Children's Health Protection Advisory Committee

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Administrator Michael Regan
United States Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

RE: *Consideration of Legally Working Children in Pesticide Exposure Assessment*

Dear Administrator Regan,

Farm labor can be legally performed by children as young as twelve years of age under the Fair Labor Standards Act, with no minimum age for children working on small farms or family farms. Child labor in agriculture is common, with as many as 500,000 child farmworkers estimated to work in the U.S.[1] Therefore, it is critical to ensure that EPA's pesticide risk assessments and regulatory decisions are health protective of children. EPA's report entitled *Consideration of Legally Working Children in Pesticide Exposure Assessment ("the Assessment")* focused on whether the Agency's current occupational pesticide exposure assessment methodologies used for adults are adequately protective of children working in agriculture. The Children's Health Protection Advisory Committee (CHPAC) appreciates the opportunity to offer comment on the approaches and analyses in the Assessment. This letter outlines the CHPAC's response to the specific charge questions provided to us regarding children's post-application dermal exposure assessment.

There is a need that extends beyond the specific charge questions on dermal exposure to pesticides to ensure that safeguards are in place to protect children working in agriculture from the combination of both chemical and non-chemical stressors. Differences in behavior and biology may increase children's risks from environmental hazards compared to adults; and farmworker youth in particular face numerous, concurrent environmental, occupational, and social hazards that may synergistically impact their health.[2; 3] Therefore, CHPAC recommends that EPA spearhead a standing committee to holistically assess risks to children working in agriculture and to identify safety policy needs and other actions to reduce these risks. Representatives on this cross-sector committee would include federal agencies, state/local governments, and non-governmental organizations that can speak to community-led solutions, such as the Farmworker Health Network.[4] Community engagement in informing decisions and policies is consistent with the principles of environmental justice, which is an Agency priority.

Question 1: Have appropriate demographic factors been considered in the identification and characterization of the population of working children in agriculture who are the focus of this analysis? Did this analysis appropriately characterize populations of working children in agriculture? If not, please identify any which were omitted.

EPA's characterization of the population of working children in agriculture in the Assessment is based on select findings from the National Agricultural Workers Survey (NAWS) conducted in the early 2000s.

However, most of EPA's exposure analysis is based on monitoring studies conducted in the early 1980s. Any changes in demographic factors since this time, such as age distribution, race/ethnicity, immigration status, mobility, education, language, housing, health status, and hours of employment, may directly or indirectly influence pesticide exposure. Here we discuss several sociodemographic factors that are not well characterized in the Assessment.

1) Language, Race/Ethnicity, Legal Work Authorization, and Migratory Status

These characteristics are missing from the description of the monitoring studies included in the Assessment. Barriers related to language and legal work authorization status may impact study recruitment as well as pesticide exposure, making clear characterization of these factors essential.[5] Legally working children are either migrant (because they are absent from a permanent place of residence) or seasonal workers (because they do not move from their permanent residence to seek farm work). These two groups may differ in work habits and level of pesticide exposure, as well as other characteristics such as pesticide safety training, field sanitation conditions, and housing type and conditions. The lack of documentation of these characteristics in the monitoring studies hinders the interpretation and generalizability of the findings. Further, the ethnicity and work authorization status of farmworkers, including child workers, has changed since the monitoring studies took place in the early 1980s.[6-8] The increased proportion of workers from indigenous communities in Mexico and Central America is one example.[5]

2) Age and Biological Sexual Maturity

The broad age range of children working in agriculture results in considerable biological and behavioral heterogeneity within this population, yet child age differences are either not addressed or are handled inconsistently in the Assessment. The minimum age to conduct farm labor is 12 years of age, but children younger than 12 years old are involved in labor activities on farms employing fewer than seven people annually. Although fewer legally working children fall into the 7–12-year-old age range, the risks and protections for this very young age group are not well-described in the Assessment, beyond the acknowledgement that the ratio between skin surface area and body weight for children under 12 years of age is not comparable to adults, which increases their exposure.

