnaire data, there were only significant associations with 2-naphthol. We assigned race/ethnicity to the child based on the parents' race/ethnicity, and as a reminder, we had a much higher proportion of Hispanic/Latino participants. So due to the low sample size across the different multiple ethnicities, we binned race/ethnicity into either Hispanic/Latino or not Hispanic/Latino. And if a participant was multiracial and selected Hispanic/Latino as one of their races, they were also included into that Hispanic/Latino category. We see

that in both adults and children, geometric means were approximately three times higher in our Hispanic/Latino participants compared to our non-Hispanic/Latino participants.

And then as a reminder, one of our aims was also to examine the differences between levels within Stockton and Fresno. And what we saw was after adjusting for race/ethnicity, there were no significant differences in PAH levels between Stockton and Fresno. But also as a reminder, we had a much smaller size in Stockton, we had an N of 12 versus in Fresno we had an N of 52.

As our Hispanic/Latino participants had higher levels compared to our non-Hispanic/Latino participants, we wanted to see if there was a similar trend in NHANES. So in these graphs, the adults are on the left and the children are on the right, and we see similar trends for both of the populations. And although we see that the levels are significantly higher in our Hispanic participants -- in Hispanic participants compared to the non-Hispanic participants at NHANES, the magnitude is just so much higher in BiomSPHERE than it is NHANES suggesting that there are probably multiple factors that are contributing to the high levels of 2-naphthol in our

population.

Furthermore, although we have a small sample size of Black participants in BiomSPHERE, we also see that they have high levels compared to our White participants. And this is similar to what we see in NHANES, but because our sample size is so small, we can't draw any concrete conclusions. But we really just wanted to highlight it and highlight the need for additional research to explore this finding further.

We then ran associations with variables from our post-questionnaire data. So as we saw significant differences in race/ethnicity, we adjusted for it in our models and we saw significant positive associations with 2-naphthol and product use. So in this table here we have the product that had significant associations and the percent of participants in BiomSPHERE that had used these products. And in both adults and children, we see significant positive associations with the use of household cleaners, air fresheners, and some personal care products and urinary 2-nap levels.

In adults, we see that the use of plug in air fresheners is associated with almost a four times higher increase of 2-naphthol in. Then we also see

two times higher concentrations on 2-naphthol and adults that use all purpose spray perfume and any types of air fresheners. In children we also see the plug in air fresheners had the highest effect size onto naphthol levels around three times higher, and then also approximately two times higher levels when children were in homes they used all-purpose spray, carpet or upholstery cleaner, any type of air freshener or air fresheners or spray -- air freshener sprays.

And then we also saw non-significant positive associations between other scented product use such as scented lotion, scented body wash, deodorant spray, as well as restroom furniture, glass and floor cleaners and urinary 2-naphthol levels in both adults and in children. And then we also wanted to examine if this product use was what was contributing to the high levels in our Hispanic/Latino population. So when we ran models accounting for the reported product use in our associations between race/ethnicity and 2-naphthol levels, the associations were only slightly attenuated and the 2-naphthol levels were still around three times higher in our Hispanic/Latino participants, suggesting that the product use cannot

fully explain the really high levels that we're seeing in them.

But yeah, moving on to our VOC results, we measured six VOC metabolites for acrolein, acrylonitrile, benzene, 1,3 butadiene, crotonaldehyde and propylene oxide. And similar to PAHs, we only selected metabolites with a detection frequency above 65 percent for data analysis, which are the values that we've highlighted here. And these are the ones again that we use for data analysis. And then the VOCs with high detection rates, we see that concentrations are higher in children, which is different than what we saw with the PAHs, but we did not see any VOC metabolites that were significantly higher in our BiomSPHERE participants compared to NHANES. We do see slightly higher levels of propylene oxide metabolites, which is consistent with what we saw in the East Bay Diesel Exposure Project and slightly higher levels of acrolein and acrylonitrile. However, none of these are statistically significant.

And then when looking at the repeatability of VOCs in urine, we see that four of the VOC metabolites with detection frequency of more than 65 percent had moderate to good repeatability in

adults suggesting a relatively consistent source of exposure for crotonaldehyde acrolein and acrylonitrile in adults but not in children. And lastly, we did not observe any significant positive associations between the questionnaire data and the VOC metabolites. If you recall, in the East Bay Diesel Exposure Project, we saw significant associations between gas appliance and candle use and BTEX metabolites, so metabolites of benzene, toluene, ethylbenzene, and xylene. And we used a CDC panel in EBDEP because at the time, Biomonitoring California was not aware of any other labs in California that measure VOCs in urine.

But the panel that we used in BiomSPHERE did not measure these BTEX metabolites. And then we think we might be missing those associations here. And then hence, moving forward, we think it's important to use the same CDC panel that we used in EBDEP and we think it may include more relevant metabolites more relevant to our exposures of interest. And then luckily for us, EHL has actually recently developed these capabilities so we can run VOCs in-house for our next study.

So with that, in conclusion, we did not see any significant associations between the

detection of PAHs in air with their corresponding metabolites in urine, suggesting that it's not a significant contributor to the metabolite levels. We see that most levels of PAHs and VOCs in urine were either similar to or lower than NHANES, except for 2-naphthol. We see the correlations between adults and children and intraclass correlation coefficients suggest in that there is a common and consistent source of naphthalene. And we also see that 2-naphthol levels were significantly higher in our Hispanic/Latino populate -- participants and were positively associated with household cleaning products, air fresheners and perfumes.

I also wanted to mention a couple of our next steps. First, we plan on having a community meeting in the fall to disseminate these findings from BiomSPHERE study to our participants and their community. And then we also plan on conducting some additional analysis. One to look at the associations between the biomarkers of exposure and the biomarkers of response. And lastly, we would also like to combine the data from the different studies in the San Joaquin Valley to identify potential sources of naphthalene in these communities and also really dig into the data and try and identify optimal biomarkers

of air pollution exposures and whether we should consider adding or dropping any of these for future studies. I would truly like to thank all our participants and project collaborators. As you can see, there's so many of them without which this study would not have been possible. And we'll take any questions. Thank you.

ACTING CHAIR CUSHING: Thank you, Aalekhya, and congratulations on getting to this point in the project. It's always really exciting to see the results after all the hard work that went into this. So we'll start again with clarifying questions from the Panel or the audience.

Maybe I'll start with one. This is Lara. Could you repeat again the timeframe for the air sampling and how it compared to the urine collection? Like, was it an integrated 24-hour sample taken around the same time as the urine?

DR. AALEKHYA REDDAM: It was around the same time. So I think air monitoring occurred in the morning -- between morning and afternoon and went for 24 hours. And the day it ended was the day we asked for the morning void sample.

ACTING CHAIR CUSHING: Got it. Thank you.

Yeah, go ahead.

PANEL MEMBER QUINTANA: Hi Jenny Quintana. Just a quick clarifying question, similar. So do you have any information on whether the participants were home that day or where they spent their time.

DR. AALEKHYA REDDAM: We do have information on that. I think most of the participants were at home that day.

PANEL MEMBER QUINTANA: And then the half-life of the metabolites is within that window. That same window is my understanding.

DR. AALEKHYA REDDAM: Yeah. I think so.

STEPHANIE JARMUL: Yeah. This is Stephanie Jarmul. I can just add they are pretty short for PAHs and VOCs, I think about six to eight hours. So we -- we're hoping to capture their exposures while they're at home during that.

PANEL MEMBER PADULA: This is Amy Padula. I was wondering if the same instrument was used both indoor and outdoor and what -- which instrument that was? If -- or I can also look that up.

DR. AALEKHYA REDDAM: The same instruments were used indoor and outdoor. We did have a different instrument for naphthalene because

naphthalene is primarily in the vapor phase. And let me see, we use for the PAHs 37 millimeter quartz fiber filter. And for naphthalene was an XAD containing sorbent tube.

PANEL MEMBER MCKONE: This is clarifying, but it may actually lead to more depth later on, but when you looked at the measurements of air pollution, you were looking -- PAHs was one of them. And even though naphthalene is volatile, if it's coming from cooking you might see a -- did you look to see if there were peaks in the household of PM when there was also a really high level of naphthalene in the markers? And since the time course is fairly --

DR. AALEKHYA REDDAM: Uh-huh.

PANEL MEMBER MCKONE: -- consistent, right? It wouldn't be like a take days to see the naphthalene. You -- was there a way to look at a high event that is associated with cooking?

DR. AALEKHYA REDDAM: That is such a good point. We didn't have real time monitoring for PAHs, so we weren't able to see any peaks. So it was just over the 24 hours how much was collected. So -- but I think that is a really good point and moving forward it would be interesting to incorporate that.

PANEL MEMBER LUDERER: Yeah. I have a

question. I think so you said that there were no significant associations between the indoor PAH measurements and the urinary metabolites, but I don't -- maybe I missed this, but did you also do a similar analysis for the outdoor concentrations.

DR. AALEKHYA REDDAM: We did.

PANEL MEMBER LUDERER: And was it the same result.

DR. AALEKHYA REDDAM: And there was nothing there, too. Yeah.

PANEL MEMBER LUDERER: Thanks.

ACTING CHAIR CUSHING: For the stenographer, that was Tom and then Ulrike.

Rebecca, are there any questions, clarifying questions online? No. Okay. So we can go ahead and move into more substantive discussion questions and comments. We'll start with the Panel.

Go ahead, Tom.

PANEL MEMBER MCKONE: I want to circle back to the naphthalene. I mean I still -- I mean we,re looking at this data and especially cultural differences, I really just have a suspicion that fried food is in there somehow. And I don't know how easy it is because when you fry something, you just get a burst of fine particles and PAHs, but they

don't last very long. I don't know if it's -- might not be fully visible and only show. So the thing about a biomarker is it's an integrator over a long time.

DR. AALEKHYA REDDAM: Uh-huh.

PANEL MEMBER MCKONE: And of course some of it may be ingested related, but was there a way to really look into the way food was prepared in the households that had the high naphthalene in their blood.

DR. AALEKHYA REDDAM: Uh-huh.

PANEL MEMBER MCKONE: Urine.

DR. AALEKHYA REDDAM: We did have questions about if they barbecued or grilled food. So it was more about the food preparation and I'm assuming it also is of food consumption and there weren't any significant associations with that. And we also asked about yeah, if they had cooked and there weren't any significant associations with that either. So I wonder if there's like a specific method that we should really be focusing on more, asking more detailed questions, but the more general questions about barbecue indoors and cooking didn't yield anything.

PANEL MEMBER MCKONE: I just want to

follow up. The reason I bring this up is Lance Wallace, the name you may recognize for doing a lot of work on indoor air pollution. His wife is Hispanic and they made a lot of tortillas on a frying pan. And of course, Lance Wallace measured everything. He has a house monitor for everything.

And he said, you know, when you take -- when you take a tortilla and put it on the pan, he said the monitors just went, you know, through the roof and then dropped and Wayne Ott -- and Lance Wallace are two people that did this all the time. So, you know, the -- you may be questioning people and they say, oh, well we don't do anything unusual.

DR. AALEKHYA REDDAM: Yeah.

PANEL MEMBER MCKONE: And -- but that might not be unusual. They may not be frying food as they think. But an activity like that is actually something we don't think of, but it produces from experimental evidence, produces a lot of both fine particles and PAHs.

DR. MARTHA SANDY: So, Martha Sandy, I have a question for you, Tom, and thank you for giving that additional information. So I wanted to know if it was frying by that you meant it was on oil or it's just the hot temperature. And I'm also

wondering, has anyone looked at, when you stir fry food, which is also very high temperature, would you also expect.

PANEL MEMBER MCKONE: So I don't think Lance looked at that, but he was -- so he looked at where you take a pan, you get it hot, put oil in, just a thin coat of oil, get it hot, and you throw a tortilla in till this crispy and flip it over. I mean, that's what he looked at, that kind of -- and I have a son who loves tortillas and it's what he does all the time. And you know, I -- we have our Purple Air goes off the roof when he does that.

STEPHANIE JARMUL: This is Stephanie Jarmul. I just want to add quickly that to your point Tom, we still did not see high levels of naphthalene in the air though, which is why any of the activities that could be contributing to the -- to high air pollution levels, we actually didn't see particularly high air pollution levels. So perhaps it could be contributing to levels by consuming those foods, but I don't really know. We didn't see any associations with the air.

ACTING CHAIR CUSHING: I see you, Oliver. We'll come to you next. There's more comments in the room. One second. Hold on.

SUSAN HURLEY: Susan Hurley from biomonitoring, California. As you know, I've been very interested in this whole naphthalene mystery. And one of the reasons I feel like it may not be related to cooking is that none of the other PAHs are particularly elevated and particularly 1-hydroxypyrene, which it's my understanding is fairly affected by frying and cooking.

So I haven't been able to find a lot in the literature about how these different PAH metabolites are related to cooking. And if anyone knows any good references on that, I'd love to see them. But that's why I'm kind of leaning towards away from thinking that the napthalene levels are being driven by cooking.

STEPHANIE JARMUL: I'm sorry, this is Stephanie. One more quick comment. I think Aalekhya actually also looked at the correlation between the PAHs and did not see -- or let's see what she saw.

DR. AALEKHYA REDDAM: Yeah. Did not see any significant correlations between 2-naphthol and the other PAHs.

STEPHANIE JARMUL: Which suggests that something really unique is happening with 2-naphthol there.

ACTING CHAIR CUSHING: Is your question on naphthalene or related.

SUSAN HURLEY: Yeah.

ACTING CHAIR CUSHING: Okay. Let me -- yeah. Pass to Oliver who's had his hand up.

PANEL MEMBER FIEHN: Okay. Now you can hear me. So thank you. I was wondering about the methods. I'm a little concerned about the high number of undetected compounds and you know, over the years, you know, methods have been improved and, you know, if concentrations were similar to NHANES I think we should expect now with today's methods better detectability of these compounds. Can you comment on those and you know, whether or not you know, improvements in methods have been considered.

DR. AALEKHYA REDDAM: Sorry, Oliver, are you talking about detections in urine or detections in air.

PANEL MEMBER FIEHN: In urine -- in urine.

DR. AALEKHYA REDDAM: I'm not sure I have an answer to that. I don't know if there's anyone else who would better.

STEPHANIE JARMUL: Well, and can you show your slide? I think we had pretty high detections

though. For a lot of the chemicals, only some of the metabolites we did not see detection frequency over 65 percent. Do you have another comment, Oliver, or looks like Jianwen also --

PANEL MEMBER FIEHN: No, that's fine, thank you.

STEPHANIE JARMUL: Okay, thanks. Jianwen, did you want to comment? I think you need to unmute. There you go.

DR. JIANWEN SHE: Yes. Dr. Oliver Fiehn, and I think that's very good question where we talk about detecting frequency, we always need to link with the method detection limits. And we didn't a lot do this study. UCSF provided the test to support the study, but you're absolute right with today's technology. For PAH metabolites, according to our own experience within the organic group, we have the most sensitive method which require the high resolution GCMS. So I don't know what's the method detection limit the other laboratory is using. But definitely that's associated with detection limits.

STEPHANIE JARMUL: Thank you, Jianwen.

PANEL MEMBER PADULA: Thanks. This is Amy Padula. I guess I have a question. I'm also wondering if traffic-related pollution is still maybe

impacting the urinary ones in a location maybe outside of the home. So I guess I'm still curious, I know you said maybe most of the people were home. Was this done on the weekend then? Like so the children were not at school presumably.

DR. AALEKHYA REDDAM: I don't know the numbers at the top of my head.

PANEL MEMBER PADULA: Okay.

DR. AALEKHYA REDDAM: I think some of the children were at school, but I think yeah, for the majority of the time was spent indoors.

PANEL MEMBER PADULA: Even at school.

DR. AALEKHYA REDDAM: Even at school, yeah. Right. Okay. But I guess I'm just still a little bit, yeah, wondering about that because, yeah, these -- it's hard to make sense of these things otherwise. And then -- and also wondering if you've looked at other traffic measures maybe in the neighborhood beyond just the measurement of that single day.

I mean if there's any other maybe differentiation we could see by where people lived and potential traffic exposure outside of this.

DR. ASA BRADMAN: I know we have a variable, we haven't looked at associations with it,

but distance to highway 88 and I think that would be interesting to look at.

But then I think it comes back to the same thing that if that's a contributor, then maybe would we see higher levels in the air and would it also potentially be associated with the metabolite levels? So that's also -- or maybe there's an another exposure source that we're missing. Is it in the soil and food? Yeah.

PANEL MEMBER PADULA: And I just feel this is so common with PAHs, this, like, disconnect between the urine and the air it's, yeah. I'm not sure which one where we're going wrong.

STEPHANIE JARMUL: And Issa Bradman's (PAH) online. You are muted. Asa, did you want to say something.

DR. ASA BRADMAN: I -- yeah, I just typed a little note in -- but one, the urine samples were collected in the morning, so they probably mostly reflect home exposure. And then we, we do have traffic information. We have traffic near the home based on the traffic tool from California Tracking.

And then we also separately plotted the distance to the 99 which is a major truck route. And we see for example, some correlations with black

carbon measurements and the 99. So traffic is something that we could look at. I don't have enough experience with PAHs to know whether naphthalene would be different than some of these other compounds we measured and why it seems to stand out in this population.

ACTING CHAIR CUSHING: Jenny, go ahead.

PANEL MEMBER QUINTANA: Hi, Jenny Quintana. Just a couple things. If you have an indoor source and you have a population like this where you have a great variation in income levels, something that can mediate that is home volume. And I'm just curious if you had collected home volume or how many bedrooms or square feet, at least, is one thing that could affect the same source, you know, be higher level than a smaller home. You see that for indoor smoking, for example. And I was also curious, I think you did say you collected information on home ventilation and behaviors like opening doors and windows, so that would be of interest.

