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PAPER

Pesticide biomonitoring report-back preferences of pregnant agricultural workers in California: findings from focus groups

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Abstract

Prenatal pesticide exposure has been associated with adverse health outcomes, and farmworkers have higher pesticide exposure than the general public. Thus, it is crucial to characterize pesticide exposure and identify strategies to reduce exposure among agricultural workers during pregnancy. Previous studies have conducted biomonitoring among agricultural workers in the US, but knowledge gaps exist regarding the accessibility of resulting report-back materials for this population. We conducted focus groups with a subset of participants from a study examining prenatal occupational pesticide exposure to assess preferences for biomonitoring report-back materials and methods. We aimed to understand (1) how to present urinary pesticide biomonitoring results in an accessible manner, (2) what additional information participants would like to receive with their results, and (3) other concerns participants have about pesticide exposure, and desired resources. Participants ($n = 7$) took part in two separate focus groups in November 2024 in Salinas, CA. Focus group recordings were transcribed, translated from Spanish to English, checked for accuracy, and analyzed using Braun and Clarke's thematic analysis framework. Participants ranged in age from 19 to 37 years, were all born in Mexico, and primarily spoke either Mixteco ($n = 4$) or Spanish ($n = 3$). Participants indicated that written materials communicating biomonitoring report-back or health information were not accessible, and some found words such as 'concentration' and 'average,' common in biomonitoring, to be confusing. Overall, participants voiced a strong preference to receive biomonitoring report-back materials (1) in person, in consultation with a subject-matter expert, and (2) via videos so they could pause, rewind, and rewatch content. Researchers should consider participants as important stakeholders when designing biomonitoring report-back materials and processes.

1. Background

Prenatal and early-life pesticide exposure has been associated with a range of adverse health effects [1–3]. While research has consistently shown higher urinary pesticide concentrations among agricultural workers compared to the general population [4], few studies have specifically examined pesticide exposure and the experiences of farmworkers during pregnancy. Farmworkers may have low decision latitude at work, which may hinder their ability to adopt protective behaviors and strategies to mitigate pesticide exposure [5, 6]. Like other populations with tenuous employment, farmworkers often work through illness and major life events, such as pregnancy [6–8]. Moreover, research suggests that biological changes may increase an individual's susceptibility to chemical exposures during pregnancy [9]. Thus, it is imperative to characterize prenatal pesticide exposure, and assess potential barriers to and strategies for mitigating these exposures among farmworkers.

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Exposure assessment provides information about a population's exposure to an agent by measuring levels of chemicals in biological samples (e.g. urine) or environmental samples (e.g. water or soil), or by using non-invasive personal exposure assessment monitoring (e.g. silicone wristbands or hand wipes) [10]. While exposure assessments occur frequently in academic research and occupational health case investigation and screening, research gaps exist regarding how often findings are communicated to participants and the accessibility of this information. Accessibility arises through (1) understanding the intended audience's literacy and numeracy skills and (2) creating report-back materials fit to these skill sets [11]. Without accessible and effective communication of individual results, participants may not directly benefit from these findings. When communicating individuals' biomonitoring results (often referred to as 'report-back'), communication gaps may exist between what researchers intend to report and what individuals can glean from their results [10]. This may be due to report-back materials that lack cultural competence, lack appropriate reading/numeracy level, or lack engaging design. Improving accessibility of biomonitoring report-back may be addressed in part by a better understanding of the study participants and incorporating their feedback into the design process of materials and methods.

There has been increased interest in reporting results back to participants within the public health research community, even in situations in which the results are not clinically relevant, the contaminants do not have established health guidelines, or exposure cannot reasonably be mitigated [11]. In addition to the belief that participants inherently have a right to receive their individual results from research they contributed to, report-back can increase retention in research studies, empower participants, and help researchers attribute exposures to sources through consulting with participants [12]. Moreover, a recent study suggests that participants prefer to receive their findings regardless of negative emotions that may be paired with the results return [12].

Creating accessible report-back materials is especially important for populations such as agricultural workers, who are frequently exposed to pesticides and other occupational hazards but may have limited control over these exposures or limited ability to adopt protective behaviors [8, 13]. Many farmworkers face barriers in accessing healthcare and environmental health resources [14], and biomonitoring report-back may be a rare opportunity for these individuals to receive personalized information about their exposures. Providing accessible biomonitoring report-back may enhance farmworkers' health literacy, empower participants to better protect themselves from occupational pesticide exposure, and build trust between research institutions and farmworker communities.