Although adolescence is a time of significant biological changes potentially affecting vulnerability to pesticides, the Assessment grouped all working children over the age of 12 years old into one category. Previous studies have identified specific age-related windows of susceptibility to pesticides.[9-11] To improve characterization of the population and protect children working in agriculture from harm, both the exposure assessment and the overall risk assessment process (e.g., hazard identification, dose response) should account for age and stage of biological sexual maturity.

3) Health Status and Access to Healthcare Services

Farmworkers in the U.S. continue to face health inequities. For example, nearly half of migrant farmworker children have an unmet health need, compared to 2% of U.S. children overall.[12] In addition to pesticide exposures, young agricultural workers may experience malnutrition, high rates of food insecurity, and multiple occupational-related hazards, including during pregnancy and breastfeeding periods.[13-16] Adolescent workers in particular may experience concurrent non-chemical stressors such as traumatic psychosocial experiences. Such stressors may influence individual susceptibility to chemical exposures.[17] Asthma, already the leading chronic disease among children in the U.S., has been identified as an important health problem among agricultural workers[18; 19] and pesticide exposures may contribute to airway reactivity and asthma within this population. Health status is also partly determined by access to health care services, which is low in farmworker populations due to multiple barriers.[20; 21; 22]

4) Educational Level, Safety Training, and Risk Perception

Behavioral factors such as handwashing, glove use, or use of protective clothing impact pesticide exposure. These factors are influenced upstream by the educational level of the child worker and prior pesticide safety training. McCauley and colleagues reported that few of the adolescents in a study of Oregon farmworkers reported having received pesticide training, yet 21.6% of participants reported that their current work involved mixing and/or applying agricultural chemicals.[23] Arcury et al. reported that adolescent workers in agriculture have little safety culture beyond what they might glean from their parents.[24] While child workers may be aware that pesticides are hazardous, they may not know how to reduce their risk, particularly without formal pesticide safety training. McCauley et al. compared pesticide safety knowledge between adolescent and adult workers.[25] Overall, adult participants scored better than adolescents on the safety test, and those with previous pesticide training scored better than those without. There were no differences in scores based on whether the test was taken in English or Spanish; however, participants who spoke indigenous languages scored significantly lower than those who did not. Pesticide safety knowledge is thus an important factor to consider when evaluating the pesticide exposures of child workers.

Perception of pesticide health risks influences safety-related practices while working.[26-28] Even when exposed to pesticide safety training, risk perception has been shown to differ significantly between adolescent and adult populations. For example, in focus groups with Oregon adolescent migrant farmworkers, Salazar and colleagues found that the youth were aware of the risks from pesticide exposure but varied in their perceptions of their personal vulnerability.[29] Adolescents in general have been shown to adhere less to safety guidance because they feel young, healthy, and more invincible.[30]

In sum, the demographic characterization in the Assessment did not consider critical factors that interact with and/or influence a child's exposure and susceptibility to pesticides, including age and developmental stage, legal work authorization, language, and knowledge of pesticide safety, among other factors. This limits interpretability of the monitoring studies and overall analysis.

Recommendations:

- EPA should not rely exclusively on the results of the monitoring studies included in the Assessment to make generalized conclusions about pesticide exposures within the current population of children legally working in agriculture.
- In collaboration with farmworker communities (such as the standing farmworker advisory committee suggested above), EPA and its federal partners should collect more sociodemographic data, with a focus on the factors identified above, for the population of children legally working in agriculture.

Question 2: The *Consideration of Legally Working Children in Pesticide Exposure Assessment* is based on research conducted by multiple universities in several crop production scenarios where adult and child exposures were concurrently measured in the same fields at the same time (i.e., under identical exposure conditions). Is the Committee aware of high-quality scientific studies or other types of data that could provide additional information on exposures of children in agricultural settings not identified in the current analysis which could be added to further evaluate the exposures of working children (e.g., exposure monitoring, poison center data, medical case studies, etc.)? If so, please identify and provide citations to EPA.

A major strength of the monitoring studies was the concurrent monitoring of children and adults as they performed the same hand harvesting tasks in the same field. We were unable to find examples of other studies that implemented this same design, which is directly relevant to assessing differences in exposure between children and adults. Since the time of this research (more than 30 years ago), the composition of the child agricultural workforce has changed as described above, new application technologies and chemicals have entered the market, and exposure science advances have been made.[31] Below, we summarize factors and methods that should be considered in the Assessment and/or in future studies to further assess pesticide exposures of working children. We also comment on the limitations of existing passive surveillance and reporting systems. Citations and additional resources are included in Attachment 2.