DR. AALEKHYA REDDAM: Uh-huh.

PANEL MEMBER QUINTANA: So one particular -- sorry, is that one of mine.

DR. ASA BRADMAN: Just to answer that question too.

PANEL MEMBER QUINTANA: Yeah.

DR. ASA BRADMAN: We do have an estimate of the -- of the volume of the dwelling. And we also and -- square foot and we also have an estimate of the air change rates. So we do have some of that information.

PANEL MEMBER QUINTANA: And I guess my last couple comments would be just that I think of naphthalene as one source in Central Valley and as is Imperial valley near San Diego is agricultural burning. And I'm just curious if you have burns and locations. And also just to say this is a fairly small sample size, especially if you have detection levels and you can't see correlations if you don't have variability. So if you have little variability in the participants, there could be a real source or something but you just won't see a correlation with a small sample size. That's all. Thank you.

DR. AALEKHYA REDDAM: Thank you.

DIRECTOR THAYER: This is Kris Thayer. I had a question. So the temporal variability, the intra class correlations, coefficients, they seem like they were generally lower for kids.

DR. AALEKHYA REDDAM: Yes.

DIRECTOR THAYER: Compared to adults. Is

that sort of a pattern that you've seen in other temporal variations?

DR. AALEKHYA REDDAM: I think so, yeah. I think children also just have higher variability, like their metabolism is more variable too and, Meltem, if you have any thoughts. But I think this is consistent with what we've seen in literature too, where children just tend to have more variability than adults do. The habits are different.

ACTING CHAIR CUSHING: Maybe I'll take this lull to check in with Rebecca, see if there's any comments.

REBECCA BELLOSO: No.

ACTING CHAIR CUSHING: Okay. Yes.

PANEL MEMBER QUINTANA: Yes. This is a more sweeping question. But especially thinking about PAHs and some of these VOCs and your comparisons within NHANES. I don't want to sound like a broken record, but I've also worked in tobacco control and if you go any other state besides California, you really notice how secondhand smoke --

DR. AALEKHYA REDDAM: Uh-huh.

PANEL MEMBER QUINTANA: Work on thirdhand smoke, there's so much more contamination and I'm almost wondering if we should really compare, say the

children to those NHANES participants with the same levels of urinary cotinine, which are usually very low in California compared to other states. And that way might be more fair comparison for the other exposures to PAHs or something like that.

DR. AALEKHYA REDDAM: Uh-huh.

PANEL MEMBER QUINTANA: I know that information is available but you have to jump through hoops to get it maybe. Yeah. Thank you.

DR. AALEKHYA REDDAM: That's a great point. Thank you.

STEPHANIE JARMUL: This is Stephanie Jarmul, too. Just wanted to add a point that some new research has come out about some trends that they're seeing in two naphthol levels and we are seeing in general an increase globally it seems, but not again to the extent that we're seeing in our population in the Central Valley. So we have had some more recent data to compare to other than just NHANES. Our values still seem very high in the Central Valley.

ACTING CHAIR CUSHING: This is Lara. I know you mentioned you're having a community meeting coming up here soon. So I don't know how many you've had so far, but I'm just curious if participants or

community members, how -- if they've seen this, how they've reacted to it and if they have any thoughts on exposure sources.

STEPHANIE JARMUL: This is Stephanie again. You know, surprisingly they -- we have not gotten many comments of concern about the naphthalene levels and we do try to message it as such that you know we're not sure of the sources but here are still some ways that you can reduce your exposures to naphthalene and other PAHs. So we try and also give them some opportunities to perhaps reduce their levels if possible.

But in general we haven't received any particular concern from community members and we haven't shared these results for BiomSPHERE. But we did just have our FRESSCA, this is a little teaser. We are seeing the same trend in our FRESSCA population. So for SAPEP, BiomSPHERE and FRESSCA. And so yeah, we did not have any comments from our FRESSCA participants on it.

PANEL MEMBER LUDERER: So I do have kind of another follow up question about the 2-naphthol. One of them is -- so they were -- so the -- it's associated with use of certain kinds of products like the air fresheners and things like that in

particular. But do you have any kind of temporal data about when they were using that relative to when they did the sample collection.

DR. AALEKHYA REDDAM: We only have data about if they used it today or yesterday and I think we were thinking about diving in a little deeper to see if it was closer are the levels higher in any way? So yeah, that is a good point but that's as high temporal resolution that we have.

STEPHANIE JARMUL: I am sorry, stepping in just to add to that we did also reach out to CARB as part of their consumer product survey to see if it's possible that naphthalene could be an ingredient in some of these fragrances and not be listed. And it is possible that it could be under fragrance but we don't know if it is in fact in these products.

PANEL MEMBER QUINTANA: I'm just curious because we're doing so much comparison with the NHANES subset that's analyzed for environmental chemicals. If that effort is ongoing at the same pace currently as we've -- as we're used to, are we going to still continue to get this same data? Do you have anybody have any information.

DR. AALEKHYA REDDAM: In terms of like the date for NHANES, we are still looking comparing

it to 2015 to 2016; is that right?

PANEL MEMBER QUINTANA: Right. But I'm just wondering if efforts are currently affected by current events at the CDC since some other things have been affected.

STEPHANIE JARMUL: Kathleen, did you get an update on that at ISES?

DR. KATHLEEN ATTFIELD: Yeah, I don't think I can speak for the CDC NHANES program really well, but did hear yeah, that the plans are ongoing for the next cycle and that the lab's work has been sustained. It seems like the epiability to chug through all the data to get it posted is further delayed than it has been. So we shouldn't expect, you know, newer rounds of data to appear super quickly.

DR. AALEKHYA REDDAM: Thank you.

ACTING CHAIR CUSHING: Yeah. Tom, go ahead.

PANEL MEMBER MCKONE: Yeah what round of the NHANES was this compared to.

DR. AALEKHYA REDDAM: The PAHs were 2015-2016. So it was.

PANEL MEMBER MCKONE: 20 -- oh.

DR. AALEKHYA REDDAM: Yeah. And the VOCs

were 2017-2018.

PANEL MEMBER MCKONE: And this was what year, sorry.

DR. AALEKHYA REDDAM: BiomSHERE was 2023.

PANEL MEMBER MCKONE: Right. So there's a lot of years in between.

DR. AALEKHYA REDDAM: Yeah there are a lot of years.

PANEL MEMBER MCKONE: So if somebody has introduced a new product on the market.

DR. AALEKHYA REDDAM: Yeah.

PANEL MEMBER MCKONE: That is -- would be in every household in the country but we wouldn't have seen it back in the last. Okay.

DR. AALEKHYA REDDAM: Yeah.

PANEL MEMBER MCKONE: I mean that's one thought is that there's something that people are using that we found.

DR. AALEKHYA REDDAM: Yeah.

PANEL MEMBER MCKONE: I mean that you saw in California. But it's not in NHANES because the product just came into the market more recently. I mean it's just speculation, but it could be something.

DR. AALEKHYA REDDAM: And we've tried to

see if there's literature out there with more recent studies that have 2-naphthol levels and all of it is outside the U.S. and -- but again, like Stephanie said, they are also increasing but there just isn't any literature on urinary 2-napthol here in the U.S. that we can compare to.

STEPHANIE JARMUL: And we do have Jianwen who would like to provide a comment online.

DR. JIANWEN SHE: Yes, thank you. I think that the team is very interested in the source of the naphthalene and also broad group of PAH. So the PAH have might have the dietary input and also the air, so for example -- so of course we find very high levels of 2-nap, which stand out.

For laboratory which raise the question, is beyond the questionnaire, is laboratory have new markers visited. I think that they might be because when naphthalene go to our bodies with which form 1,2-epoxide. 1,2-epoxide form 1,2-dihydroxynaphthalene instead of monitor 1-monohydroxynaphthalene, dihydroxynaphthalene could be a good marker. And then so the laboratories explore that part because dihydroxynaphthalene might better correlated with inhalation instead of the dietary exposure of the PAH especially for the left

naphthalene exposure.

Second comment as presentation show MTBEX tended to have a better correlation between the urine and air. But MTBEX is always single benzene rings and then naphthalene have two benzene rings, which is also qualify naphthalene as a VOC. So MTBEX volatile metabolites as a VOC. So the -- what my point is naphthalene could be -- have VOC metabolites, which more capture the acid when it's combined with the glutathione. So laboratory also looking for the way to find the VOC metabolites the new biomarker and on to characterize naphthalene overall total exposure because mono or di, plus VOC may give us full picture. So that's that one comment how we try to solve from analytic technique part of the issue.

ACTING CHAIR CUSHING: Okay. Any more comments or questions online or in the room? Amy.

PANEL MEMBER PADULA: I have one other thing and I was just wondering, I noticed this was done across several different months and I was just wondering if there's any difference by season.

DR. AALEKHYA REDDAM: Oh, that is a good point. I think we did see differences by season. Dan, do --? Yes, we did. I don't have those results off the top of my head.

ACTING CHAIR CUSHING: Okay. If there are no further comments or questions, we can wrap up this section. Thank you so much Aalekhya for a really provocative thought-provoking presentation and to Nerissa for the great overview of all the great work go -- happening at Biomonitoring California. So we'll have, I guess a little bit longer lunch than expected. We'll reconvene at 1:05, so please be here before that. So we can start promptly after lunch. Thanks.

(RECESS).

ACTING CHAIR CUSHING: Dr. Anderson has more than 110 peer reviewed articles and holds five patents. She is a member of the Gulf Research Program Advisory Council for the National Academies of Science, and has served on the board of directors for both North America and World Council for the Society of Environmental Toxicology and Chemistry.

Dr. Anderson has been developing passive samplers since 1999, and in 2008 developed the personal silicone wristband sampler technology to measure individual chemical exposure. So we are thrilled that she's here today to give a presentation on the development and use of silicone wristbands as an exposure tool. So thank you, Dr. Anderson, and

I'll hand it to you.

DR. KIM ANDERSON: Thank you. Just verifying that you can see my slides. Can you see my slides.

STEPHANIE JARMUL: Yes. Actually, we see the notes view.

DR. KIM ANDERSON: Okay. Just a sec.

STEPHANIE JARMUL: So I think if you go to display settings, you just say swap presenter view.

DR. KIM ANDERSON: How's that.

STEPHANIE JARMUL: Perfect.

DR. KIM ANDERSON: Okay, well -- so thank you for the introduction and thank you for the invitation to come speak. Remind me again how much time I have. I tend to jabber on.

STEPHANIE JARMUL: 25 minutes, but we can be a bit lenient.

DR. KIM ANDERSON: Don't tell an Italian woman that. So today, I'd just like to share a little bit at a high level about some of the things we've been doing with silicone wristband and general passive sampling, some background about you know, the technique itself, the application and how we've applied it.

So I think it'll overlap really well with some of the presentations this morning. I don't doubt I have to tell folks here that sometimes stationary monitors are a poor estimate for personal chemical exposure, and that's really where my interest stemmed from. I've made many different types of stationary monitors for fit for purpose of understanding bioavailability and different chemical classes.

But it was really the connection between stationary monitors and the individual exposure that got me interested in trying to design something that could be worn by an individual because there is kind of this unknown at the time. But -- we highly suspected that stationary monitors might not be a good estimate.

So we started looking at personal samplers and I've worked in the passive sampling with different kinds of polymer carbon polymers and silicone polymers. And we eventually ended up on the wristband again trying to understand the environment and the chemicals in the environment as an important contributor to disease in humans. So sort of where my interests lie in trying to understand developing this technology.

So with that we tried to build a sampler with purpose. Not to solve all problems, but to solve a slice. And one of those being quantifying bioavailability. From my work in environmental tox and environmental chemistry, the use of passive sampling, different types of carbon polymers and silicone polymers was to try to capture from the environment the bioavailable fraction, whether that be in waters or sediments or the air, was trying to understand the difference between what is there and what is biologically available from the exposure side.

So lots, many people before me, obviously we stand on the shoulders of many, have developed passive samplers to try to take up that space and try to develop different kinds of polymers that would, you know, very, roughly mimic biology. And so that's sort of where my history came from, and I brought that history from the environmental side into under -- trying to develop something for that people could wear or, and we eventually expanded that beyond people, but companion animals and so forth.

So the passive sampler has both lipophilic, meaning fat-loving nature, and pore sizes that are quite close to a cell membrane. And so just

trying to bridge that gap a little bit between what's in the environment and what is actually an exposure. So as I'm -- we developed the passive sampler in the -- in the two thousands late two thousands. And then we eventually published that and that sort of started the ball rolling with the silicone wristband.

And in general, the approach of putting these passive samplers on folks. So the idea also was fit for purpose. So build a passive sampler or build a sampler that people could wear. We want to actually have a lot of the questions that you all will probably ask me at some point this afternoon about how do we know this? How do we know that? We wanted to really do all that as much as possible leading up to our present -- our publication. A lot of times different kinds of chemicals are not always tested in the matrix. They're collected. Like for instance, how long can you keep chemical X in urine at temperature X, right? If there's kind of someone had to do those work.

But when you build a brand new technology, in this case a silicone wristband, we had to do that. So we had to do, you know, what is -- what is the testing that's necessary, which is often called storage -- transport and storage stability.

So we tried to do all that because it's important to understand the application of the technology.

First and foremost, what we wanted to do was make something that was connected to the bioavailability, right? We wanted to get that fraction from the environment, and we wanted it to be on the individual. We already have great monitors for doing stationary monitoring and lots of choices there. What we wanted to do is get something on the individual that was easy to use, didn't require power. It's one of the downsides of some of the technology. So we wanted it to be power free and something that would be easy to wear during all of life. So whether that's, you know, sleeping or doing your everyday activities. And so those were some of the reasons why you know, our goals of the passive sampler.

This is one of our first studies on transport and storage stability. We have some subsequently done more, but the first study out was 150, almost a hundred fifty, a hundred forty eight chemicals. And we looked at transporting those samples at various temperatures, storage at various temperatures and what was their stability. And in the end, the short story, you don't have to go into

all of these different graphs, but the short story is we can transport at ambient temperature, which was another really important goal of the passive sampling technology, because it is really hard in remote areas, or even not in remote areas, but during times of stress or disaster to have to deal with complicated transport conditions, like minus 80, minus 20.

And so really I think that was an important component of the design -- of the passive samplers, was that we'd get something that was easy to transport. So we've subsequently tested these for like many years now. So another attribute was to be able to archive these samples, either as the wristband itself or as the extract. And we've proven that both of those things, once stored at minus 20 have really long storage stability study. This was just the first one, which was six months. We've subsequently done other studies extending these out to multiple years. So that was an important component.

We also had questions, you know, sort of left field questions like, well, you have a -- you have a sampler, but your wrist is in the sun, and that might degrade something like PAHs. So there was

a lot of pushback. Oh, there's going to be UV degradation, turns out that the wristband actually stabilizes these chemicals in ways that we could have predicted. But having the data is certainly important.

So we actually stuck the wristbands on top and beat the heck out of them with some UV. And I know it's hard to believe that the sun does come out in Oregon for those in Southern California, but it does. And so you know, we did that study and showed that there were no statistical differences with the PAHs. They were quite stable even if we left them out for days in the sun on reflective services.

So the other attribute that we wanted to incorporate ideally, was to be able to look at a lot of chemicals. You know, one of the things we hear back is that there's a type of sampler that's used, and it can only measure one thing that gets to be difficult for those to do study designs because it's so limiting. So it's like, well, can't put, you know, 20 samplers on an individual, or we can't afford probably just as important. We can't afford to put 20 samplers on individuals, but yet we have this interest in a really broad range of chemicals.

So one of the attributes of the passive sampling, whether it be a carbon polymer, in this case, the silicone, is that it's applicable to a wide range of chemicals. And I can throw up different kinds of chemical physical properties, and a lot of times it's hard for people to get -- it's even hard for me to get a feel for that. What does that mean? You know, boiling point or log KOA, in this case octanal-air partition.

So I just put up as an example, in the case of log octal water partition, we have demonstrated that we can measure chemicals in the wristband over you know, eight log units. Well, what does that mean? If we can measure chemicals over eight log units, how different are those chemicals? So I just kind of use the analogy of temperature water in this case, zero degrees to the temperature at the center of the sun would be seven log units. And this is a very educated audience, so you guys don't need that, but I still think it kind of gives you a sense of how wide the chemistry range is that, that is applicable that we've demonstrated with the wristband.

So then it's a question of doing all these things inside the laboratory, but then the real

rubber meets the road when you actually do studies. And so we have now done thousands of wristbands in various places that where we've tested with an actual biomonitor with other types of traditional sampling technology in various kinds of communities. And, you know, these are just some pictures of various places we've been. I'm glad to answer questions on any of them. They're all on my website, which I'll identify at the end. And I'm glad to talk about them.

But just to kind of give you a sense of the wide applicability and the quick adoption. I mean, new technology usually takes decades to get integrated. It's not like sort of computers which are really quickly integrated. Chemistry technology takes a long time. You have to get everyone on board with how to do the chemistry part and be ready to adopt a new approach and the field. And a lot of times there's resistance to new versus the comfortable.

And so really in the last 10 years, it's been pretty amazing how fast this has come along in my view. I guess I was expecting slower. So well, I'll talk about a few of these studies. And again, anyone is welcome during the Q and A to ask me anything as we go on.