The objectives of this study were to (1) solicit feedback on prototype biomonitoring report-back materials through focus groups with a subset of participants from a study examining prenatal pesticide exposure among farmworkers, (2) incorporate participant feedback directly into their results-return process, and (3) create a set of recommendations for other public health researchers working with agricultural workers to apply when soliciting participant feedback may not be feasible.

2. Methods

2.1. Recruitment and participants

We conducted focus groups to solicit feedback on biomonitoring report-back materials with a subset of participants ($n = 7$) from a larger biomonitoring pilot study ($n = 57$) examining farmworkers' prenatal pesticide exposure and experiences working in agriculture during pregnancy. The focus group sample was an intentional subset of the larger biomonitoring cohort, to capture in-depth perspectives and feedback from a sample of the full cohort who would be receiving results from their urinalysis. Participants in the broader study cohort were recruited during their regularly scheduled prenatal visits through partnerships with local clinics, snowball sampling, and community events (e.g. health fairs) in the Salinas Valley and Mendota/Fresno area from May to August 2024. We enrolled and administered surveys to 118 individuals who had worked in agriculture while pregnant within the last 3 years. Participants who were currently pregnant and working in agriculture at the time of the survey provided a urine sample ($n = 57$). Of this biomonitoring cohort, 45 individuals were invited to participate in the focus groups based on (1) consent to participate in further research and (2) indication they would like to receive their biomonitoring results during the initial informed consent process. For logistical purposes, only participants who had been recruited from Salinas Valley sampling locations were contacted for focus group participation.

A bilingual member of the research team contacted eligible participants via phone calls and text message two weeks prior to the focus group to gauge their interest in participating and to identify a convenient date and time. One week prior to the focus group, this research team member contacted interested participants to confirm attendance. We recruited 11 participants for two separate focus groups, but

some were not able to attend due to extenuating circumstances. Seven individuals participated in the focus groups, five in the morning group and two in the afternoon group.

All study procedures were approved by the UC Berkeley Human Subjects Review Board.

2.2. Prototype report generation

Participant biomonitoring results were not available at the time of the focus groups. As the purpose of these focus groups was to gather feedback for the development of effective report-back materials, we created example materials using anonymous urinary pesticide data from a previous study with farmworkers. We developed prototype graphs using best practices from existing resources (e.g. the Silent Spring Institute 'When Pollution is Personal Handbook for Reporting Results to Participants in Biomonitoring and Personal Exposure Studies') [15] and revised the prototype materials through consultation with advocates and researchers with subject expertise (e.g. from the Mount Sinai Health System, Boston University, and California Environmental Protection Agency (EPA) Office of Environmental Health Hazard Assessment). Hemingway Editor (.38 Long, LLC, Durham, NC) was used to ensure that sample reports were at a fifth-grade reading level, as suggested by a local health educator who interfaces with farmworkers. The sample report consisted of one introduction page, one page reporting the prevalence of pesticides among the entire cohort, and three separate prototype graphs presenting individual-level exposure of one of the analytes measured (i.e. glyphosate) (see supplementary materials).

2.3. Focus group procedure

The aims of the focus groups were to solicit participant feedback regarding (1) how to present urinary pesticide biomonitoring results in an accessible manner, (2) what additional information or context participants would like to receive with their results, and (3) other concerns participants have about pesticide exposure and additional related resources that may be helpful. The focus groups were approximately one hour in length, and participants received a prepaid $50 Visa gift card for their participation, as well as breakfast or lunch, depending on focus group start time.

Focus groups were hosted in a private conference room at the office of a trusted non-profit providing legal assistance to farmworkers and immigrants in Salinas, CA, in November 2024. All participants provided informed consent to participate in the focus group and for the conversation to be audio recorded. Two bilingual students, referred to henceforth as the focus group facilitators, led the focus groups in Spanish using a guide with questions and prompts covering the three main objectives. We designed the focus group guide so that questions pertaining to each aim were grouped together, and facilitators encouraged relevant discussion beyond the scripted questions. Additionally, facilitators asked follow-up questions based on participant responses. Prior to the focus groups, the guide was translated from English to Spanish by the focus group facilitators. These individuals had previously administered surveys to participants in the broader study cohort, thus, some level of rapport may have been established prior to the focus group discussions.