So the very first study that we did was with roofers, it's an occupational exposure. And so we had roofers, workdays and then we had roofers at a training site. And I guess this really stuck to home for me just how important the individual wristband was for understanding individual exposures.

So one of the outcomes of the study was, interestingly enough, the training site in Oregon had higher PAH in the wristbands of those trainees for 40 hours and eight hours than the actual roofers did. And so that was kind of interesting and counterintuitive because they're training and they're in this, you know, big, big facility versus, you know, thinking of the -- of a more intimate right on top of someone's roof going, you know, such as this. And so it was kind of surprising. We subsequently learned that in Oregon, the training site, because it does rain here a lot that the training site is roofed. And that roof actually holds the tar fumes in clearly you have what, four times higher PAHs in the wristbands than the outdoor workers.

So whereas the outdoor workers, you have this sort of open air component versus the training site has a roof on it, so they don't have to get rained down when they're doing training. But that

holds in even though the sides are open. Not a lot of -- there's less movement of the air -- of the air. We've subsequently trained -- looked at military, I'm not going to share that data. I'll be glad to talk about it.

So one of the other components with using technology is to get adoption by communities. And in all cases we've had really good enthusiasm about use -- almost too much enthusiasm about using passive samplers. We've looked at children as young as three and community members as old as 93. And so there's -- there has been good adoption and we've actually discovered a lot of things about whether it be flame retardants. And turns out children do have a lot more flame retardants than adults because of their nature, you might of -- the activities.

And again, you wouldn't be able to necessarily pick that up if you had a stationary monitor, and of course a lot of complications pulling blood samples from that kind of a population study. This is a study that was done about a decade ago and -- or seven, eight years ago. And this was where we had a very small, tight community in Ohio, and we had stationary monitors all over the place.

But then we also had community members

wearing wristbands. It's kind of a classic example now of where we've shown that the stationary monitors are not really a great reflection of the individuals. And so in this case, our stationary monitors whether there was a well -- a natural gas fracking well on the property, much higher, just as you expect those that have one sort of adjacent as a neighbor and then none.

So kind of a typical stationary monitor. You know, we had concentric circles around various places. And what we found though, with the wristbands on the graph on the right is that -- well, there is a -- an association here clearly between the stationary monitors and the wristbands. You see that there is in fact some underestimates and overestimates on the individuals. And this is a pretty small study.

So -- and each are -- have their own, both underestimating and overestimating risk are equally bad. And so an example of where knowing these individual exposures are important, and this is just PAHs and in a very, very small community, as an example.

The use of the wristbands we have found have been really nicely accepted by many communities.

We did a study I think it was in 2015. We had been in the Senegal community for about a decade. And so we had done all these exchanges back and forth. And so these folks knew about the wristband because we've been working on them in the laboratory, and they were -- they wanted to be one of the first to use the wristbands, which is -- which is very sweet and nice because they're wonderful group to work with. It's a very small community and a lot of the folks in the community have similar jobs. And we actually also had people from the same household in the community.

So it's a small study, one of the first ones that we did. And we had folks in the community wear a wristband, two different periods, five days each and what was interesting, and of course all of the adjacent types of questions and so forth. And so we had 35 folks. And what you can see on the graph on the left is that all 35 of them are different. So even though we have people with the exact same jobs working in the same fields, even and we have some people who are in the same households, but different jobs, all 35 were different.

So it's kind of another example too of understanding the exposures at a community level really are individual and I guess viva a difference,

right? I mean, I would like to think that I'm individual and then that's a good thing and to be celebrated. And -- but then when we're trying to understand exposures and chemistries of exposures, then that makes it harder. But the wristband certainly can help.

The other part of this little study was that we had them wear them from two different periods of time. And we found that within a given period of time that you were very much like yourself while you were different than the other person that lived in your home, or you were different than the other person that worked nearby you in another agricultural field, you yourself were very much like yourself week to week. And that sort of made sense after we had the data because well, my husband and I have the same -- we share the same household. He starts -- you know, he's goes to a different job than I do, but I -- you know, I start off my morning making my coffee and I come to campus, I drink my coffee and meet some people, and then I go take my dogs for a walk and then I make some dinner. And I -- you know, that -- whether that's a Monday one week or a Monday another week, that's very similar.

And so what that tells me is that, you

know we tend to have the same exposures. Our life is kind of, you know, has some similarities, but we're very different even with other people in our communities. I guess in hindsight, maybe that was a duh for a lot of people, but I found it quite interesting that here we are with the chemistry and that that's what that is saying.

And so from that study we detected 26 different pesticides. And you can see the -- again, going to chem phys properties, there was a really wide range of pesticides in folks' wristbands. Everything from dimethoate and bifenthrin. We saw anywhere between two and 10 pesticides. And from the questionnaires, all pesticides reported by the participants that they had used or were in fields that had been used in their fields that they were working in were found, that's a good thing.

But what was the companion to that were that we found 19 pesticides in their wristbands that hadn't been reported by participants. So the good of questionnaires and I guess the bad of questionnaires, all in -- all in one little baby study.

So understanding chemical exposures I think in an ideal world, we'd have biomarkers for every chemical, but we don't live yet in that ideal

world. And we're a long, long ways from that world. So all chemicals do in -- do not, in fact have a clear link to an internal biomarker. So while that might be a gold standard, it's not a current standard that we can achieve, but we still want to understand our chemical exposures, and we certainly want to try to do interventions where possible when we do understand what those exposures are.

And those interventions are not going to be off of a biomarker either. Those policies and regulations are going to be based on some kind of chemical exposure on the external exposure. You're not going to see a regulation based on a biomarker in a person's blood for all the reasons that I list.

So there's space. It doesn't mean that biomarkers don't have super important space in understanding chemical exposures and health effects, but there's still space for understanding that external exposure, which is the -- you know, the space that the chemical -- that the chemical silicone wristband sets.

Small study again, one of our early studies looking at DNA damage and pesticides and wristbands, and we did find an association, but in children in North Carolina. So I think you saw an

awful lot of data on PAHs earlier. So this just kind of reiterate some of that data. We have urine data with polyurethane foam, samplers, urine metabolites with polyurethane foam, whether filtered or unfiltered. And then we have the urine metabolites with the wristbands. And what we found in this study was that the wristbands did seem to have more positive significant correlations between the urine PAH and the -- and the wristband, than the PUFs with or without filters.

So there's a place, you know, I just personally like to have more tools in my shop than fewer tools. And then I pick the right tool for the job. So there's certainly a place for the backpack PUF. But then there's also a place for the wristband. So I guess I collect tools, so this seems to be one that would have value. And hopefully you folks can see some of those things.

So how do the role of silicone wristbands and biomonitoring? So we have now expanded our studies with children, as I mentioned everything -- every age group from three to 93, we've also put the silicone wristbands on cats, and we've looked at hypothyroid, both flame retardants and other, we have a screen with about 300 endocrine disrupting

chemicals. And so one of the nice things about the silicone samplers is their ability to archive.

So we have sample archived and we can go back and now look at, as we develop additional methods for looking at the wristband, we can now use those methods to determine other additional hypotheses. So you know, just kind of trying to wrap up here in the next few minutes, we've applied these to many different places. We look -- as I mentioned, a whole host of types of chemicals from different chemical classes to different uses of chemicals like personal care products.

And we've -- have had done everything from the Arctic to Antarctic and this little -- this study, which has only about 250 people, but from all over we see the same kind of thing we saw in Africa, which is that no two individuals had the same chemical detection profile. With that said we did see that there were many chemicals that were common.

So, you know, whether it's phthalate or we have 90 percent detected in all those different places or a fragrance compound. We do see some similar chemicals at very high frequency rates in these wristbands, some of which have had little study. And I think that's an interesting component

that we can bring with the technology.

Finally now since I'm going through this myself, the role of the wristband in biomonitoring and environmental disasters where this is wildfire disasters first responders, we have had many firefighter studies and structural firefighters now with wristbands as well as community members. We've had the wristbands in trained derailments, cleanup crews, assistant science focus projects, flooding, hurricanes.

So quite a few different ways. And I think part of that whole piece of being ready for a disasters is the -- it lends itself well to the wristband because there isn't a lot of like, oh, we have to ship this on dry ice, right? That's not going to happen when there's no power in Houston for a week due to Hurricane Harvey. And also the breadth of chemicals. I mean, I quoted the Houston Health Department saying there are millions of contaminants, maybe yes, maybe no.

But what you can for sure say is that in any given disaster in a complex mega city like Houston is that you won't know ahead of time what are going to be the important chemicals that you should be looking for. And a technology that can grab lots

of different chemical classes is going to have value. I think that's part of what we can bring.

So with that, just sort of wrapping up, what are the limitations? I haven't listed all of them, but they are on my frequently asked question page. A few of them that I'll go through. These are organic chemicals. They're not PM 2.5. We clean the particulates off them. They're not form metals, so we're not going to find Chrome-6. They are time integrated. They're not real time. You do have to take them back to the lab. So one of the questions I used to get, do they change colors? They do not change colors. But we -- you know, they do have to go back to the laboratory.

Where are we with that turnaround time to real time? Right now we have a purge and trap method for VOCs, for the wristbands. And so from the time you drop the wristband off to the, when I can give you a result, if I'm -- if I'm already got the purge and trap running, I can give you a result the next hour. That's not real time. In a two week period, we actually analyzed 1000 wristbands, not real time, but in my world, that's pretty good. We have worn the wristband for as little as eight minutes in a firefighter demonstration piece, and we were able to

detect PAHs.

However, in that sort of, that's a contrived situation, I would say that the samplers should be worn for a few hours. I like seven days just because I get a workday and a weekend to understand your total exposures, but they could be worn for a month, they could be worn for multiple months. They are an external exposure, obviously. And an independent measure. And I'll probably stop there.

There's a lot of -- there's a lot of limitations. Don't try to hide from them. Again, I just feel like it's a tool that you should, that as a -- someone who's interested in exposure science would want to learn about. I will point out that my management plan over here on the far left requires that I give a disclosure on my acknowledgement pages. I realize from your folks that normally you would give that on the front page, but I was not able to get through my management plan. I'm sure they would've approved it, but I'd rather stick with my management plan than the -- than the SOP.

So, here's my acknowledgement that I have a conflict of interest that OSU manages and lots of people to thank too many to go through, but at this

point I am think I'm at my 30 minutes. So I will stop there and answer any questions or wait till the **Q and A period.**

ACTING CHAIR CUSHING: Thank you so much, Kim. So we'll take 15 minutes for questions now, and we'll have a longer discussion period to talk more with Dr. Anderson after the next presentation. But let's start with any questions now for 15 minutes. Anyone has one? Yeah, go ahead, Jenny.

PANEL MEMBER QUINTANA: Hi, Kim. Thank you for that. Jenny Quintana at San Diego State University. You've talked a lot about what a great tool that wristbands are. Mostly you're presenting worn wristbands as well as the pet one with a little hanging pet tag.

DR. KIM ANDERSON: Yeah.

PANEL MEMBER QUINTANA: But I recently, we've been hanging them in the air, mostly for thirdhand smoke or tobacco related issues, but also for other air pollutants in environmental justice communities. I'm just wondering if you could just briefly comment on the utility, just hanging them up on a outside the environment.

DR. KIM ANDERSON: Yeah I get that question a lot. Thank you for asking. So we've --

we have put them on cats, dogs, and horses so far. So just to kind of finish that thought. I'm not a big fan actually of hanging them in the environment or hanging them on a tree or something.

And the reason is most folks would like to calculate an air concentration, and right now I don't have all of those calculations ready to give you. We're working on them in the lab right now, so you are going to be able to tell what is in the wristband, but you're not going to be able to calculate that back to an air concentration.

So if you were interested in pesticides or PAHs, there are other samplers available to you that you would be able to calculate an air concentration back to. So I usually like to direct people to those. 3M has some, there's other people, I mean, we use other passive samplers so that we can, again, get that air concentration. So you'll only -- yeah, I'll just stop there and you can have a follow up or not.

PANEL MEMBER QUINTANA: So thank you for that. Yeah, I think that if one's looking for the presence or absence of compounds, such as with non-targeted, sometimes they can have a different pattern, you know, so that's interesting. And it's

amazing to me even semi quantitatively com -- not worrying, not worrying about what the actual air concentration is, but comparing, let's say indoor environments to each other. Like you can actually relate that to behavior in the home. Thank you.

DR. KIM ANDERSON: Yeah. So you can do that also with the other samplers. You can do -- we do semi targeted, and then we all a colleague of ours does non-targeted. You could do that with those other samplers too. So you're not relegated to those quant methods.

But yeah, you wouldn't -- necessarily calculate back from a non-targeted method to an air concentration. Still kind of feel like there's more known about those other samplers than the wristband as far as an air sampler. And not every commercial laboratory knows how to deal with the silicone sampler. So just, that's a -- that's sort of another caveat. I saw another hand. Go ahead.

ACTING CHAIR CUSHING: Oliver has his hand up. Oliver, do you want to ask a question.

PANEL MEMBER FIEHN: Thank you very much for your presentation, Dr. Anderson this is really enlightening and it's I feel your pain when you said you have to -- or joy when you say you had to

validate every single question yourself and, you know the duration and the storage and the -- you know, the do's and the don'ts, and that's great.

Now, there's been a couple of years now that these many years I'd say that the wristbands are out, and I wonder what's the adoption in the field? Because of course, the more studies are there on wristbands, the more people will like it and, you know, apply it.

But, you know, is there anything similar to NHANES or other large scale studies where, you know, they almost become authoritative, where at some point people say, yeah, you got to have it, you can't just rely on, say, urine and whatnot, but you have to have the response. What is your take on the adoption in the field?

DR. KIM ANDERSON: Yeah, so I think there's about 150 publications only, like 20 or 30 are mine. So I would say from an academic standpoint, there's good adoption because it -- you know, it was a pretty slow rollout. I mean, I was by myself essentially in the first few years, sort of, you know talking about these and probably talking about them to -- in communities that weren't necessarily the early adopters as far as I wasn't

going to the ISES meeting, you know, initially.

So I still think it's -- I think it's being accepted by the academic community really quickly. The military seems very keen on adoption, so I think that's interesting. You bring up something very near and dear to my heart. But I have not been able to break through, which is NHANES. I think you are absolutely right that if it were put into the NHANES, and it's perfect for NHANES because, you know, they end up archiving so much and not necessarily doing all the testing on everything they collect.

And this particular technology archives really well for future interest. I think that's right. I would like to get this in NHANES as a technology. And then I think, yeah, then you've made -- you've made it to the big times as it were. That process, I keep pinging through that process and it's a -- it's, there's some bureaucracy there, and that's probably not my best gig, but you know, I just agree with, I agree a hundred percent with you. When you make it to the, to being in something like NHANES, then that's just it.

Not sure how to complete that circle, but I feel like the more people who use it, like I said,

there's about 150 pubs and I'm really surprised how many are coming from all different places on the planet that it is making lots of headway in the space, in certain space. And, you know, there's a certain amount of it's not ownership, but it's also -- but it's like, I really want to emphasize using it in its fit for purpose, because if it is not used in its fit for purpose and people misuse it, then that's going to give it a bad wrap.

But that's because they're not really using it for its -- you know, in the way it was intended. So I do like to get out and say like, this is where it's -- that's this is the really good lane that it's in. Be careful over here because then, you know, it's not really what it was intended for. So there is probably too much passion on my part to make sure it gets used properly. But yeah, I totally agree with you.

ACTING CHAIR CUSHING: Let me check if there's any questions that have come in online, Rebecca.

REBECCA BELLOSO: We do have a question from Jeff Wagner. Jeff, would you like to ask your question.

DR. JEFF WAGNER: Sure. Thank you. Jeff

Wagner from CDPH. I was curious if you've done work with field replicates, say one bracelet on each wrist, maybe from the same individual and looked at like CVs or even common chemicals detected or not detected.

DR. KIM ANDERSON: Yeah. So actually in the very first study we did with roofers we put it on both wristbands. And you see a difference in roofers because they preferentially used their dominant hand versus their less dominant. And it didn't really matter for the certain work type. So depending on the roofer's job if the roofer was -- I forget all the names of the roofers now, their job titles, but if they were like pushing the stuff on the roof there wasn't really any difference. But the guy who was -- and it was a gentleman, the guy who tended the pot where all the Cresol was, his dominant hand, which was closer into the pot, had higher PAHs than his non-dominant hand.

Yes, we do it all the time internally and in studies where people wear three, four, or five wristbands, it's a pretty common thing for us in all of these studies that we load up each other with a lot of wristbands as we're doing these things. Probably 50 percent of all the samples I run in my

laboratory are quality control. I'm actually a good laboratory practices facility, gone through multiple audits, both for EPA and FEMA and private.

So -- and I -- and I actually have taught classes on GLP back in the day when I did a lot of pesticide reregistration. So we're pretty heavy, probably too much, so on quality assurance. So there's an -- everything in my lab is pretty heavy in the -- in the quality assurance. I've had a quality assurance program plan, like I said, I brought with me in 1999. As I spent 10 years in a -- in a QA lab prior to coming here. So lots of replicates, lots of over spikes of every kind, lots of labeled compounds for recoveries, both surrogates internals and, and other QC samples throughout the process.

DR. JEFF WAGNER: That's great information, thank you.

DR. KIM ANDERSON: Field trips, trip blanks, both every study every time.

ACTING CHAIR CUSHING: Did you want to ask? Okay, let me take one more question, I think, and then we'll move to the next speaker.

DR. KATHLEEN ATTFIELD: Hello, Kathleen Attfield from CDPH Biomonitoring California. So I want to press you on your earlier point. What advice

would you give to our Program if we were to use the wristbands as far as avoiding the missteps? So avoiding the ways that you could use these and maybe not learn what you think you're learning from them.