Participants were seated at a round table with the focus group facilitators and two other members of the research team. Family members or friends who accompanied participants to the location were asked to wait outside of the conference room while the focus groups occurred. During the focus groups, each participant received a clipboard with printouts of prototype report-back materials, which facilitators explained to the group. The focus group facilitators asked participants a series of open-ended questions: (1) soliciting feedback on the graphs (e.g. assessing how easy they were to understand, which graphs they liked best, potential adjustments to improve the clarity of the graphs) with particular attention to identifying scientific vocabulary (e.g. 'concentration') and visual design elements (e.g. color choices) that were confusing or misinterpreted by participants; (2) their preferences for reference groups for comparison (e.g. other members in the study, other occupational populations, non-occupationally exposed populations); (3) strategies that support their ability to learn about health and science topics; (4) participants' knowledge of pesticides; (5) what they would like to learn about pesticides; and (6) how helpful they found resources on reducing pesticide exposure that we had offered to them when they had initially provided their urine sample a few months earlier.

2.4. Focus group analysis

The focus group audio was transcribed verbatim in Spanish and then translated into English by the two focus group facilitators. Each focus group facilitator transcribed and translated one focus group recording and then swapped transcripts to check the transcription and translation for accuracy and understandability. Transcripts were analyzed using hybrid thematic analysis; the transcripts were deductively and inductively evaluated for themes based on Braun and Clarke's thematic analysis framework [16], in which two researchers (1) familiarized themselves with the transcripts, (2) generated initial subcodes and

Table 1. Sociodemographic Information of Biomonitoring Study Cohort and focus group subset.

Variable	Biomonitoring cohort ($n = 57$)	Focus group subset ($n = 7$)
	N (%) or Mean (SD)	
Age (years)	27.8 (5.1)	28 (5.7)
Recruitment location		
Salinas Valley area	48 (15.8%)	7 (100.0%)
Central Valley area	9 (84.2%)	0 (0.0%)
Highest grade of education completed		
None	4 (7.0%)	0 (0.0%)
Primary	14 (24.6%)	3 (42.9%)
Secondary	21 (36.8%)	3 (42.9%)
High school or GED	14 (24.6%)	1 (14.3%)
University	4 (7.0%)	0 (0.0%)
Primary language spoken at home		
Maya Q'anjob'al	1 (1.6%)	0 (0.0%)
Mixteco	16 (28.1%)	4 (57.1%)
Mixteco and Spanish	1 (1.6%)	0 (0.0%)
Spanish	32 (56.1%)	3 (42.9%)
Triqui	7 (12.3%)	0 (0.0%)
Country of birth		
El Salvador	1 (1.8%)	0 (0.0%)
Guatemala	2 (3.5%)	0 (0.0%)
Honduras	3 (5.3%)	0 (0.0%)
Mexico	48 (84.2%)	7 (100.0%)
United States	3 (5.3%)	0 (0.0%)

subcoded all relevant segments of data, (3) combined subcodes into overarching codes, (4) reviewed and compared coding to confirm participant sentiment was truly captured, (5) identified the essence of each code, and (6) presented the findings in this report.

The transcripts were initially evaluated for codes that fell within themes closely resembling the focus group aims: (1) understandability of prototype report-back materials, (2) additional information/context desired to accompany results, and (3) other concerns about pesticide exposure, then evaluated for additional themes. The transcripts were analyzed by two researchers separately. Researchers engaged in regular comparisons of their analyses following each step of the process. In particular, coding was compared after step 4, and any discrepancies were resolved through conversation.

3. Results

3.1. Participant demographics

The seven focus group participants' ages ranged from 19 to 37 years; all participants were born in Mexico and primarily spoke either Spanish ($n = 3$) or Mixteco ($n = 4$), an Indigenous language of the Mixteco people, originally from southern Mexico and spoken today in Mixteco communities across Mexico and the United States (table 1). In Focus Group 1, four out of five participants indicated that they primarily spoke Mixteco, and one participant primarily spoke Spanish. In Focus Group 2, both participants indicated that they primarily spoke Spanish.

3.2. Biomonitoring report-back

3.2.1. Data presentation

Many participants initially expressed a lack of understanding of all the graphs they were shown. Individuals expressed confusion regarding the graphical representation of lower and higher exposure (e.g. which bars corresponded to lower pesticide concentrations and what level of exposure was 'better' or 'healthier').

> *'It's just that sometimes I get confused by the numbers.'*
> *'If they just give us this paper here, we won't know what it says.'*

Similarly, participants expressed confusion regarding the colors of the bars in graphs. They explained that the color coding was not intuitive and that they had assumed that darker colors corresponded to higher concentrations.

> *'Like, for example, here. This is low, then, but it is in a stronger color. So what does that mean? What does this have more of something than this, or is this less or more?'*

Generally, participants who primarily spoke Spanish understood the graphs better and expressed less confusion compared to those who reported Mixteco as their primary language.

Participants expressed a slight preference for the last bar graph presented to them (example 3 in supplementary material 1), but neither focus group voiced a strong preference for a specific graph type. Much of the conversation focused on the importance of having someone explain the graphs to the recipient, regardless of format.