DR. KIM ANDERSON: Yeah, I think that lots of easy things to recruit there. Recruitment is easy. The consenting is easy. Getting people to wear them is usually pretty easy. I think we did have one 3-year-old who kept biting the wristband, but assuming that you have something three or older, I think until we release this paper we're working on for what's called performance reference compounds, I would design the study that everyone wears them the same amount of time. I think that's an important component until we have our PRCs worked out so that you can compare one count.

So you can compare bifenthrin with participant one and participant 351. So bifenthrin, bifenthrin. Some, a lot of the things are the interpretation. So again, until we get the PRCs, I think that performance reference compounds, those are usually labeled compounds or non-natives. That's an important component. Is the study design set up so that you have everyone wearing it, nominally the same amount of time. I -- as I mentioned, I like to have

people wear it workday and weekend because I think their -- a lot of people's weekends looks different from an exposure standpoint than their weekdays.

I've done a lot of studies with indoor/outdoor samplers and the wristbands. That's always interesting. Takeaway indoor air is terrible which you all probably know more than most audiences. I think that's the biggest. And then recognizing what you can't do. So, you know, you can't do PM 2.5, you can't do metals. I think the length of deployment is important and the continuity of that is important. That's probably one of the things I always try to stress when people use the wristband.

STEPHANIE JARMUL: And this is Stephanie Jarmul, I just have a really quick follow up. In terms of comparing similar time points, how exact do you think they need to be? Could you compare a 24 hour sample with a 36 hour sample, or does it need to be plus or minus a few hours.

DR. KIM ANDERSON: Yeah. So that one's probably harder on the chemicals that are more quickly taken up by the wristband. So if you were looking at 1,3-trimethylbenzene, that one might be harder to compare a 24 hour with the 36 hour. But if you were looking at phenanthrene or a flame

retardant, probably not so much because those are pretty similar times. But the quicker -- the quicker the analyte comes to equilibrium, the more important it is that the times be closer together.

So if you're looking for PAHs so that's naphthalene and above, you know, the difference between six days and 12 hours and seven days, not so much of a difference is what we've seen in and even in through our mock calculations. But that would be different if it were 24 hours and 12 hours with toluene, there would be a difference probably. Does that answer your question?

STEPHANIE JARMUL: Yes, thank you.

DR. KIM ANDERSON: If not, then just shoot me an e-mail. Anyone have any follow up questions, you're welcome to e-mail me.

ACTING CHAIR CUSHING: Fantastic. Thank you, Kim. Okay. I think we're at time, so we should move to our next speaker. But we have Kim for the discussion section as well; is that right? Are you able to stay on for the.

DR. KIM ANDERSON: Yeah, I mean, right now I'm under a mandatory evacuation and there are.

ACTING CHAIR CUSHING: Oh dear.

DR. KIM ANDERSON: Yeah, thank you. For

wildfire. And they're saying they might let us back in because we went from code one to code three. We skipped code two so we had to get out within 10 minutes and I didn't have everything packed. So yeah -- it's okay.

We're -- our house is still standing and they're making good progress, but if I do get a notice that they open the road so we can go, I might leave, but I'm not optimistic that's going to happen. But I don't want to be rude. But I do have my great grandmother's dining table that I would really like to get out if I may.

ACTING CHAIR CUSHING: Okay. Well, we're hoping that does happen then. Sorry to hear about the evacuation.

Okay. So our next presentation is from Heather Stapleton. Dr. Stapleton is an environmental chemist and exposure scientist in the Nicholas School of the Environment at Duke University. And her research interests focus on the identification of halogenated and organophosphate chemicals in building materials, furnishings and consumer products and estimation of human exposure, particularly in vulnerable populations such as pregnant women, children and firefighters.

She currently serves as the director for the Duke Superfund Research Center and director of the North Carolina Firefighter Cancer Cohort Study. Today she will give a presentation on the strengths and limitations of silicone wristbands in assessing personal chemical exposure. Welcome.

DR. HEATHER STAPLETON: Great. Thank you. Can you hear me okay.

ACTING CHAIR CUSHING: Yes, we can hear you great.

DR. HEATHER STAPLETON: Great. I will bring up my slides here. Can you confirm that you can see them or is it this notes section.

ACTING CHAIR CUSHING: We see your slides.

DR. HEATHER STAPLETON: That's fine. Okay, great. Well, thank you for that introduction and I'm happy to be here to talk about some of the work that we've been doing in our lab using silicone wristbands. It's really follow up to the great work that Kim has done and just explained to you in the previous presentation.

So conflicts of interest, I really have no major conflicts of interest. I will just state that I am a science advisor for the San Francisco

Estuary Institute on their emerging contaminants work group. And all of my funding sources are listed here. Right. So one of the reasons I'm really interested in using the wristbands is because I'm really interested in exposure science but particularly this concept of the exposome, right? Which the exposome as defined seeks to assess the totality of exposures over the life course and understand how these combined stressors impact health.

But the exoposome is very, very complicated, as you can see from this diagram, from Roel Vermeulen's paper in 2020. It's multifaceted. It's not just chemical exposures, it's, you know, social lifestyle, physical chemical factors, et cetera.

But it's this concept of trying to understand exposure over time. That's really interesting to me and how it applies or how we can use wearables to support this because, you know, a lot of prospective epi studies, you're getting maybe a biological sample once a year, once every two years. But our exposures change quite a bit over time. And I think wearables have an ability to help us understand exposure over time and patterns of

exposure, particularly as it relates to our behaviors, you know, our built environment, consumer products, our occupations, et cetera.

And as I know Dr. Anderson already explained you know, silicone wristbands have their strengths, they have some limitations I think based on the state of the science, the data suggests that they are capturing chemicals in which exposures are occurring via inhalation and through dermal exposure.

And then I have this question about whether it's capturing chemicals that may be the exposure route is inadvertent dust ingestion, particularly in children. I think we have some data suggesting that is possible, but I think that needs more work for sure. And obviously we're not capturing any kind of dietary exposure. That could be a strength or it could be a limitation. It really depends on your question, right? And we know that in general, chemicals accumulate initially in a linear fashion and then eventually they reach this equilibrium portion. We do try in our studies to keep within that linear uptake phase. And in our case we do normalize to deployment periods.

What's great about them is that they can integrate your exposure in all the different

microenvironments that you spend time, if that is your question, right? Because we know our exposures are very different at home versus maybe commuting in your car or on the subway or in your work environment. So what's great is they go everywhere with you and then they're integrating that exposure that you're -- that you're receiving in all those different microenvironments.

But maybe your question is really what's just your exposure in your occupational setting and then they have utility in that application as well because you can just have someone wear them just while they're working to isolate that exposure, which can be difficult by relying on biological samples because you can't disentangle what portion of the measurement internally is from your diet versus the ambient environment.

So what I hope to do in the next 20, 25 minutes here is kind of go over some of the questions that we've gotten a lot in terms of how well do they correlate with internal dose, how long do you wear them, can children wear them? I know that Dr. Anderson covered some of these already really well. Is there variability around the wristband? I know that question came up, we have some data on that.

And then I was going to talk about one of our studies with wristbands which is with firefighters, kind of showing you how we've been using them, what type of questions we're asking and trying to answer. And then I'll just close with some strengths and limitations.

So let me just start with how we are using the wristbands in our lab. This is a picture of our wristband kit. We have these Mylar bags that are resealable. It has a label on it for the participant's Id. And then we ask participants to, you know, record the date and time they put it on and the date and time they take it off. And we also send them a YouTube video that shows them how they should be wearing it and recording this information. It's a really quick three minute video. Inside this bag is an aluminum tin with a screw top lid. And the wristband is inside.

So when they're done wearing it, they put it back in the tin, they put it back in the Mylar bag. They either give it to one of our study managers or they mail it back. Sometimes we provide self-addressed envelopes. We get them in the lab and we store them in the freezer until we analyze them. And we are only analyzing a very small part of the

wristband. It's about 0.7 grams, one fifth of the wristband. So plenty to archive. This is -- I know this is a complicated side, but this is kind of an overview of the approach we're using. We do buy these in bulk and we clean them. Historically, we were cleaning them with the solvent extraction and the sock slits.

But we have moved to a heat cleaning method where it just gets us away from solvents, hazardous solvents and allows us to do more at one time. So they're cleaned under high heat, under vacuum with nitrogen purging to kind of remove particularly siloxane residuals that are in those wristbands. And then we keep them in airtight containers until they're deployed. We store them in the freezer after collection.

And then for analysis, we do have different panels that we use depending on what the study is and what the target chemicals are of interest. Most of our panels use GC high resolution mass spectrometry. We have three Orbitrap systems that are operated in different modes to be sensitive to different chemicals. What we do is we take that small piece of wristband and we extract it using sonication, and then we do conduct a dispersive

florisil cleanup to remove some lipids, things like squalence that sometimes get on the wristbands to purify that extract a little bit.

But then we take that extract and we can inject it into all three of these mass spectrometers to collect a wide range of data. We have our workhorse on the left, which is our Q Exactive that's operated in electron impact mode. And we perform both a targeted and non-targeted analysis in the same run with the same method.

So we run calibration standards for all 113 chemicals that you can see here on the left, which span flame retardants to pesticides, the PAHs, combustion byproducts, industrial chemicals, et cetera. And we support non-target at the same time. And I'll mention that briefly, but then we can take that extract and run it on our exactive system that's set up in negative chemical ionization mode. That allows us to get these high molecular weight BFRs, which can be difficult to measure unless you have a very short, thin column with a specific type of inlet. Makes it more sensitive. And we also measure dioxins and furans in that method.

And then we can take that extract and also run it in our -- we have an Explorers Orbitrap,

which is set up in positive chemical ionization mode, which is more sensitive for some of these volatile PFAS that are of interest for some of our studies. So that's a wide panel. It gives us -- it collects data of about 170 different chemicals in total.

But sometimes we have interest in measuring non-volatile PFAS, like PFOA or PFAS, or parabens triclosan. In that case, we will take a separate piece of the wristband extract in methanol and analyze it via an Agilent triple quad LCMS using isotope dilution.

Now I just mentioned we do have this non-targeted method we also apply. This was developed by a former postdoc, Nick Herkert. When we run these samples for both targeted and non-target it collects a full spectrum all the features or chemicals that are identified.

So we use our vendor software to pull that data out. We use their deconvolution program that also does alignment of the peaks and library matching. We have three libraries for mass spectral matching, the NIST mass spectral library, Thermo Fishers high resolution library, and an in-house library that we've been curating. That data is then exported with a custom R script that we developed to

do some standard QA/QC procedures, mainly blank subtraction and normalization to internal standards.

And then we pull in data from online resources, particularly PubChem, CPCat, and that's data is used in our algorithm to rank these features in their annotations as likely matches. And so then we can develop a list of annotations for each feature in our workflow. And then we visualize these with some volcano plots. And I have a few volcano plots, that I'll show you here shortly.

So let me just start with these questions about how well do they correlate with internal dose. That's a question we receive often. So we've done several different pilot scale studies to look at correlations with internal dose. The publications are all listed here and all of these studies we had these -- some of these are children, some of these are adults, anywhere from 30 to seven people wear a wristband for five days.

And we would ask those participants to collect their first morning void urine samples on days one, three, and five. And we pooled them and that pooled urine sample was analyzed for the standard biomarker of exposure, the specific metabolite for each of these compounds.

So on the left, you see chlorinated tris or TDCPP was well correlated with its metabolite in urine, BDCIPP. In the middle, that's benzyl butyl phthalate, right? A phthalete that's common in things like vinyl flooring and other plastic products.

And on the right is DEET the insecticide. I know that Dr. Anderson mentioned this was one that was really surprising to me. Not only was it a very strong correlation, you can see here of 0.92, that data actually came from our non-targeted analysis and not our targeted analysis. So what you're looking at there on the x-axis are actually the normalized area counts. It's a semi-quant method, but it was nicely correlated with the urinary metabolite, which is a targeted analysis that was performed by Antonio Calafat's Group at the CDC.

So that was really exciting for us that we could see that even this -- the non-targeted data is providing reliable, robust measurements for some of these chemicals. Now these are all chemicals with short half-lives. We wanted to look at chemicals that had long half lives. So we did some other studies with brominated flame retardants and namely PBDEs. The one on the left is from adults. The one

on the right is from children. So you can see that BDE-47 has a half life of about 1.8 years. This is what it's estimated at. It was correlated with blood serum levels of BDE-47. And this pilot study we conducted booster samples collected in 2016. It was correlation coefficient about 0.52. There's definitely some variability there.

But given how long this chemical is in the blood, it was really nice to see that just wearing it for, in this case that was seven days, did correlate with the blood levels, probably because most of our exposure to these compounds does occur in the indoor environment. And most of these people did live in the same home for the last couple of years.

And then on the right you have BDE-209, which is estimated to have a half-life of about two weeks. This was a smaller number of children, ages four to six that wore this. But we did have a really nice correlation. So this was really exciting for us. And this is where I said I wonder if this is capturing chemicals that are exposures through inadvertent dust ingestion. Because BDE-209 is not really volatile. It's really associated with dust in particulate phase, given how hydrophobic it is. And it is thought that for that -- for BDE-209, that most

of our exposure, particularly in children is through hand to mouth or inadvertent dust ingestion. But we did have a nice correlation. We're hoping to see if we can repeat this in the future.

And then we get this question about PFAS a lot because I know PFAS is a big topic. For PFOA and PFAS and PFHxS, these common PFAS that are of concern for cancer and health risk. We know that diet is a main exposure route for those chemicals. So I don't think wristbands are useful for those main pelyfluoroalkyl acids. However, there are some PFAS that are used in building materials and, you know, thinking about your stain repellent carpets and upholstery and even paints, and many of these are what we call PFAS precursors because they can break down to the pelyfluoroalkyl acids like PFOA.

In a recent study we conducted, we did find a very nice correlation between MeFOSE, which is a volatile PFAS on the wristband with N-MeFOSAA in the blood. And this is a known parent metabolite mixture. So meFOSE is oxidized to N-meFOSSA. N-meFOSSA is one of those seven PFAS that are recommended for monitoring, for clinical guidance by the National Academy's report. And while so most PFAS I do think diet is exposure, I do think in this

one case and N-MeFOSAA it seems our data seems to suggest that exposure is likely inhalation or dermal exposure and coming from the indoor environment. Now, this was a population in Michigan. We have since repeated this trend in a population in North Carolina that data's not published. But it was statistically significant. So this seems to be similar in other areas.

Now, not every chemical is correlated with the metabolites, right? So this is from one of our pilot studies where we were looking at pesticides and we were able to detect chlorpyrifos on the wristbands, 83 percent detection frequency and a hundred percent in the urine. And those samples are analyzed by Antonio Calafat's group at the CDC, but we did not see a significant correlation. And I think this is likely because there's low level residues on our food and diet's just more, more important. So we don't see that correlation.

But that doesn't mean the wristband measurements are invalid. It's probably just picking up this low level exposure in the home. And I particularly say that because we have a collaboration with a group at Johns Hopkins University, where they were deploying wristbands in Central America in an

area where they were applying chlorpyrifos in the fields.

And we analyzed their wristbands. And first of all, the chlorpyrifos measurements on their wristbands were much higher than what we've seen here. And they were significantly correlated with this same urinary metabolite in their cohort. And they presented on that at the ISES meeting. So I know they're working on that. And that's in draft and should be published soon. So there's going to be some cases where you don't see a correlation because exposures from the diet. But in other populations, when it's a non-dietary exposure, you could see that correlation.

Then we give the question to you about, you know, can you use these in children? I think just so like Kim Anderson suggested, you know, we can use, we've used these down to age of three in children. But then there's this question about infants, right? They're vulnerable population, very difficult to get blood and urine from them.

So we tried this use of wristband but made it a little bit bigger and put it on the ankle. So an ankle band. So we conducted a pilot study with 21 infants here in North Carolina where we had them

wear one of these ankle bands for three days. The kids were between six to 18 months of age. And here we just asked the parent to collect a spot urine sample sometime during that three day window. So either using one of these pediatric urine bags or one of these toddler body training units and then transfer it to a urine specimen cup. And these were all analyzed in my laboratory. Here's some of the data. This publication was just accepted last week, so it'll be out soon in an ES&T Letters. But we can see for the two main organophosphate esters that we're able to measure particularly in urine in our laboratory, we saw very nice correlations that were statistically significant.

On the right is TDCPP, that chlorinated organophosphate flame retardant. On the left, what you're looking at is the diphenyl phosphate metabolite in urine. And on the x-axis is the sum of all the parent molecules of DPHP. Our panel has a 30 different organophosphate esters in there that we target and measure. So we looked at the sum of these because all of these could potentially break down to diphenyl phosphate and there was a significant correlation.

This also just highlights another

advantage of the wristbands because sometimes with biomonitoring you're looking at a metabolite that has multiple parent compounds, right? So you can't always know which parent it came from, but using the wristbands, you're getting information and all the differences in exposure for the various parents. So that's just one nice advantage about using these wearable technologies.

I still heard someone ask about the variability and measurements around the wristband. We have looked at this as well. I know Dr. Anderson has as well. In our study we said, well, what's the difference if we take a sample here versus a sample here versus a sample here? This is published in our paper from 2022. It's in the supporting information. So we took 10 wristbands and cut three pieces from three different sections and then calculated the percent relative standard deviation. We only focused on chemicals that had a hundred percent detection in every single sample. So we can avoid any biases from imputation. But you can see here for a wide range of organophosphate esters, brominated flame retardants, PAHs pesticides and phthalates, that percent RSD was pretty low. Among those three different samples around the wristband, I've highlighted the 20 percent

mark because that's a typical threshold in many EPA methods. So you can see almost everything was below that.

There was a few that were higher, there was some variability, but overall average was about 13 percent, which is actually pretty similar to the you know, precision measurements you get in a lot of methods using mass spectrometry. So we felt really good about this.

How do they compare to spot urine? I know that this question was asked too. We did do one small pilot project a few years ago where we asked people -- 10 people to wear five wristbands and take one off every day. We also asked them to collect all of their urine, a 24 urine sample each of those five days. So we gave them a very large jug and we did compensate them because I know this is not fun. We also asked them to collect a spot urine sample at different times on those five days. So using the 24 hour urine samples, we can look at total mass excreted over those five days.

And then with these different wristband measurements, we could look at the concentrations on those wristbands over those five days, depending on if they wear it one day, two days, or five days. So

what I'm showing here is actual data for one of our participants for the flame retardant TDCPP. So you can see there was variability in the urine every day and then this rather linear uptake on the wristband.

And then we just compared these, right, spot urine as a predictor versus wristband as a predictor. So the top panels are data for TDCPP and the bottom panels are data for TCPP. Those are two different chlorinated organophosphates. The left is the correlation between wristband and total mass excreted, on the right is a spot urine sample versus total mass excreted. Now when we picked spot urine samples, we had five different spot urine samples.

So you get a very different correlation depending on which day you pick we -- the right I'm showing you here is just day three. It was in the middle. So for TDCPP, you know, the correlation for spot urine was a little bit higher than the wristband, but for TCPP it was lower. But what you see if you use a different spot urine sample, sometimes it's significant, sometimes it's not. And I -- you know, it's 10 people, so we have to take this with some caution. But if you look at the spread of the data with the wristbands, to me that seems a little more robust and linear compared to the

variability you see on the right. Now these correlations are Spearman correlations, which are ranked sums and they're not looking at linear relationships. But this data is also published.

And then we took those samples and reanalyzed them for phenolic compounds, namely parabens and triclosan. And that is also published in the Levasseur 2024 paper. And we actually saw something very similar. Lots of variability depending on what spot urine you pick. But the wristbands actually predicted it total mass excreted fairly well. So they're at least as good as a spot urine, I would say sometimes better.

Now, we couldn't analyze every chemical in our panel in urine. But we did have data in all these different chemicals in the wristbands. This was published in the Samon et al., 2024 paper. I'm just showing you three chemicals I picked out randomly diethyl phthalate, phenanthrene and permethrin. Each line represents a person in the study and what their levels were, depending on if they were at five days, three days, one days, et cetera. Right, so the slope of that line is the difference in their exposure. And you can see for most of these, it's looks like a nice linear uptake.

I will note that there's very different Y scales here on these different chemicals. For example, permethrin is on a log scale. Some folks had a thousand nanograms per gram of trans-permethrin and others had 10. We think a lot of this is actually due to use of pets because that's a really common flea and tick medication in pets. So we often see people with higher levels are pet owners. But you can see, although, so that this is a nice measurement. Now there's some variability. Some people had higher levels on day one versus three. But overall, most people you see this nice linear uptake for many of these chemicals.

So now I wanted to kind of just switch gears and talk about how we've been using these with firefighters, because it -- just as an example of the type of questions we're asking with wristbands I'll start with this paper that was published in 2019. We started collaborating with the Durham firefighters here in North Carolina. And we wanted to ask this question about how different their chemical exposures were off duty versus on duty and even how they were different when they responded to a fire or not. So this was a study that was led by my former PhD student, Jessica Levasseur. And so we had 20 -- more

than 20, but we ended up giving multiple kits to firefighters and just kept asking them to wear one until they completed a wristband or wore wristband for all three periods here, either off-duty or home for six days or working with or without responding to a fire.

And so when those samples were analyzed, we performed some regression analysis on the data. So these are the targeted data results. So what you're looking at here is changes on-duty versus off-duty. So the horizontal line at one, that's kind of a baseline or the average for all the firefighters, their exposure is off-duty. And then the y-axis is a multiplicative change in their exposure on-duty compared to off-duty.

So you can see all of these symbols are above the one line. So their exposures were higher on-duty versus off-duty, which is what you'd expect for these, which are PAHs combustion byproducts. Many of these were statistically significant, which is whether it's filled in or not. And you can see the squares are higher than the circles, right? So their exposures were higher when responding to a fire, which makes sense. That's what we would expect. What was interesting to me is why are they

also higher if they're working but not responding to a fire? So it seems like they had additional PAH exposures, even if they didn't respond to a fire.

So is that because they went to a training event and they didn't tell us that was a fire event? Or is it because they respond to a car accident and there's some exposures, so it's not fire, but it's also work related? Or is it because there's exposure in the station or through the rigs? We just don't know. But to us, this is an important question to ask so we can understand where these exposures are coming from because particularly in firefighters who are worried about cancer risk, we need to do everything we can to mitigate those exposures.

And we use the same approach for brominated flame retardants right here, looking at exposures on-duty versus off-duty. So like the PAHs the BFR's are also higher on-duty versus off-duty. Many of them statistically significant. Some of these are legacy BFR's that have been phased out and some of these are current use alternative BFR's.

But what you can see is here there's not much of a difference between the circles and the squares, which means it doesn't seem to be related to

a fire event. It's just something about being a firefighter overall that led to higher exposures. So my question is why do they have these higher exposures when they're working, if it's not related to the fire? And I don't think we know the answer to that yet. Is it something about the equipment they use? Is it something in the fire stations, the rigs? We're not quite sure. And there is one study with 20 firefighters and we are actually working more with the firefighters to answer some of these questions, but I think that's an interesting one.

And then you'll get something like phthalates and phthalates actually were generally not different on-duty versus off-duty, with the exception of few of these low molecular weight phthalates, which are actually higher off-duty than on-duty. We hypothesize this is due to use of personal care products that they use personal care products when they're off-duty or home that they weren't using when they were on-duty because we saw something similar for some pesticides that are common indoors.

And then we switch to our non-targeted analysis of data. This is with the same fire department although this was the second pilot study. So these are samples that were collected in 2023.

These are not yet published. But I wanted to give you an example of some of the work we can do with wristbands using a non-targeted approach. So here you're looking at a volcano plot where every dot on this volcano plot is a different feature or a different chemical that we picked up in our analysis, right? The x-axis is the bold change and the relative amount of that chemical on the wristband. And here we're differentiating between wristbands that went to a fire and those that didn't go to a fire, right?

And the Y axis is the P value. And so what's statistically significant is in the upper right hand corner, we had 22 features that are not in our targeted panel. One targeted chemical was statistically significant and that were higher in these wristbands that went to a fire. But you can look at the volcano plot, and see there's a skew to the right. So overall there's more exposures that are ongoing within firefighters. Some of these were statistically significant, some of them were not when you responded to a fire and that makes sense, right? And this is only 23 people, so it's still a small number.

We also asked the firefighters to record

the total amount of time they were at a fire. So if we plot that we just here plotted by the median. So the median amount of time our wristband was at a fire in this case was 0.75 hours or 45 minutes. Well, now it's more statistically significant, right? Because you're really separating things that spent longer, closer to a fire. Probably makes sense now we have 75 unknown features and four targeted features that were statistically significant.

And again, you see that skew to the right, more time in a fire, more exposures overall. But what really I found fascinating, which really confused us for a while, is this one where we plotted years as a firefighter. We had quite a range and 23 firefighters, some were right out of the academy, only had been working as two years. And then we had other firefighters that had been there for 30 years. The median was 15.5 years. So here we're splitting at the median. And what you see is that there's much more exposures in the participants that had been a firefighter for fewer years as opposed to more years, which is not what we expected.

Now we've highlighted a bunch of flame retardants in here because I took this slide from one of our talks, but here we have 500 features that were

statistically significant. So this was baffling to us until we started talking to our fire service partners and learning more about what they're doing. And what we learned is that it's often the new recruits that are the ones going into the fire performing the overhaul more active on the scene and it's the fire chiefs and the battalion chiefs that are coordinating farther away from the fire. So we think this may be due to the different tasks they're performing based on their seniority in the fire service. Or maybe it's just that younger people are more active and they have more exposure to things. It is a Pilot study and needs more needs replication. It needs to be looked at some more.

But if this is true, that's, it's an interesting thought because that means maybe some of the exposures that contribute to long -- to the risk for cancer are happening when firefighters are first on the job, maybe over the first 10 years. But I think it's something again that needs to be looked at. And this provides an example again of some of this differences we're seeing in exposure patterns and how you can use the wristbands to kind of glean this type of an insight.

So I'm almost done here. I just wanted

to kind of -- I know there this question came up of how you use these in exposure framework. I know there was a question, can you take them and estimate indoor air concentrations? And I know that's a direction a lot of people are going and I've seen that happen. I think when they're stationary, I personally think that's okay. I know there's been a couple of calibration studies that have already been published.

I'm more thinking that maybe we should be thinking about how we can use the data to predict internal dose using machine learning algorithms and having lots of training sets because the data seems to suggest it's integrating both dermal and inhalation exposure. But on top of that, I worry about movement, right? Because what's happening is this is a flux calculation. Flux are influenced by movement. And I wanted to evaluate this. So I collaborated with my colleague here in the Civil and Environmental Engineering Professor Heileen Hsu-Kim and her PhD student Josh Miller. And what we did is we took these wristbands and we put them on a test tube rotator. And we deployed these in the family room of the house here in North Carolina for 30 days.

And we had multiple of these test tube

rotators with the wristbands going at different speeds. And so we estimated the speed, you can kind of see in this diagram to the right, how we measured the dimensions and then they rotated and they didn't touch anything. They're only touching air, but they rotated at different speeds. And if you look our data, this was accepted for publication just recently. You can see that speed has a big impact on accumulation rates.

So the three -- these are three different chemicals. There's tris(chloropropyl) phosphate, there's 4--tert-octylphenol in the middle because we picked that up quite a bit. And lilial from personal care products from the right. Now first you see that some of these look linear and some look like they're reaching an equilibrium. So it is important to figure out where those occur. But what you can see is if it's stationary, which is the black line versus moving at 1.1 meters per second, which is the green line, there's a very big difference in the rate at which these accumulate.

So 1.1 meters per second is basically a walking speed, right? So if you're stationary versus walking, the rate at which that accumulates on the wristband could be very different, right? And so

kind of using this we estimated what we call an enrichment factor compared to worn wristbands and looked at these relationships. And there was one with KOA. This -- the point being that I think the data suggests that what accumulates on the wristband is a very complex process. It's not solely driven by gas phase partitioning. There's the role of the skin, the dermal exposure, and particularly maybe particles. Now we don't rinse particles off of our wristbands. We do keep them on here. And we've seen some correlations with chemicals that are particle bound. So I think it's just multifaceted and there's a lot yet to un-package on what pathways are contributing to accumulation on their wristbands.

So advantages, I think there's many I know we've already discussed them, right? They're non-invasive. We can use these to measure exposure to hundreds of chemicals over time. You can mail these back and forth. You don't have to have a clinic visit. I like looking at patterns of exposure and I'm really excited to use them in those applications. And lastly, these can help us reach some, you know, isolated communities that may have difficulty participating in research otherwise.

Now limitations as Dr. Anderson already

said, right? They don't work well for metals. I get worried about their use for chemicals that have higher water solubility like glyphosate or very, very volatile, because We just have a tendency to store them for longer periods of time. And I worry about that. And I think it is, I know we mentioned hand dominant, so I was really glad Kim mentioned that.

I think we need to understand that a little bit better for the general population. I still don't know what the difference is if you wear long sleeves versus short sleeves. That's another factor. Physical activity I think has to be looked at. And I think we need to understand more what time points, where do you reach that equilibrium? All of our studies are usually either five days or seven days like Dr. Anderson just trying to keep them. It's also logistically easier. Now our lab is our continues to support some of these other ongoing studies.

We are working with the firefighter cancer cohort study. We also working with the NIH Cure Consortium, which looks at chronic kidney disease. So they have wristbands deployed in six different countries. We're analyzing those in our laboratory right now. And we're supporting

wristbands for two of the five CEECR cohorts, which is an NCI funded study to look at environmental exposures and cancer risks. So those are all ongoing. Certainly want to thank my lab groups has changed a bit over the time and all of our collaborators and funders. And I'll stop there. So thank you for letting me go over time a little bit. Thanks.

ACTING CHAIR CUSHING: Thank you so much.

Tom, go ahead. We'll do 10, 15 minutes of questions and we'll take a quick break before we discuss more.

PANEL MEMBER MCKONE: Thank, Tom McKone. Thanks Heather, that was very interesting. I want to start with just two quick comments. One is, you were talking about chlorpyrifos and in a agricultural community you expected more correlation. I just want to -- I think about a decade ago when we were looking at organophosphates in the Salinas Valley, we found out that the biomarker levels in the women were higher compared to NHANES. And they were systematically higher reflecting that the indoor environment there was equilibrating and accumulating PAHs. And that made up the difference.

So we actually saw that in Salinas where

if it's used locally, your home or your living environment will trap the organophosphates and serve as a nice delivery system to the population so that's consistent. Another quick comment is I have a friend who's a firefighter. They spend a lot of time driving around in their diesel trucks. So I don't know if you've thought about that as the added source for PAHs, you know, if they're not --

DR. HEATHER STAPLETON: That's exactly a question we want to answer.

PANEL MEMBER MCKONE: Yeah, they're always -- they're always out, you know, buying groceries or just driving around in their -- they don't sit in the station all day and even if they do, they run the trucks half the time and get exposed. But the question I have, and this is sort of a broad question that we may discuss later, is, you know, you've really taken us in the direction of showing, you know, how we're moving more and more to using wristbands to be more quantitative to characterize either concentrations or biomarker levels.

But if you could speculate where we are now in having wristbands as a key element of an exposome. I mean, are we -- are we -- are we starting to get there? How many years? I mean, have

you thought about what it might take to actually make this a piece of what we call like the exposome the record of what people are exposed to and a reliable one? And again, I think it's moving there, but you might have a better sense of if it's -- if it's likely to move in that direction.

DR. HEATHER STAPLETON: Yeah. That's a great question. I do know that some of the larger exposomics initiatives in the European Union are including wristbands in many of their studies and they're moving ahead with those you know, NIEHS just funded, you know, one center for exposomics here in the United States. And my understanding is that they are trying to do some inter lab calibrations or harmonization studies to think more about how wristbands can be used in these exposomics studies.

So I do think we're going to see more of those moving forward. Yes. I mean, my personal thought is we can't replace blood sampling with the wristbands, but I think it's an important compliment to have because there's always limitations of blood sampling and urine sampling. Right? But I think we need both of them to understand the full picture.

And personally, I'd love to see us use them to understand exposures and how they change over

time. I get really worried about cross-sectional analyses or just measuring them once a year. I didn't have time to get into it, but we have another study where we looked at variability by latitude and longitude and temperatures and over seasons and you just see very drastic exposure profiles that change. So I just think there's a lot of questions that could be answered or a low hanging fruit by using the wristbands.

PANEL MEMBER LUDERER: Ulrike Luderer. Thank you. That was a really great presentation. I just have a question, you know, related to the firefighters where, you know, when they were not -- when they were on duty, but there was no fire, the levels were actually kind of paradoxically higher, right.

And so I was wondering whether you are have or are planning on looking at things like turnout gear and levels of, you know, PAHs and you know, other chemicals on the turnout gear because I -- you know, as I understand it, they're not always being cleaned all the time you know, from one fire to the other. So just a question about that.

DR. HEATHER STAPLETON: Yeah. We do have -- we have done that we have a paper under review

that's looked at both PFAS and BFR's in turnout gear. And I share your concern that there could be some exposures that are just coming from contaminated gear. Yes. The topic of gear within the fire service is very controversial right now because of the PFAS issue. So it becomes really complicated. But yes, I do think that's a factor that needs and something that needs to be looked further into.

DR. KATHLEEN ATTFIELD: Hello Heather, it's Kathleen Attfield from Biomonitoring California. Thank you so much for talking about the issues about the interpretation of thinking about inhalation versus dermals. You know, what does it represent? Because that's been something that's always confused me. You know, to what extent is this telling you what it's absorbing from the air versus what might land on it from a pesticide spray or use of a personal care product.

But since you already started to address that, I'll ask something sort of similar. What about from sweat or from sloughing of skin, like things actually coming off the body and into the wristband? Is that something you've thought about and how do you -- how do you talk about it?

DR. HEATHER STAPLETON: Yeah, I mean, I

do get the sense that wristbands are picking up dermal exposures. So I do believe that there are chemicals that are in our air, some of them absorbed to the wristbands, but some of them just absorb directly to our skin, right? And so what we pick up on the wristband could be coming from these chemicals that are on the skin onto the wristband. Certainly we see things like squalene and other biological molecules that we know the skin secretes on the wristband.

Now what fraction of that is from dermal versus inhalation is very difficult to tease out. I know of one paper that tried to look at this, that was a group at Indiana University and I think their data suggests that both routes of exposure are integrated in wristband measurement, but it's going to be different for each chemical and it's hard to tease out. I think this is an area where we do need some more research to understand this a little bit better.

I know we're often asked the question like, do PBDEs in our bloodstream -- are we excreting them at our pores, and that's accumulating and that's why we see a correlation? I don't believe that is happening. I think it's more of that we're picking

up the signal from the air or the particles in the air on their wristbands and sometimes those stick to the skin and they are on the skin and then they partition onto the wristband.