3.2.2. General understanding

Participants had difficulties with some vocabulary used in the prototype report-back materials, including words such as 'concentration' and 'average.' Participants understood the graphs better when a focus group facilitator explained the content and purpose of each graph.

> *'Like the word concentration. And even if we read it, we didn't know what it was.'*
> *'Well, I think that if they explain it to us, we can get more or less an idea.'*

3.2.3. Reference groups

We asked participants if they would like to see their results compared to those of other studies, and if so, who they wanted as a reference group. Generally, Focus Group 1 had trouble understanding the concept of reference groups. Participants in Focus Group 2 were excited by the idea of reference groups and expressed interest in seeing how their exposure compared to those who worked on different crops or in different job tasks within the biomonitoring cohort, as opposed to external groups (e.g. findings from other studies).

3.2.4. Format

Participants expressed a strong preference for receiving any printed report-back materials with an in-person consultation with a subject matter expert, allowing the opportunity to ask questions. For this consultation, participants expressed an interest in smaller groups.

> *'Well, I'd rather have a talk so that they can explain it to me. Because sometimes I like to read them. But there are times when there are things that I don't understand. And so, as a conversation, I can ask them what it is or what damage that pesticide can bring or something like that.'*

Moreover, participants were excited about the idea of receiving their results with a video accompaniment, which would allow them to pause, rewind, and rewatch content.

> *'When you watch something on YouTube, you can pause it and rewatch it. Yes, when I don't understand something, it's the way I try to understand….I go back and play it again, looking for the parts I didn't understand. If I still don't get the meaning of a word or what it's trying to say, I look it up so I know what it means.'*

3.2.5. Prior experience with report-back

None of the participants had ever received biomonitoring report-back findings as part of a research study. We did not ask participants if they had participated in other biomonitoring research; however, none indicated that they had. When probed, no participants could recall ever having received similar results, such as test results from a medical appointment, highlighting that this is a new experience for them.

3.3. Pesticides

3.3.1. Use information

Participants generally understood that pesticides were applied to crops. However, many participants stated that pesticides were applied to plants to help them grow faster and be more productive, indicating that pesticides may be confused with other substances, such as fertilizers. No participants associated pesticides with killing pests.

> *'They are liquids that they put so that the fruit grows.'*
> *'They are liquids that they put in the plants so that they grow or don't spoil.'*

Participants wanted to understand (1) how pesticides reported in this study are used and (2) what crops these pesticides are typically used on. Participants in Focus Group 2 wanted to understand how long these pesticides can stay in the body and how long after crop application there is still a significant risk of exposure. Participants explained that they are generally warned not to access areas marked by skull and crossbone signage, but that they receive very limited information about which chemicals have been applied in these areas.

> *'They talk about pesticides, but they never talk to us about the danger that exists in each pesticide… they just put the sign of the skull so we won't go in the field, but they never tell us if it's bad, the consequences.'*
> *'They do not explain to us what the pesticide is, they only say that we should not cross the skull [signage] because they put chemicals in [the area]. That's all they say, and we don't ask.'*

3.3.2. Health concerns

Some participants in Focus Group 1 explained that they were not curious or concerned about occupational pesticide exposure prior to participating in this study, in part due to the lack of information from their employers about pesticide use and potential health implications. Others in Focus Group 1 reported becoming concerned only after being told to avoid certain areas at work.

> *'To be honest, until now I hadn't been curious.'*
> *'When they tell us that it is dangerous, we get curious.'*
> *'Sometimes one is pregnant and we are working. They need to explain to us what the risks of being there are. We want to rest, but we may lose our jobs.'*

When prompted, participants in both focus groups shared anecdotes regarding pesticide exposure and expressed concern about potential long-term implications of pesticide exposure for pregnant persons and their children.

> *'When I know I'm pregnant, I always call my supervisor because I do have fear. I always have questions about whether it's bad… They say it's pure soap… They say it's not a pesticide, it's not bad. Workers can enter… And when he tells me he knows that this one does have the skull and crossbones signage. This one is more dangerous, and I don't put myself at risk and I stop working.'*

Some shared anecdotes about experiencing acute symptoms after pesticide exposure.

> *'I'm pregnant, but they don't tell me that it is dangerous. But when I get closer to where there is a stronger chemical [odor], sometimes I get a headache.'*
> *'Our heads hurt when we pass by… we would like to know how much damage that does to us.'*

3.3.3. Mitigating exposure

Participants explained that they rarely received communication about when pesticides were applied and precautions to take to mitigate exposure. Also, they explained that commonly touted strategies for mitigating the take-home pesticide exposure pathway may not be practical. For example, farmworkers are advised to remove work clothing and bathe immediately after returning home from work, but participants shared that it is hard to resist immediately hugging their children when they get home.