Not that we're excreting it out because I just think that the thermodynamics of that, and I'm not a dermal absorption expert, I just think the thermodynamics of that would be very difficult. So to me, the more likely explanation is that our skin absorbs these chemicals as well. And then there's some transfer to the wristband.

DR. MARTHA SANDY: Thank you. Martha Sandy from OEHHA Biomonitoring California. So along those same lines, I was thinking could someone be excreting something in the sweat and it's absorbed to the wristband. And I guess you could look in the wristband for a metabolite that we know is excreted in the sweat and see if you pick it up in the wristband. That's an experiment that could be done. But are you aware of anyone doing that.

DR. HEATHER STAPLETON: I'm not. Certainly, we could ask Dr. Anderson if she she's aware of anything. I haven't come across a lot of studies where they actually identify metabolites of chemicals coming out in sweat either. I know this

has come up a lot in the firefighters because we get this question a lot of whether they can go in a sauna and they'll sweat them out.

I know there's some evidence to suggest that some of the PAHs are reduced on the skin from sauna, but I'm wondering if those are just ones that were on the skin to begin with and were not fully absorbed. I just don't think we know. But I think that's an excellent question and something that should be explored. Yes.

DR. MARTHA SANDY: And a related question. You did say you're wondering about long sleeve versus short sleeve, so.

DR. HEATHER STAPLETON: Uh-huh.

DR. MARTHA SANDY: We know that some clothing is treated with PFASs is and maybe, you know, a variety of other compounds. Have you again, tried to do some sort of a controlled experiment with wristbands and people that are wearing clothing, you know, has something and it's in contact with the wristband versus people that aren't? And do you see -- have you ever done that type of an experiment or I guess this question could also be for Kim later.

DR. HEATHER STAPLETON: We have not. It's certainly been on the back of our mind and it's

on kind of these list of experiments we would love to run if we have enough time. And we started off really trying to understand more about these relationships between wristband and internal dose.

So multiple studies there and then the 24 hour urine study. So we just haven't had time and we don't always have funding kind of to do all these additional validation studies. But I agree it's an important question to ask.

STEPHANIE JARMUL: And we do have one public comment too. Great. We need to get to.

ACTING CHAIR CUSHING: I was just going to ask about that.

DR. KATHLEEN ATTFIELD: Kathleen Attfield again. Same question I asked of Kim. Sort of what are the missteps you see people making in trying to use silicone wristbands and what would you advise us to look out for.

DR. HEATHER STAPLETON: I haven't seen a lot of missteps. I mean, most people are happy to wear them. People often forget to mail them back. We have to remind them. In our case we do normalize to deployment period. If somebody wears them for five days and somebody else wears them for two days, we normalize to per day. Just based on our studies

we seem -- it seems to be fairly linear for us.

So we feel comfortable doing that before we apply statistical methods to analyzing the data. You know, but as I said, there's just -- there's more questions that we have to answer. Like is there variability from the clothing, hand dominance? I get nervous about measuring things that are too volatile because they'll wear it, then they hold onto it, then they'll mail it to us. And I don't know how long it's been around at 25 to 30 degrees Celsius for some of those really volatile chemicals.

So we stick to chemicals where they are a certain range. I know Dr. Anderson mentioned this right of KOW or KOA where we feel more confident that the chemicals are more stable on the wristbands over time and don't go into the more volatile things. I just think what we have to be aware of is there are different methods being used to analyze these. And so that can contribute to differences in what you detect or don't detect just because the methodologies are different.

ACTING CHAIR CUSHING: Rebecca, do you want to invite the commenter online.

REBECCA BELLOSO: Yes. And this comment was submitted by Lily Wu and I'll read the comment.

It says, "Thanks for your presentation. Along the lines of other silicone passive samplers such as infant ankle band, there are silicone brooches that could be more closer to people's necks to potentially get a better indication of inhalation exposures. Do you know of any studies that might compare a wristband versus a brooch type wearable."

DR. HEATHER STAPLETON: Yeah. So I do know that Dr. Miriam Diamond and Marta Veiner, Miriam Diamond's at the University of Toronto, Marta's at Indiana University, they've been looking at that and has -- they have a paper out. I can't remember what the exact differences were off the top of my head. And sometimes it's restricted to like one class of compounds.

But there is some data out there on that. I get worried about using a brooch. I don't think there's anything wrong with it. I think it will work. I just want our participants to wear it for more than a day. Right? And you're changing clothes. So our -- for our -- for us, the ideal situation is to have someone put it on and forget about it. So you don't change your behavior, you don't do anything differently.

So the wristbands are nice in that regard

because you can put them on, go about your daily behaviors, activities, and you don't have to worry about it. But a brooch you're going to have to take on and take off when you change your clothes. And that could -- I worry just a little bit about contaminating it in that way.

ACTING CHAIR CUSHING: We'll do one more question and then take a little break.

PANEL MEMBER LUDERER: Ulrike Luderer again. I just have a sort of a couple of basic -- really basic questions. So one of them is, I mean, have you looked at all whether people, you know with bathing or washing, you know, whether that makes a difference? Are you losing things from the wristband? And also how long, you know have you looked at various different times, you know, that you've stored the wristbands to see, you know, whether the things that you find in them change over time, you know, from the same wristband, for example, do that kind of a study.

DR. HEATHER STAPLETON: Right. We have not done the latter yet. I agree that's very important. With regards to showering and bathing. When we conduct all these pilot studies, we ask that question, how often do you bathe or shower or go

swimming? When we looked at the survey data, we don't see any difference that maybe because most people in our Pilot studies are showering every day. There's not a ton of variability there.

But even the data I presented to you where we started off with five wristbands and we took one of every day, all 10 of those participants were like showering just about every day. And you still see a linear uptake with time. So they're not being washed off. And the chemicals we focus on, again, are very hydrophobic. They're not very soluble in water. So I don't think it's very likely that they're going to wash off during showering or in the pool or things like that.

ACTING CHAIR CUSHING: Great. Well, thank you for an excellent presentation. We'll go ahead and take maybe a 10-minute break.

STEPHANIE JARMUL: Yeah, 10 minutes and we can come back at 2:50.

ACTING CHAIR CUSHING: 2:50. Okay.

(RECESS)

ACTING CHAIR CUSHING: Okay. Welcome back. We will carry on with our discussion on the use of silicone wristbands to complement biomonitoring studies. I'm going to introduce

Stephanie who will help moderate this discussion. So Stephanie Jarmul is the Chief of the Safer Alternative Assessment and Biomonitoring Section at OEHHA. And she'll be walking through some of the potential questions for the Panel and the guest speakers and the audience to consider throughout the discussion period.

STEPHANIE JARMUL: Thanks so much, Lara. So for this afternoon's discussion period, we really wanted to delve deeper into the utility of the wristbands that we've been hearing about from Kim and Heather to complement the Program's, biomonitoring studies, and also some of the issues the Program should consider before deciding to add wristbands to any of our future studies. And to help guide this discussion, we've created some informal questions I'll present on, but we welcome your input on these as well as any other issues that the Panel or audience would like to raise.

So to preface this -- the Program's exploring the possibility of using these wristbands as a potential screening tool to help identify chemicals to consider for biomonitoring. And then to that regard, should the Program consider a semi targeted approach to be used to only identify

chemicals with established methods for biomarkers in humans, whether that's urine or blood or other bio matrices. Or shall we consider a more non-targeted approach that it seems like it's possible to do both? And then are there certain biomonitoring matrices such as urine versus blood versus serum that are more appropriate to pair with the wristbands? And if yes, which chemical groups should we consider for pairing, considering what is on our designated list?

And then are there study designs or populations such as surveillance studies or certain occupational groups that we should prioritize for including wristbands if we are to move in this direction? And then finally, since many of the metabolites used in our studies have half-lives of hours or days, is it suitable to have participants only wear these wristbands for one day to correlate with the biomarkers? There's more questions to come.

And related to the last question, if the wristbands are only worn for one day, then how could we compare our results to other studies where participants generally wear the wristbands for one week or more? I know Kim talked a bit about how you don't really want to compare concentrations on wristbands from different time periods. And so how

can we make this data useful as a program if we are only wearing the wristbands for one day?

And then can we compare chemicals and wristbands from studies done in humid and hot climates, for example, to studies done in opposite climates? I think there's been some research that shows that the different climates can have an impact on the levels in the wristbands as well. And I don't know if Kim or Heather would be able to talk a bit about that. And then we talked also a bit about active air samplers and how they are sensitive to detecting small amounts of chemicals in the air. And this again might be a question for Kim or Heather. Do the chemicals need to be at specific concentrations in the air to be detected in the wristbands? Would it not be as good as detecting small levels in the wristbands?

And then wristbands are used as personal passive samplers. If our resources are limited, can wristbands take the place of air monitoring and our air pollution focused biomonitoring studies? Or do we still need to consider having both? And one more page communicating wristband results to participants. Since the concentrations on the wristbands are not considered biomonitoring results, we are not required

to return participants' results. And so just thinking what would be of most use to the participants and how we should think about sharing the wristband results for chemicals. Should we only share the ones that were also included in their biomonitoring samples? Or if you have other recommendations on how we can interpret these wristband results and communicate them to participants.

And lastly, if we get to some other considerations such as the cost of analyses, best practices for field deployment and additional challenges or limitations we may have missed that you want to bring up for discussion, but we might not get to all of these in the next hour. But we would like the Panel and audience to consider these questions. And Kim and Heather, glad to see you're both still here. And I welcome Lara to start the discussion.

ACTING CHAIR CUSHING: Is there one of those four kind of major areas that are highest priorities.

STEPHANIE JARMUL: Start with the first.

ACTING CHAIR CUSHING: Okay. Then maybe we can just have those questions up so we can --

STEPHANIE JARMUL: And I can --

ACTING CHAIR CUSHING: -- ruminate on them a little bit. Thanks. So please just go ahead and raise your hand if you'd like to comment or question any of these. And I am able to see the -- our two presenters on screen. So if you'd like to say something, please just use the raise hand function on the Zoom.

DR. HEATHER STAPLETON: Okay.

ACTING CHAIR CUSHING: Go ahead, Heather. And then Kim.

DR. HEATHER STAPLETON: I guess I just wanted to ask for a clarification on one of these questions. So the first one says, should a semi targeted or approach be used or use non-targeted, why does it have to be just those two? I mean, there are -- we use fully targeted methods when using wristbands, which I think are best for -- if you're -- it can be supporting a biomonitoring study.

So I'm just kind of confused about why you're saying semi targeted versus non-targeted and ideally personally, this is me because this is what we do. We can do both at the same time, targeted and non-targeted. So I think that provides a wider breadth of information. So I just wanted to -- I was just wondering why it said semi targeted there?

STEPHANIE JARMUL: Sure. So I can give an example. You know, for many of our studies just thinking about our air pollution studies, for example, you know, we're looking at PAHs, VOCs and metals. And so I think we automatically would want to include any that we already are including in our biomonitoring samples.

But in terms of a semi-targeted approach, if we wanted to see if there are other VOCs or PAHs we might be missing or pesticides for example, but we still want to focus only on biomarkers that we already have established methods for, then I think we'd want to do a semi targeted approach versus the non-targeted approach. We could expand and look at chemicals that the Program should perhaps consider developing methods for or adding to the designated list. And for some background, sorry, Kim and Heather the Program can only include biomarkers for chemicals that are on our designated list in our studies. So that's why this is of particular interest to us.

DR. HEATHER STAPLETON: Okay.

ACTING CHAIR CUSHING: I think -- Tom I think Kim had her hand up first. Did you still want to say something Kim.

DR. KIM ANDERSON: Oh yeah, I have the similar question. Why not use targeted methods.

ACTING CHAIR CUSHING: Okay.

DR. KIM ANDERSON: So you know, there's -- and that's the beauty of somewhat the wristband is you could tier it so you could use a targeted method. There's semi target -- like we have a semi-targeted method has about 1,530 analytes in it. And then you mentioned presence-absence. We have a presence-absence method that has like 300,000, but it's still, it's not non-targeted. They're 300,000 in the sense that it's a sort of semi targeted method versus truly non-target. That's -- there are very different questions and in case of Heather's lab, she can do both. So, but they're very different questions. So it's hard to answer -- it's hard for me to answer that question. I'm seeing Heather shake her head. So that's a hard one. I don't know.

It's-- I guess I will say we do see caffeine in wristbands. To go back to an old question, and I'm going to -- in about 80 percent of our wristbands, we see caffeine. So I kind of think that's coming from the skin, not that people spill caffeine on their skin. But then we actually avoided looking for metabolites like metabolites of

pharmaceuticals because we wanted to encourage people to wear them. And that can actually discourage people if they think you're going to look for like drugs of abuse or something. So we've actually purposely stayed away and do not include those metabolites or analytes in our method because it could discourage participants.

Concerning your last question, may the metabolites used in the programs have a half life of hours or days? Are you presuming that they only have an exposure once during the wear time? Because if they're constantly exposed through the wear time, then yes, I mean there's how it gets correlated that's different. And Heather spoke to that. But if it's a constant exposure or do you think it's just one acute exposure and it has a half life of hours or days? Either way there's an answer in which you could use -- still use the wristband. So you can use the wristband on the order of days or longer. But if it's that they're being exposed to it continuously but that it is clearing that's kind of a different question. Heather kind of addressed some of that in her work. So --

STEPHANIE JARMUL: I think it will depend on the chemical of interest. And I think for a lot

of the chemicals that we include in our studies, we're expecting different exposure routes at different parts of the day, which is why the wristband is so interesting because, you know, for a lot of our air sampling, we can only sample, you know, for example, at a participant's home and get the air concentrations there, but the wristband would be able to tell us other exposures that they're experiencing while at work or in their car or doing other activities. So I think we're expecting sort of continuous exposure over the 24 hours, but from different sources. I don't know if that makes sense.

DR. KIM ANDERSON: Yes, it does.

STEPHANIE JARMUL: Which I -- we want the wristbands to -- it would be a better indicator of the cumulative exposure --

DR. KIM ANDERSON: Exactly.

STEPHANIE JARMUL: -- from that 24 hours.

DR. KIM ANDERSON: Right. So that's your question. Wristbands are great. It is a great tool.

STEPHANIE JARMUL: Yeah.

ACTING CHAIR CUSHING: Go ahead Tom.

PANEL MEMBER MCKONE: Well, I want to take a sort of a broader approach to this instead of the specific questions, but the -- I mean the broad

question is how do or can and how can silicone wristbands play a role in biomonitoring? And I think we have to, you know, pose the philosophy view I think we've had since the beginning, which is for the designated chemicals, what we're trying to do is the best job of understanding through biomonitoring and other tools to enhance biomonitoring, what's going into the California population, what's in the population and what's going in.

And we even like to go beyond that and say, where's it coming from? So with that in mind, I think we have to look at tools like this that come along and say, can it help us with this process of saying, okay, now we have biomonitoring data, is there something that would help us make it more reliable, make it more understandable? Because our goal isn't just to go out and take the designated chemicals and make measurements of urine and blood. It's ultimately to gain more understanding and protect the health of the health California population by understanding how to use biomonitoring.

So I think we have to frame this and I think the answer is yes, we've seen examples and I think that has to be kind of a project to explore where's is -- where is it that silicone wristbands

can really enhance or fill in some gaps or help us understand the sources of exposure better. When we have -- like even today we learned there are things where we don't understand why there's differences.

You know, why is this population higher and we're speculating. So we need these kinds of tools when they come along. And if they're demonstrated as their reliability and their feasibility increases, I think we have to make sure they're in our tool set too to do the best job we can in biomonitoring. Anyway, sorry, little philosophical, but I think that's kind of the approach to answering that question.

ACTING CHAIR CUSHING: That -- is that Heather with her hand raised? Okay. Oh yeah, please go ahead.

DR. HEATHER STAPLETON: Well, I guess I just wanted to provide some feedback on the question about wearing one day versus others. I think ultimately it always comes down to the specific question you're trying to ask and answer. I personally don't recommend one day I would recommend, you know, five or seven days if it's logistically feasible.

And would just direct you to the paper

Samon et al, 2024 because that's the study where we started off with five wristbands and then took one off successfully every day. And in that paper we report on the number of chemicals we detect based on the number of days it was worn. And the longer the wear it, the more sensitive it becomes to chemicals that are found at lower concentrations in the air. So I mean, what you measure on the wristbands a function, if it's for inhalation, right, the concentration gradient between the air and the wristband and the physical chemical properties.

So chemicals that are at low concentrations, you're going to hard -- have a harder time seeing them unless you wear it for longer periods of time. And this is exactly what we see for volatile PFAS. So for research studies that we want to measure volatile PFAS, they have to wear it seven days or we're not going to be able to detect it. You wear it one day, you're not going to see it.

But there is exposure that's ongoing and I just think because it integrates exposure over time, and if your question is what's the average exposure, I think five or seven days is going to be better than one day and you're going to have more signal and you're going to be able to measure that a

little bit better. So that's just my perspective and just something to keep in mind.

STEPHANIE JARMUL: Thanks, Heather. And I should note that ideally, you know, we would want to collect a urine sample every day for a week, for a year, you know if we had unlimited resources and participants had unlimited time. So, you know, for a lot of our studies they do end up being more cross-sectional. And so just thinking about if we can only collect one urine sample from a participant, wouldn't we -- wouldn't they only be able to wear the wristband for the 24 hours previously because that would correlate with the levels that we're seeing in the urine or do you think that we could still have them wear the wristband five days prior to collecting that one urine sample at the end of that five-day period.

DR. HEATHER STAPLETON: But it sounds like maybe you're limiting yourself to what you're measuring in urine and if you're doing that, and if you're sure of the half-life and the chemicals, then maybe that's okay. But not all chemicals are -- have half lives under 24 hours. Sometimes they're longer.

STEPHANIE JARMUL: That's true. I guess it depends on the approach we take. If it's a

screening tool, then they could wear it for much longer. I mean, ideally, perhaps they'd wear two wristbands, one for one week and then one for one day. And the one day one would correlate with the urine and the others would be used more as a screening tool to identify other chemicals we may have missed.

DR. HEATHER STAPLETON: Or you might need to measure wristbands like three days and then collect the urine samples right before it. Because the urine may be picking up chemicals or the exposure occurred in the few days previous to where you collected that urine sample.

STEPHANIE JARMUL: Yeah.

DR. HEATHER STAPLETON: I see Kim has her hand up. I'll let Kim speak.

DR. KIM ANDERSON: Yeah, no, I agree. I mean I just -- I guess it comes down to what's the important question. If the important question is to really get the strongest correlation between a short half-life metabolite and the wristband, then you'd want them to match up. If you really believe it's a half day, you know half-life. I think you limit yourself for the reasons that Heather said. And I had said earlier that by doing short wear times, you

are limiting that you're not going to pick up as many chemicals. And if you're trying to understand the breadth of exposure to, to identify new chemicals of exposures understand that, you know, that bigger picture you're limiting yourself.

But again, if that's the most important question, then you would try to design the study to match as much as the information as you have. But if you want to take advantage, you know there's some other things that could happen there as far as taking advantage of the wristband technology as far as additional chemicals, all the things we've talked about.

ACTING CHAIR CUSHING: All right I'm going to call, I'm going to call on myself. This is Lara Cushing from UCLA. Yeah, I think to me the beauty of the wristbands is really not to try to replicate what we're doing with biomonitoring, but to perhaps elucidate novel compounds, co-exposures, you know more of the exposome type idea in a surveillance project.

So I could see, and I don't know how this lines up or is feasible with our restriction to designated chemicals, but if these could somehow be used to perhaps identify populations or identify

chemicals that have not been a focus but need to be a focus due to their ubiquity in the California population, I think that would be really amazing. Who -- sorry, I lost track of hands. Ulrike, why don't you go ahead.

PANEL MEMBER LUDERER: Yeah, I mean, one, one thing, you know, you were talking about populations and occupational groups, so obviously occupational is near and dear to my heart. One of the things that I was thinking about is it seems like these wristbands would be great for monitoring you know, people who say farm workers who are, you know, not -- it's not going to be very easy to, you know, get blood samples and, you know, do multiple samples or, you know, sample over time.

And you could do that, you know, having someone wear a wristband is not asking, you know, a lot of them, you know, they don't have to do the types of things that they often, you know, you might have to do for, you know, if you have to come in for blood sampling or urine or whatever.

And then also I was thinking, you know, when we were talking about the BiomSPHERE and those, you know, it would be really interesting to compare farmer, you know, people who are actually working in

the fields versus the families and, you know, looking, you could assess, you know, maybe exposure to pesticide drift and things like that by -- so I just think that this would be a really great tool for different populations and that's just one that came to mind.

ACTING CHAIR CUSHING: Jenny.

PANEL MEMBER QUINTANA: I was going to basically say what you said, Lara. It's a comment, but I -- just to build on what people have said before, I think the purpose is important. So if it's sources, I think the firefighters study was really interesting because it had wristband when they were doing one activity, going to a fire and then wristband when they weren't, and it allowed them to look at those exposures separately. So that would be one way to do it, to actually have different, you know, wristbands being worn or taken off and put back on or whatever. Kind of for understanding sources in the -- understanding dangerous occupation -- occupational activities for example.

But also like Kim said, if the behavior is stable, it doesn't matter if it's a short half-life because it will correlate well with a seven day exposure, you know, so for example, cotinine,

again, metabolite of nicotine is only 17 hour half-life, but it's extremely stable in people very, very stable because of exposures to secondhand smoke or whatever tend to be very reproducible, but not always, you know, there's kids that see grandma once a week or so, there's value of looking at, you know, seven days like Heather said as well.

So -- but I think that getting back to what you said, how does this add value to what we already do? I think it's important because when I first read the last bullet point, I was thinking in terms of kind of validating in a sense the wristband versus the urine. And I think maybe that's why you wanted the thing, but maybe we don't want to do that. We want to have another reason for doing it, I guess.

STEPHANIE JARMUL: Thank you for those comments.

ACTING CHAIR CUSHING: Oliver?

PANEL MEMBER FIEHN: Yeah. So I would like to say one thing that I think is not quite clear yet. And that is the cost and the opportunity here. So one thing that you do when you have blood or urine taken is that you have significant cost in collecting the samples. You have to have phlebotomist, for example. You need to reach the people or people have

to drive someplace.

And with the wristbands, I think it is much easier to do a much larger scale study. You know where it's much less costly to do, you know, a study on a thousand people for example. And with that you get a lot more statistical significance. So I think we should not try to mimic or directly replicate what you find in urine or plasma, but rather saying, you know we want to know what people are exposed to.

We want to know the different populations in California. And that gives us an opportunity to do so. And in the sense of what to report and how to report back to participants, that's an interesting question, but at least we can say, look, we have large suspect screening lists. These are the ones that we usually don't report on because we usually go for something in plasma or urine, which is very hard to detect, very low abundant, and we don't often see it.

So that's why we need very dedicated methods because of the turnover in the body. But with wristbands we can accumulate and we don't have the problem of enzymatic degradation like we have in humans. So we have opportunities to do much larger

scales across California in different populations, including in vulnerable populations like children. So I think we have a lot of win-win-win situations here and I would highly recommend trying this route for specific questions.

STEPHANIE JARMUL: Thank you, Oliver. I do want to mention though or reminder to the panel too though that I -- we are a Biomonitoring Program, so I think we still have to include biomonitoring regardless in all of our studies. And so then it's how can we add on the wristbands to complement those studies? And maybe it is that we should think of it more as simply a screening tool, and so we don't have to think so hard of how to correlate it with the measurements that we're seeing in our biomatrices. I think that's what I'm getting from this conversation.

ACTING CHAIR CUSHING: Kim and then Tom.

PANEL MEMBER MCKONE: I just was.

ACTING CHAIR CUSHING: Oh, sorry. Okay, let's do Tom and then Kim.

PANEL MEMBER MCKONE: I mean your statement that it has to be biomonitoring to use it. I think it's important to recognize that we have used non biomonitoring types of studies to designate chemicals, right? So it is -- I mean, given our

precedence, we did like for siloxanes, I think as a class, we didn't look at biomonitoring to decide to list it as something we wanted to Biomonitor.

We looked at the growing use of the chemical and the fact that it was showing up in different samples, not biomonitoring samples to say we should Biomonitor it. I mean, it's kind of like chicken egg in a way, but I mean, if we did a wristband study that found chemicals that we hadn't thought of before showing up all over the place, that would enter into our process for designating, which we haven't really used a lot lately. But early on that's all we did all the time was we were building up our lists. So we were doing a lot of studies where we did not use biomonitoring to decide to Biomonitor.

STEPHANIE JARMUL: That's a great point. Thanks Tom. And that is also what we were thinking of using the wristbands for potentially as well. And that's where the question came from if we should use semi targeted or non-targeted analysis. And it sounds like maybe we should use a more non-targeted analysis to identify chemicals that we might want to add to our designated list.

ACTING CHAIR CUSHING: Kim, did you still

have a comment.

DR. KIM ANDERSON: I think I forgot my first comment, but as far as I can't remember. It'll come to it back to me. Yeah, I guess I kind of doubled down on the idea of what is biological monitoring? This is measuring and a biological exposure. So it -- I guess it depends. It's a fine line, right? And how you define biological monitoring. I think you are measuring a biological exposure, which is the intent, but it's also the ability to explore, which I think someone, Tom maybe just said, explore new chemicals, right.

I mean, the idea is to understand that exposome that hole, which is more complicated than just chemical exposures, but you know, just living in some really finite space with, you know, a blood or a urine sample is really putting your blinders onto a whole lot of exposures of chemicals that might actually be more important.

I -- you put this page up. Thank you for putting this page up because I couldn't remember all of your questions. We've been reporting back to the community for a decade now. First of all, they love wristband results. They're not overwhelmed with the fact that this is new technology or that there isn't

a clinical level that says, oh, this means you have high cholesterol, or this means your cholesterol is okay. They really do with proper, you know report back, understand the idea that this is a new technology and they like, but they -- what they do like is that they want to see everybody else relative to themselves.

So we do tend to always include, this is you and this was everyone else that we did. And that is incredibly satisfying for folks. They understand, oh, I'm high. Like what are some, like I'm high. And then we can talk to them about, do you burn incense? Do you have a natural gas stove? Do you -- you know, do you have candles? You know, in the case of PAHs, you know, or I'm low compared to everybody else. It really is a very important engaging conversation. And it doesn't have to be about a clinical level defined that you have cholesterol above this level or cholesterol below.

So I get that it's not required to report back, but I find that the participants really enjoy it and they get over what I think we are paralysis by analysis scientists that we don't have all these questions answered. They don't even think about all these questions. They're like really wanting to know

like, hey, these are -- these are chemicals I didn't even know I was exposed to. Where do they come from? How might I change or how might I not change? So I find that it's been very rewarding to report back results and, you know, I would strongly encourage it.

STEPHANIE JARMUL: Thank you, Kim. I'll just mention that we have a similar approach to our biomonitoring results return packets where we share participant results to others or compare participant results to others in the study. And it's nice to hear that you've had positive feedback in doing something similar for the wristbands.

ACTING CHAIR CUSHING: I saw Martha had a comment and then Amy.

DR. MARTHA SANDY: Martha Sandy. Oh yeah. Maybe just the terminology. It -- the wristbands are really a nice way to figure out what people are coming in contact with. So it's better than a stationary air monitor, which is, you know, an improvement on that is something in measuring air in your house and just outside your house. An improvement on that is putting a personal air monitor on your lapel and walking around all day, or a backpack. The wristband is capturing more, but measuring a chemical in the body, in the urine or the

nails or the hair or the breast milk or the blood is biomonitoring. So we do have these different terms that we have to deal with. And I -- we are thinking of how do we use wristbands to identify, as you all discussed, other chemicals we should be considering measuring in our biological fluids.

And maybe adding to the designated list if we need to because we're seeing that people are exposed because it's on the wristband. So perhaps our terminology, the way the Program is using the term targeted versus non-targeted or semi targeted is confusing to the analytical chemist because we -- you know -- we had -- we -- our wristbands, we did a small pilot study that you'll hear more about -- you've heard a little bit about, you'll hear more about at another meeting. You know, there was a set -- it was targeted for many different chemicals, but we -- they didn't necessarily correlate with the chemicals we were measuring in those people in the biomonitoring study we were doing.

So I think maybe our use of the term semi targeted or non-targeted is we were misusing the term when analytical chemists call -- say that. So I just wanted to clear the air on that. That's all. Thank you.

ACTING CHAIR CUSHING: Thanks, Martha.

Amy?

PANEL MEMBER PADULA: Amy Padula. I guess I just had a quick comment just to, in concert with, I think what most everyone else is saying that I agree that having a, you know, a longer term sample of -- with the wristbands would be a really kind of illuminating to be able to kind of a broad scope. And I think also is just to get away from the idea that this one -- this kind of urine sample is our gold standard is I think a kind of misconception that we maybe are holding onto. I mean, I think of course we naturally compare. It seems every study we've read shows the comparison, but if we're going to move forward, I think this seems like a logical direction. I also wanted to bring back what I think both Kim and Heather mentioned that the, you know, the day of the week really matters.

And so then the one day really kind of makes -- it's problematic in that sense. The one question I had about the report back, I agree that showing people's value in relation to everyone else is a -- especially in a graphical form, is a really excellent way to convey that information, especially when we don't have levels or standards that are

considered high and low.

I was curious, given the number of chemicals that are usually measured in the wristbands, I was wondering how you decide how many -- which ones, I know there's -- I know you've mentioned hundreds or even thousands of chemicals. This is something we're trying to sort out and I was just curious how -- what -- how to deal with the volume of chemicals for the report back and that was directed towards Kim, if you don't mind.

DR. KIM ANDERSON: Yeah. So we usually have a one pager that summarizes the study and then we have an individual report that gets generated for each individual. So the summary, oftentimes I'll pick out two or three, usually like three, I don't know why three chemicals where I feature just what those chemicals were, where their typical sources are, and the individual report that the person gets -- which just gets generated on the backside of that.

We can -- we -- it's actually not that hard if you write laboratory information system. So we generate a plot for all of them. It's like where you are versus where the rest of the group was. So we actually do include that, but a lot of times we feature, for instance, a PAH, that's -- we do a lot

of those and we feature like if you -- and so you can go back and look at your data, your individual data, and you can see how you rank are sort of in the spill of data.

And then on the one pager there'll be featured ways in which you could reduce your exposure, but they actually get like a one pager with, with some interventions and then they get their individual report and individual report shows everything for them relative to the group.

So each one has a little dot. And here's the rest the group. I can have, I can connect you with Diana Rohlman, she makes all these for us if you're interested. And she can send you some examples of we've used, that's with when we used the really big method, like if we were just doing PAHS, that's sort of different. Or if we were just doing phthalates or something that's, you know, it's smaller. It doesn't take that much to do. It's kind of push a button at this point for us because we haven't already coded.

ACTING CHAIR CUSHING: Thank you.

STEPHANIE JARMUL: We do have a couple of online.

ACTING CHAIR CUSHING: Great. Let's move

to the online comments and questions.

Jianwen, did you want to unmute?

DR. JIANWEN SHE: Hi, it is Jianwen again, thank Kim and Heather for excellent talk. And then also thank you everyone for discussion. I learned from this talk, I also think what's the Biomonitoring Program's purpose? We look for the source, we look at the time trend. Does the key -- does the wristband help to address these questions.

We look at the environmental component, monitoring air, water, soil. Does that help to address questions regardless which compartment we monitor, we can't share the common objectives. So we showed a lot of look at this approach separately. We need to integrate them together.

So what I see, at least like many people already talked this complement advantage provided by wristband, biological sample doesn't have a time delay and for collecting blood and the urine we cannot do large scale studies and the band, wristband maybe provide pre-warning systems, also can monitor the trend, monitor the interventions and effectiveness.

I think the programs needed to consider from the objective of the biomonitoring and the

environmental monitoring and the active sampling, passive sampling that we all address the same, try to go to the same place. So I like to thank the presenter and for also think suggest the Program to comprehensive overlook this -- this possible and valuable tools. Thank you.

STEPHANIE JARMUL: And thank you Jianwen. We do have one question from Beth. She said, "I noticed the bands are labeled with -- labeled with embossed and colored ink lettering. Do those chemicals need to be considered that are used for the coloring of the wristbands?" That might be a question for Kim or Heather.

DR. KIM ANDERSON: So we don't usually put paint on, we don't usually paint the wristbands. We have different colors and then we just press the study, whatever we're going to put in the study line so we don't put paint. We went through this with about 20 plus colors where we tested.

So we have this whole process for testing background after we're done processing them elasticity, you know, right? There's all these good manufacturing practices that every batch gets tested and every batch gets samples actually put into archive in case anything comes up from that batch

that we've produced. And after about 20 chemicals we stopped.

However, you know, it's one of those you can't prove the negative. So I finally, you know, everyone wants to their own special color. I don't actually let people choose anything beyond the 20 I've already tested because like I'm kind of tired of doing all that. It is a lot of work to test every color and every situation because there's a QC question in here too that, that Heather and I can answer. So we did test all those, but I admit I don't add any more colors to my set colors that I offer people.

DR. HEATHER STAPLETON: Yeah. And I just wanted to add onto that, that we're always analyzing field blanks anyway. And so field blanks, if there is something in the coloring or a dye that doesn't come out during the cleaning process, most of those come out in the cleaning process that some of them that they remain, they're accounted for in the field blanks. So we've never had a problem with it.

We, like Kim only use a handful of colors. I will say though because I just -- because I found this interesting. We did have a group that really wanted to use yellow wristbands and when we

cleaned them and analyzed them, we found PCB-11, which I think was in the yellow dye in there.

Now it was really low level and we can account for it in field blank, but it was just interesting that it popped up and we saw that. So it is something to be aware of, but we always account for that with field blanks and checking them with the cleaning process.

DR. KIM ANDERSON: Yeah, we don't use, we don't use yellow either. Concerning the QC question, so I -- as I mentioned, about 30 to 50 percent of our samples are QC. We usually do triplicates in the field. We do trip blanks, field blanks. Those are two different kinds of blanks. We do extraction blanks. We also have from every batch that we make, we include one of those. We have prep blanks. We have on instrument blanks and CCV. So we do a CCV continuing calibration verification every eight to 10 samples.

And so all of those are sprinkled all through there. Somewhat to my chagrin because the staff are analytical chemist with a big a-n-a-l apart as in and it's very costly. But the -- I'm always saying we don't need to run that much QEC. We know these, we can -- we run fewer blanks, but I get the

-- it's a safety -- it's a safety blanket for them. They're Linus, they want to hold their blanket. What else was in here? I think -- I think that's it. And all that information also gets included if you want in a report. Yeah.

ACTING CHAIR CUSHING: Thank you. Are there any more questions online, Rebecca or Stephanie? No. Okay. I had one. Okay. I wanted to follow up on the report back. I'm curious, so I think, Heather, you mentioned earlier that you normalize sometimes by the amount of time somebody wore the wristband if there were slight variations.