> *'They tell us, 'When you get home, take off your clothes, then take a bath, and then [pesticide residue] is washed off…' As a mother, the first thing you want to do is to pick up the children, and you don't have a chance to change, and then go get your children, and even if you don't want to, you [expose] the children.'*

3.4. Resources

3.4.1. Current resources

Participants shared that they receive some regulatory and safety information in workplace meetings referred to as 'La Escuelita' or 'Little School.' In these meetings, workers reported sometimes receiving information on what areas of the field to avoid after pesticides were applied, but receiving minimal information about the specific pesticides being used. Some participants shared that their workplaces showed safety videos, but that they struggled to stay engaged, citing reasons like being hungry, being cold, or finding the videos boring.

3.4.2. Desired resources

Similar to findings for the biomonitoring report-back materials, participants voiced preferences for receiving pesticide and health-related information in formats such as in-person, radio, or video, and

often found written materials to be too complicated. Some individuals explained that they listened to the radio while commuting to work, but that they were not familiar with podcasts.

> *'Well, I want there to be more meetings, either like these or with a chemical expert, so that they can explain it to us people.'*

3.4.3. Barriers

Many shared that they experienced language barriers and faced challenges understanding resources presented in Spanish, especially those who primarily spoke Indigenous languages.

'That is the problem when we do not understand, because we speak Mixteco, because we almost do not know what it means in Spanish. It's more complicated for me.'

'Like she said, I speak Mixteco. It's difficult to understand the meaning of words; I go little by little, but I can hardly say that I understand. But I can understand it in Mixteco.'

Participants also recalled receiving pamphlets and handouts from our research team, but indicated that these handouts were too complicated to read. Others explained that they commonly misplace or lose handouts.

'Yes, I looked at [the handouts from your team], but like her, I only knew some words, I didn't even understand.'

3.5. Other concerns

Participants explained that they did not feel like many people cared about the health and safety of farmworkers. They also expressed concern about heat exposure and heavy lifting at work.

'Because there are many people who don't care what we do, if we are well or unwell.'

'Not all of us have the ability to walk under [the sun]. There are people who seriously get sunstroke, and you look at the other people acting as if nothing happened.'

Moreover, some shared anecdotes about other colleagues applying pressure on pregnant workers to continue working, business as usual.

'Between colleagues, I don't know if it has happened to you, but sometimes they joke around or poke you, saying things like 'as if you were the first person to be pregnant."

4. Discussion

This study solicited feedback from a subset of participants of a pilot biomonitoring study of pregnant agricultural workers through focus groups to inform our report-back strategy and develop recommendations for other researchers. We aimed to improve the accessibility of our report-back strategy through (1) understanding the literacy and numeracy skills of the participants in our cohort and (2) creating report-back materials fit to their skill sets. For this study, accessibility was operationalized and assessed based on three interconnected criteria that arose from the focus groups: (1) understandability, which is the ease of comprehending scientific vocabulary and graphical representations as they are presented, (2) language and cultural appropriateness, which is the ability to understand information based on presentation language and cultural context, and (3) engageability, which is the format's effectiveness in allowing participants to ask questions and re-review complex content, specifically to aid in understandability. The focus groups revealed that, for this population, (1) written report-back materials, alone, present understandability issues and are not an accessible format, (2) in particular, graphs are often difficult to understand if not accompanied by in-person explanation, and (3) gaps in language appropriateness exist with written materials, particularly among materials presented to individuals who primarily speak Indigenous languages (e.g. Mixteco). These findings inform our conclusion that report-back strategies should prioritize in-person discussions with subject-matter experts and/or individualized videos in collaboration with professional translators and interpreters as needed to address these accessibility issues. Our findings also support conclusions from similar studies that report-back processes must (1) identify knowledge gaps among participants (e.g. familiarity with vocabulary and concepts such as 'pesticide,' 'concentration', and 'average'), (2) respect cultural context and lived experience, (3) acknowledge clinical relevance/irrelevance of the findings and related uncertainty, and (4) set expectations with participants about what information they will be receiving from the research team and in what format [10]. Typically, expectation setting should occur during the initial informed consent process, but the nature of this research study was to use participant feedback to inform and adjust participant report-back; thus, any changes to this process should be communicated to participants after revision, prior to results return.

4.1. Report-back materials

While data gaps exist regarding report-back preferences, specifically for farmworkers, other studies in diverse socio-demographic populations underscore that most participants desire to receive biomonitoring study results [17–20]. Some studies suggest a video approach to report-back in which participants would be able to hear the researcher share research findings and explain context [17], and others stress participants' preference to receive report-back in-person with a subject matter expert [17, 18]. This preference to receive results in-person was consistent with our findings.

Participants clearly indicated that graphical representations of exposure data were initially extremely difficult to understand and that their understanding improved when the focus group facilitators explained the graphs to them. All participants consistently indicated that written materials alone were not accessible and expressed a strong desire to meet with a subject matter expert when receiving their results, so that they would have the opportunity to ask questions. We designed reports in Spanish at a fifth-grade reading level based on consultation with a health educator with extensive experience interacting with farmworkers; however, participants shared that they had difficulty understanding the written materials. In particular, many participants were unfamiliar with words such as 'average' and 'concentration', which are commonly used in biomonitoring report back materials. Our findings point to the importance of report-back being an iterative process in which materials are refined based on participant feedback, as well as the importance of communicating results to participants face-to-face to identify and bridge knowledge gaps.

Participants also displayed different levels of comprehension of the written materials, likely due to educational background and primary language. The first focus group was mostly composed of participants who reported speaking Mixteco as their primary language (80%), whereas both participants in the second focus group spoke Spanish. Although it comprised only two individuals, the second focus group also had slightly higher levels of educational attainment than the first focus group. Notably, Indigenous communities in Latin America, such as in Mexico, often face unequal access to education; for example, one report indicated the average educational attainment among Indigenous individuals in Mexico is about 6 years, compared to 10 years for non-Indigenous populations [21].

Many of the Indigenous languages used in our study population (i.e. Mixteco, Zapoteco, Triqui) are primarily spoken, and not uniformly written, highlighting that investigators may unintentionally provide materials that are inherently inaccessible if only providing written report-back, particularly without in-person consultation [20, 22]. Further, not all words have direct translations from Spanish to Indigenous languages. For example, previous research with Mixteco-speaking farmworkers identified specific vocabulary that would be difficult to interpret (e.g. focus group, pesticides, and legal protection) and formulated alternative explanations for the purpose of increasing participants' understanding [23]. In our study, one of the focus group facilitators familiar with Indigenous languages identified terms (e.g. 'pesticide') that might be difficult for some participants to understand. As a result, our research team was familiarized with alternative phrases that may be used by participants to refer to pesticides (e.g. 'venom'). Our findings underscore the importance of conducting in-person report-back with an interpreter, when possible, so that participants can engage in their primary language, in an effort to bridge gaps in language and cultural appropriateness.

When asked about their understanding of pesticides, participants generally understood that these were substances applied to crops to aid in production, but did not associate them with killing pests. Based on their explanations, participants seem to have been confusing pesticides with fertilizers. Even though some participants shared anecdotes of symptoms associated with acute pesticide poisoning (e.g. headache) following exposure to chemicals at work, some participants in the first focus group explained that they were not concerned or curious about pesticide exposure until either (1) meeting with our research team, or (2) being told to avoid certain areas at work after chemical application. These findings suggest potential gaps in farmworkers receiving and understanding Worker Protection Standard (WPS) training, which is mandated by the U.S. EPA. This is consistent with previous research [24, 25], including one study which found that as few as 56% of farmworkers working in pesticide treated areas reported having received pesticide safety training [24, 25], even though pesticide applicators and field workers are required to receive annual training covering topics such as what pesticides are, routes of exposure, and pesticide protective behaviors [26, 27]. WPS also mandates that product-specific application information such as product name and active ingredients, are displayed in a central location at the workplace [26, 27]; however, participants in our study reported smelling odors at work and experiencing subsequent physical symptoms, but rarely felt like they received communication regarding what pesticides had been applied. These gaps in WPS training requirements and the information workers actually understand are likely greater for those speaking more minoritized languages. Participants' general lack of

concern regarding occupational pesticide exposure may stem, in part, from inadequate pesticide safety training, and could result in adoption of fewer pesticide protective behaviors and greater health risks.

4.2. Other pesticide resources

Similar to the results for biomonitoring report-back materials, participants generally preferred to receive informational resources (e.g. how to reduce pesticide exposure) in-person, through the radio, or by watching videos. Participants in both focus groups, regardless of primary language, faced challenges understanding written resources, and largely indicated materials like pamphlets, a common format from academics and other community groups, were not accessible. Most participants could recall receiving handouts from our research team upon initially providing their urine sample, but had trouble understanding the written text in the pamphlets and did not find them useful.