So is that kind of standard since Kim you emphasize that people really like to see where they stand relative to others. If people, you know, took it off a day or two later than instructed, how do you handle that in the report back? So that's one question.

And then the second question was, and forgive my ignorance here, but I'm guessing the units on the results are like, you know, micrograms per gram of silicone or something like that. So for analytes, where there are -- where we do know certain concentrations are hazardous in air or in the body, I know this is a little bit different. It's not

biomonitoring, it's not internal dose, it's not ambient to air. But can you speak a little bit to how, for example, we have, you know, a practice, if we see really high levels of something in somebody, you want to follow up with them and let them know.

So are there kind of levels you've established where you would become concerned that someone's extremely exposed and needs to be followed up with? Or can in some way compare sort of the units of measurement that you end up with to regulatory or health-based benchmarks?

DR. HEATHER STAPLETON: Well, I'll go first and then over to Kim. I know there was a lot of questions in there, so I hope I can remember them all. When we first started reporting on wristbands in our lab, we were reporting on nanograms of chemical per gram of wristband.

After we did that study, the Samon el at, 2024 study where we looked at accumulation over time and just saw that there was a strong almost linear dependence. We have now moved to doing nanograms per gram per day in all of our statistical analyses and how we report them. You know, previously we made sure there wasn't a lot of variance in the deployment period, right? So if it wasn't more than 20 percent

we usually let it go and left it nanogram per gram.

Now I become more convinced, at least for the chemicals we monitor, because I think they are in the linear phase and there is some variability depending on deployment time. We do a nanogram pre gram per day and that's how we report them and share them. But like Kim, I do think it's important for the report back, you know, we have some studies where report back blood PFAS levels and then we have some with wristbands.

But both of them, you know, they look for that strip chart, right? That strip chart is comparing them to everybody else. And that's exactly what they hone in on and they want to know are they at the top, the bottom or the middle of the pack. So I completely agree with what Kim said. I think it's valuable and that's really what they want to know.

Not, you know, even with PFAS, I don't think they care as much am I over the Nassim clinical guidelines of 20 nanograms per ml? They want to know if they're in the middle or in the high ends. So I just, I do think there is some value to report back there, keeping it on that basis. But I do use nanograms per gram per day. I'm probably forgetting the rest of your questions. If you want to remind me

or we could have Kim comment as well.

ACTING CHAIR CUSHING: I think you pretty much hit on it. So you normalized by the amount of time they wore it. That was my first question.

DR. HEATHER STAPLETON: We do.

ACTING CHAIR CUSHING: And the second one was if you have any strategies for kind of comparing your units to regulatory or health based benchmarks for at least some chemicals and/or like flagging particular individuals who are off the charts that you think need to be followed up with. Because there's actually like an acute health risk.

DR. HEATHER STAPLETON: Sure. We don't actually put them into the framework right now. I don't think we've had the case where we measured some exposure that was really, really high that we were worried about. You know, sometimes like in the firefighters we'll see really high exposures to some of the -- in one case, we saw really high exposure to some of the flame retardants, but there's nothing they can do about that.

And I don't want to alarm them because they've already been banned. And some of those exposures are probably coming from legacy products. And we don't really have a threshold in blood, right?

So we haven't been confronted with that yet. And I think that's something that needs some attention if they're going to be put into that framework moving forward, for sure. I don't know if Kim, if you have additional thoughts on that.

DR. KIM ANDERSON: So we usually give the results in like nanograms per gram wristband because our screens do flirt with both ends of those equilibrium and curve linear areas. So we're oftentimes really broad chemicals. We do have Steven O'Connell put a paper out where we have a pretty good idea where the break is between dermal and air based off some chem phys properties and some other things that we've done with controlled exposure studies in exposure boxes.

And so we have a pretty good idea. Is it a inhalation or is it dermal? And where we're going is we're adding performance reference compounds. Those are essentially internal surrogates. And so it gets at things like do you run all day or do you sit all day? Or are you in the sauna all day or are you in the Antarctic all day? So the performance reference compounds essentially benchmark you into where you are because those dissipation rates for a few of those could be then modeled into the rest of

the compounds. And that's done with all the other kinds of -- many of the other kinds of passive samplers. So we're working on that.

But right now we're giving like nanograms per gram wristband to our clients. Most of our -- I think almost all of our chemicals don't really have like a level that's part of the story is that we're -- the chemicals that we're finding that are in 93 percent of the wristbands actually don't have a level. And so that's why the story becomes how are you relative to everyone else? What are the sources of these chemicals? And so we really haven't gone into that space yet.

PANEL MEMBER PADULA: We could share.

ACTING CHAIR CUSHING: Yeah. Amy.

PANEL MEMBER PADULA: One question I had for Heather, this is Amy Padula. You know, I was impressed with how many chemicals are, how are able to be analyzed and also how you kind of cut the wristband up to be able to do it all. I was wondering, you know for the Biomonitoring Program, whether there are certain classes of chemicals that you would prioritize over others based on your experience of analyzing so many different ones. Like I guess, you know, with other studies there seems to

be a lot on pesticides, but it seems like other ones haven't been done as much. I was wondering if you had any thoughts on that.

DR. HEATHER STAPLETON: Yeah, sure. I guess based on our experience I know pesticides come up a lot. I just think we have to be careful with pesticides because some of them are exposures all diet and so we don't pick up a lot of them. But there are some pesticides that are used in building materials. So azoxystrobin for example, is a fungicide that's applied to drywall. We picked that up actually more commonly than I would expect, which I think is coming from an indoor source.

But then you look pyraclostrobin and that one's really more food and not in building materials and we hardly ever picked that one up. So I think we just have to keep in mind what we look for. Again, you're focusing on those exposure routes that are more inhalation, dermal, indoors. And so you're going to miss things that are coming from diet.

I do think pesticides are of interest. There's a lot of, you know, new use pesticides out there, but there's so many of them. Ones that have -- I think are really interesting are some of these volatile PFAS that we're seeing in indoor

environments that haven't been well studied.

There's also, we're seeing a lot of -- I think I showed it in one of those plots, 4-tert-octylphenol and nonylphenol, which I know there's a lot of attention on those back when I was a PhD student, but it kind of fallen off the radar. We see very high levels of nonylphenol in almost every single wristband we measure. And I am wondering if that's coming from breakdown of an antioxidant that has a nonylphenol substructure in it as a used in some plastics. I'm not quite sure. We typically think about that being coming from like detergents, but we have phased those out of detergents a long time ago. So I don't think they're coming from detergents. I think there's probably another source.

But plastic additives in particular I think are a big class of compounds that need a lot more attention. And we pick up quite a bit of those, whether that's a flame retardant additive or an antioxidant, dyes, stabilizers, vulcanization agents. There's a whole slew of these that I think have been understudied that need a lot more attention as well.

So those are the few, and I'm kind of biased to the flame retardants. I think there's still some interesting things to focus on for some of

the flame retardants. Particularly, we focused a lot on uses in furniture, but there's so many used in the electronic sector that we don't know about. And so I think, you know, more attention on those would be helpful as well. So those are just some of my initial thoughts.

PANEL MEMBER QUINTANA: Hi Jenny Quintana. I was just -- I have a very practical question. You showed that very nice Mylar bag and little tin, Heather, for mailing to people. How do you instruct participants to prepare a field blank? Do you tell them like, open the tin and touch it and pick it out and put it back in and mail 'em separately or, you know, we've had a few participant related mixups where everyone does it apparently well, and then suddenly one of the exposed ones is very low and the field blank is really high. I'm just curious how you -- how you do field blanks for those mailed in participant studies.

DR. HEATHER STAPLETON: So in many of our studies we're doing consenting in these community settings or specific site, and that's where we hand out the kits. And so we bring field blanks with us to those sites in the same packaging and in the same materials. And then once we hand it to our

participant, we give it to a participant with a self-addressed stamped envelope to mail it back to us, you know, maybe the following week. So in those cases, we're just taking field blanks with us to those community events. Usually we try to open and close them and put them back in the tins and then we bring them back to the lab and that serves as our field blank. We do not send a second wristband with all the participants. Although that's something we've talked about.

But I'll say in my experience, we haven't come across big issues with field blanks compared to what we measure on the wristbands. You know, we certainly monitor them, blank, correct, we estimate our detection limits based on the field blanks. We do run laboratory processing blanks as well.

But they haven't really been an issue for us, at least for the chemicals that we monitor in our targeted panel. So that's, you know, that's typically how we've been handling it. I'm sure there are better ways to do it. But and we do have a lot of collaborations with other groups across the country and so sometimes they do things a little bit differently than what we do, but so far it hasn't been an issue.

PANEL MEMBER QUINTANA: Thank you.

ACTING CHAIR CUSHING: Sorry, you said there were a couple online or these two that I see before me. Okay, great. Nerissa.

DR. NERISSA WU: I think Kathleen had her --

ACTING CHAIR CUSHING: Okay. Kathleen.

DR. KATHLEEN ATTFIELD: Kathleen Attfield. Back to the results return type of questions. So we have the situation where we're picking up both the concentration in the air and perhaps the dermal deposition but also the absorptive capacity of the wristbands, of course, which is going to be different for all your different chemicals. So I'm just thinking like not only do participants look at where they are for each one and that kind of normalizes it, right.

But we've also talked to our other biomonitoring colleagues in other states and they say people also look, okay, which one's has the highest numbers. And so then you have sort of two things feeding into what makes the highest numbers. So wondering if you've had to communicate on that aspect at all to participants.

DR. KIM ANDERSON: We really have not had

a lot of people ask about the numbers. They barely look at the axis. They just look at where they are relative to the axis. Again, there aren't regulatory levels even in air for most of the chemicals that we're looking at. Like if we look at a host of Alkylated PAHs, which are very abundant, other types of chemicals, fragrances you know a lot of personal care products, et cetera, there aren't regulatory limits.

So the numbers are -- don't really mean that much. I -- you know, if really if the numbers, if you feel like they're going to be distracted by the numbers, really don't have to put the numbers on there if you felt it was a distraction, right? It's just really to communicate that you're in the pack or you're high relative to the pack. And these might be the sources that you might consider reducing in your -- in your life to reduce your exposure.

DR. NERISSA WU: This has been great. Thank you so much for everything you've presented. I think we have a lot to think about for the Program in terms of, you know, what is and isn't biomonitoring and how do we deal with our designated list. But one of the real logistics for us is the cost of adding new panels, the methods that we have and, you know,

the time it takes for to turn around results to our participants because we try to get things back to people within a year. Are -- can you talk a little bit about that in terms of how you work with other collaborators about the costs and how they compare with some of the -- some of the more traditional methods that we see.

DR. KIM ANDERSON: Right. So for us we usually cut the wristband in half, archive half and extract half. And the reason I extract half is because my PAHs method, my alkylated method, my flame retardant method, my phthalate method, my pesticide method, my OPH method, chlorinated paraffin method, my massive method, they all come off that one ml extract. So I just aliquot out and go to all those different instruments. So there's a cost savings, I only have to extract the wristband once.

So they go to all those. So there's -- if you do more than one method, you get a discount. Because I'm only extracting it once. The purge and trap would be different because that has its own, that -- then consumes the wristband for the purge and trap method just like it would for a water sample or otherwise. Typically, we like to get samples out within 30 to 60 days. You know, we had 450 samples

here. We had them here for like 10 days. But those are because they're using methods that are turn the crank kind of methods for me. It would be different if there was a method development or something.

But you're talking about probably doing one of our methods that are off the shelf. Other commercial laboratories I think would be under 30 days, typically not Antionia's at CDC, she's much longer, love her, but she's long. But for us it's usually 30 to 60 days.

DR. HEATHER STAPLETON: Sure. My situation is probably a little more complicated. My lab is part of the NIH, Human Health Environmental Analysis Resource or HHEAR, which is going to be sunset, but it's still running right now. And because of that, I have to set my lab up as I can't do fee for service. So we have to write subcontracts and be part of funded studies to support any analyses in my lab because the lawyers consider it an audit risk.

So when I collaborate with folks, it's usually through some kind of subcontract on a NIH grant. And we kind of give them a budget based on the number of samples and what kind of panels they are interested in. And so the numbers I'm about to

give are for direct costs because then Duke adds on the indirect costs on top of that as well.

So we start with our basic panel, that's just the extraction on the electron impact mode, which does that targeted panel that I talked about for BFRs and PAHs and phthalates and pesticides and things. We charge $250 a sample for that one. If you add on the injection into the NCI instrument for the brominated flame retardant stacks and furans, it's an extra $50 per sample. If we add on the volatile PFAS, it's another $50 a sample. And then if we do both targeted and non-targeted on those samples, then it's $500 a sample. So that's our current rates. We'll likely have to adjust those.

But like Antionia, we have a large queue because we are supporting analyses for all these other programs and consortiums right now that we actually have a queue of samples to run that will take us through at least next summer right now before we can do anything else.

Now we do provide wristbands to a number of collaborators because, you know, we ask them to buy the wristbands and then ship them to our lab and we just clean them and put them in the Mylar bags and tins and then return them to them for use in their

studies. And if it's a small number of samples, less than a hundred, we usually do it at no cost. If it ends up being hundreds to thousands then we set up a subcontract and they help buy some supplies for that.

But the cost of the kits that we prepare are under $5 a kit. They're not that expensive. When you account for the labor and the raw materials are very small. It's the labor and just packaging them. That takes time.

ACTING CHAIR CUSHING: Thank you so much Heather and Kim. This is -- I personally have learned a lot and I think this has been a very valuable conversation for the Biomonitoring California. We're going to have to move to our open public comment period. If there are no open public comments, we might have a few minutes for another question or two.

But let me pause here and announce that we do have time allotted here at the end for open public comment during which commenters can provide comment on any topic related to Biomonitoring California. Webinar attendees can submit written comments and questions via the Q and A function of Zoom or by e-mail to biomonitoring@oehha.ca.gov and we'll read them out loud. Or if you wish to speak,

you can use the raise hand function and Rebecca will call on you. And if you're attending in person you wish to comment, please come ahead -- come to the front or raise your hand so that I can call on you.

Rebecca, do we have anyone online wishing to comment?

REBECCA BELLOSO: No, not at this time.

ACTING CHAIR CUSHING: Nerissa?

DR. NERISSA WU: So just to move us away from the wristbands for a minute, I want to make sure we had time if we spoke about speciated arsenic and phenols this morning. And we're looking for input if you have ideas for any additional analyses we should be doing or partners who might be interested in working with us. Particular subject matter experts whom we could talk to about either arsenic or phenol.

So just wanted to remind you that that's an outstanding question. If you have thoughts, we could either bring the conversation there or reach out to us as a program later. I know there are probably lots of other questions about wristband.

ACTING CHAIR CUSHING: Any thoughts on that -- on that question about arsenic and phenols? I mean, I will just off the top of my head say I haven't given it much thought, but you know, similar

to the work that was done, looking at PFAS and drinking water, seems like that would be worthwhile to do something similar with the arsenic. Especially if you have some geographic variation in where you're CARE-2 participants are, there's 200 water systems in LA County, so there is quite a bit of variation in arsenic. It might tell you something about the source.

Anyone else in the public wishing to speak online or in person?

REBECCA BELLOSO: No, we haven't received a request from the public.

ACTING CHAIR CUSHING: Okay. So I guess we can just open back -- sorry. Okay. So we have five more minutes. We can return again to the question of wristbands or this question about arsenic, phenols or anything else if anyone has remaining thoughts or comments to share.

Okay. Well, then we'll go ahead and wrap up and adjourn. Thank you everyone for participation and to the staff for their fantastic presentations and to our guest speakers for everything you've shared. Now I will -- a transcript of this meeting will be posted on the Biomonitoring California website when it is available. And the meeting is

adjourned. Thanks.

(Thereupon, the California Environmental Contaminant Biomonitoring Program, Scientific Guidance Panel meeting adjourned at 4:00 p.m.)

STATE OF CALIFORNIA)
) Ss.
COUNTY OF LOS ANGELES)

I, BRANDON T. IORLANO, Notary Public in and for the State of California, do hereby certify: That on August 27, 2025, at 10:00 a.m. PST appeared before me, the foregoing meeting of California Environmental Contaminant Biomonitoring Program Scientific Guidance Panel, and was recorded by me, Brandon Iorlano, a Certified Electronic Reporter of the State of California, and thereafter transcribed under my direction, by computer-assisted transcription.

I further certify that I am not counsel for or any of the parties hereto, nor in any way interested in the outcome of said meeting.

DATED: October 5, 2025

BRANDON T. IORLANO, CER 4221
Notary Public, State of California
Expires: November 21, 2026

State of California)
)Ss
County of Los Angeles)

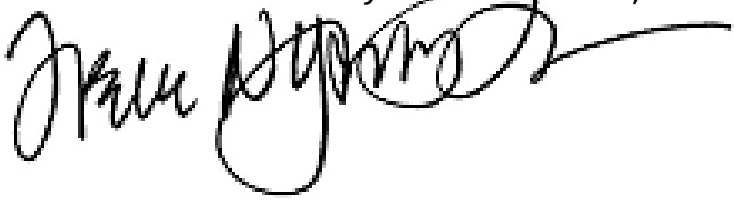
I, IRENE NAKAMURA, Certified Shorthand Reporter, Certificate No. 9478, for the State of California, hereby certify:

The foregoing meeting was thereafter transcribed by me;

The foregoing transcript is a true and correct transcript of the proceedings;

I further certify that I am neither counsel for nor related to any party to said action, nor in any way interested in the outcome thereof.

In witness whereof, I have hereunto subscribed my name this 5th day of October, 2025.



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