There has been very limited research on improving accessibility of methods to provide environmental and occupational health safety information to individuals from Indigenous communities. However, one study among Indigenous farmworkers in Oregon compared the effectiveness of enhanced pesticide safety training from peer educators/promotoras with Indigenous-language educational materials ($n = 83$) with 'standard' training in which participants received a brochure and watched a Spanish-language video, but in a smaller group ($n = 57$) [22]. Assignment to the enhanced pesticide safety training group was associated with a greater reduction in pesticide metabolite levels, but both interventions were associated with a reduction from baseline [22]. Researchers asserted that the reduction in metabolite levels in the standard training group may have been due to the video being administered in a quiet, small-group setting in which participants had the opportunity to ask questions with Indigenous language-speaking peer-educators. This suggests that environmental health education and outreach initiatives should be designed in a manner that prioritizes interactive, small-group discussions, with Indigenous language interpreters as needed. Moving forward, researchers, non-profit organizations, and advocacy groups should aim to create more creative and engaging resources instead of hard-copy materials alone.

4.3. Revisions from participant feedback

We have updated report-back materials and methods based on findings from these focus groups. First, we revised our report-back documents to include simple bar graphs with clear captions to indicate individual-level exposure (supplementary data 3 and 4). We also included additional background information, such as what pesticides are, what crops they are used on, and suggestions to avoid exposure. We avoided vocabulary that may not be familiar to participants and provided further explanation for any concepts and words flagged as confusing in the focus groups, such as 'average' or 'concentration' in personalized videos. We are mailing individual paper report-back results to participants, accompanied by a personalized video in the participant's preferred language explaining their results and addressing any common questions we received during the in-person focus groups. These videos were developed in Spanish by our bilingual (English/Spanish) study staff and or in the participant's preferred Indigenous language in collaboration with a local non-profit specializing in outreach in Indigenous languages. One of our bilingual study staff will contact participants via phone shortly after they receive mailed results to answer any questions.

4.4. Limitations

This study has several limitations. First, we recruited a relatively small convenience sample and we experienced some participant drop-out prior to the focus groups. Although we recruited 11 participants in total, the two focus groups only included five and two participants, respectively. This drop-out may have been specific to the population because all participants were either near their due date or had recently given birth. Although we conducted both conversations as similarly as possible, the second did not function as a true focus group with only two participants. We recommend that future studies recruit more participants than may be needed to account for potential drop-out, particularly in studies with pregnant individuals. Further, the focus group subset may not have been fully representative of the larger biomonitoring cohort. We limited focus group recruitment to participants in the Salinas Valley region for logistical purposes, whereas about 11% of the biomonitoring cohort was recruited from the Mendota region in California's Central Valley, and this subset of participants may have had different lived experiences and feedback to share. Further, all focus group participants were born in Mexico, whereas the larger biomonitoring cohort included nine individuals born in El Salvador, Guatemala, Honduras, or the US. The focus group subset also included a higher number of Mixteco speakers (57%) compared to the biomonitoring cohort (28%), and none of the focus group participants had attended university, while 7% of the biomonitoring cohort had. Moreover, because this sample was a subset from a pilot study that recruited a convenience sample, it may not be representative of the larger target population of agricultural workers

in California. That said, all of the focus group participants were born in Mexico, and an estimated 8 in 10 agricultural workers in California are Mexican-born [28].

Additionally, it is important to note that these focus groups were conducted prior to the inauguration of Donald Trump in 2025. Our group's continued farmworker-facing research, outreach, and collaboration with community partners across California has demonstrated that many in this population are increasingly hesitant to attend in-person gatherings, particularly in large groups, due to increased immigration enforcement. We had originally planned to host an in-person report-back for all participants in the larger biomonitoring cohort in August 2025; however, our team decided that, to prioritize participant safety and comfort, we would not host any in-person gatherings with multiple participants. Additionally, we want to note that research of this kind may not be feasible at this point in time due to this hesitancy for in-person meetings. Were we to conduct this research today, participants' preferences may have differed, and they might not have expressed as strong a preference for receiving results in-person with subject-matter experts.

Our findings bring to light the importance of conducting in-person report-back with an interpreter; thus, the biggest limitation of our research was the lack of Indigenous language interpretation. The original recruitment materials, outreach, and prototype report-back materials were in Spanish. While all focus group participants were able to speak conversational Spanish, many reported that their primary language was Mixteco. Conducting at least one focus group in Mixteco or with in-person Mixteco interpretation may have allowed participants to communicate more comfortably and for us to gather more detailed feedback. We are collaborating with a local organization specializing in outreach in Indigenous languages to provide report-back videos in participants' preferred languages.

4.5. Strengths

To our knowledge, this is the first study in the US to conduct focus groups with agricultural workers to solicit feedback on biomonitoring report-back practices. Additionally, we believe that this is the first study to solicit feedback on this topic from pregnant agricultural workers specifically, capturing and documenting feedback unique to their experiences. There are a variety of resources available encouraging researchers to custom-tailor their report-back to their study cohort (e.g. the Silent Spring Institute's 'When Pollution is Personal Handbook for Reporting Results to Participants in Biomonitoring and Personal Exposure Studies') [15]. However, by soliciting feedback directly from study participants, we can more effectively address potential points of confusion and refine our report-back materials and process. Further, the same research team recruited participants, collected urine samples, and conducted focus groups, allowing for rapport and trust building that may have made participants feel more comfortable and forthcoming during focus group sessions. Moreover, one member of the research team has a deep understanding of Mixteco culture and language, allowing us to consider the lived experience of Indigenous agricultural workers in our methods. While some biomonitoring research can be inherently extractive, our approach attempts to foster long-term collaboration and to improve the self-efficacy and environmental health literacy of the agricultural workers we interface with.

4.6. Recommendations

The most consistent finding across the two focus groups was that written report-back materials would not be accessible for this study population, and that any efforts to provide biomonitoring results and/or pesticide education should be accompanied by formats such as in-person consultation, videos, or radio. This challenges the status quo of biomonitoring research, which is to send results to participants via mail or online portals. Taken with findings from other studies, our results indicate that it is not reasonable to provide written biomonitoring results to agricultural workers in the US, and expect participants to be able to glean important takeaways without in-person or video discussions. Factors such as the intended audience's preferred language, including whether that language is primarily written or verbal; educational level; numeracy skills; and lived experiences should be carefully considered by researchers conducting report-back.

While time and resource-intensive, we recommend the following strategies, in order of priority, for studies conducting biomonitoring report-back in similar populations. Ideally, each of these strategies should be paired with researchers engaging with the participant cohort to inform and refine report-back materials and methods. Our findings and these recommendations are based on focus groups with pregnant agricultural workers in California and may not be generalizable beyond this specific population, further underscoring the importance of consulting with participants about their preferred methods and materials for report-back.

1. Return results in-person (e.g. in group meeting) and offer one-on-one consultation with the study team, if this can be done in a safe and trusted space that prioritizes participant safety and wellbeing; and, provide individualized videos in the participant's preferred language to reinforce information and allow for repeat viewing. This group format aids in scalability but allows participants to consult a subject-matter expert if they have questions.
2. Return results remotely (e.g. via mail or email) and offer one-on-one consultations with a subject matter expert via call or video conferencing; and, provide individualized videos in the participant's preferred language to reinforce information and allow for repeat viewing.
3. Return results in-person in a one time community meeting, as described in Recommendation 1, with template videos for all participants, explaining how to interpret the results packet at a high level (e.g. explaining what the graph shows) and defining pertinent vocabulary, without referencing individual results.
4. Return results in-person in a one time community meeting, as described in Recommendation 1, without videos.
5. Return results remotely (e.g. via mail or email) accompanied with individualized videos as detailed in Recommendation 1.
6. Return results remotely accompanied by template videos.

This process should be built explicitly into the research design from the start.

5. Conclusions

Participants have a right to receive their biomonitoring results by participating in the research. When report-back is well-designed and accessible, it can increase retention in research studies and empower participants. However, data gaps exist regarding the accessibility of current report-back materials and methods. Our findings underscore that this process must be customized to meet participants' educational and cultural backgrounds, particularly when working with populations composed of individuals who (1) have not previously engaged in biomonitoring report-back, (2) have lower levels of educational attainment, and (3) speak non-written languages. Focus group participants in our study consistently highlighted gaps in understanding that would arise if they were to receive written report-back materials with no other context or guidance, and they were clear in their preference for in-person consultations with a subject matter expert to review results and address outstanding questions. Researchers planning to share results with their participants should pursue engaging report-back formats that extend beyond written documents; we recommend combining in-person consultation and individualized videos as feasible.

Data availability statement

The data cannot be made publicly available upon publication because they contain sensitive personal information. The data that support the findings of this study are available upon reasonable request from the authors.

Supplementary data 1 available at https://doi.org/10.1088/2752-5309/ae3c3b/data1.
Supplementary data 2 available at https://doi.org/10.1088/2752-5309/ae3c3b/data2.
Supplementary data 3 available at https://doi.org/10.1088/2752-5309/ae3c3b/data3.
Supplementary data 4 available at https://doi.org/10.1088/2752-5309/ae3c3b/data4.

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