1) Exposure Conditions: Meteorological Factors, Crop Type, and Work Task

Climate change influences temperature, humidity, and atmospheric levels of $C0_2$, which can impact pesticide exposure. For example, a report released by the Intergovernmental Panel on Climate Change suggests that climate change-related impacts on plants may result in more pest pressure and therefore, higher and more frequent pesticide usage on crops.[32] Higher temperatures can also increase pesticide volatilization rates leading to higher airborne concentrations, increase dermal absorption (e.g., via increased perspiration[33]) and reduce the use of protective clothing. More recent studies may capture changes in exposure as a function of climate change. As temperatures and humidity increase, exertional heat stress for agricultural workers also increases.[34] Pediatric thermoregulation may differ from that of adults,[35; 36] and, therefore, children may be more vulnerable to adverse impacts of heat exposure combined with pesticide exposure. More research is needed to assess how climate change influences farmworker's pesticide exposure and associated health outcomes.

Children labor within a variety of agricultural and horticultural settings. These heterogeneous scenarios result in a broad range of pesticide exposures and potential risks. While EPA noted that the crop-related tasks performed in the monitoring studies have not changed between the 1980s and today, it is unclear whether EPA considers these crop types and tasks to be the ones most likely to result in differential exposure between children and adults. For example, certain crops may be taller than the child worker but not the adult worker, leading to more torso and head exposures among children. While the monitoring studies did find higher pesticide exposure among child workers for some scenarios, EPA did not conduct further assessment of factors that may have led to these findings, which may have been informative. Working with living plants may also lead to co-exposures of greater health concern for children. Examples include exposure to fungal spores and pollen that may exacerbate childhood asthma, as well as exposure to nicotine (a neurotoxicant) in tobacco plants leading to green tobacco sickness, which has been documented to occur more frequently in young workers.[37-40]

2) Advances in Exposure Assessment Tools and Analytical Methods

Multiple exposure methods are useful to capture different aspects of exposure (e.g., external exposure to specific parts of the body versus total absorbed dose). Newer exposure monitoring techniques may be especially useful to assess exposures in populations such as children, for which compliance with some monitoring methods may be difficult, prone to error, and/or difficult to bring to scale. For example, studies have shown wristbands to be low cost, non-invasive, and capable of capturing chemicals from various classes,[41] making them useful as personal exposure monitoring devices for large scale studies within special populations. A recent study in eight-year-old Latinx boys and girls in rural North Carolina farmworker families and urban non-farmworker families demonstrated that silicone wristbands worn for one week could be used to assess differential exposure to 75 pesticides and pesticide degradation products.[31] In another recent study, wristbands were found to be sensitive to exposure differences in groups of children for a range of air pollutants as a function of sex, asthma status, home characteristics, and modes of transportation, again indicating the utility of wearables to obtain high quality data across large populations.[42]

Biomonitoring and personal air sampling (discussed further in our response to Charge Question 4) are exposure tools that can provide more complete information about pesticide exposures among child workers. Questionnaire data on health status, family history, and behaviors can be combined with biomonitoring data to explore relationships between exposure, external factors, and resulting body burdens. Behavioral observation studies (e.g., to assess children's use of personal protective equipment, non-work activities in the field, etc.) may also be particularly useful. To summarize, advances in our understanding of the personal exposome underscore the need for additional assessment, including studies that make use of innovative technologies and methodologies capable of more fully capturing pesticide exposures experienced by children working in agriculture.

3) Limitations of Existing Passive Surveillance and Reporting Systems

Data from Poison Control Centers (as mentioned by EPA in Charge Question 2), the National Pesticide Information Center, and hospitalization records document adverse events involving pesticides, including those occurring in agricultural settings. Pesticide registrants are also required by law to report adverse incidents (of which they are aware) resulting from use of their products to EPA.[43] Further, several states conduct occupational pesticide-related illness and injury surveillance as part of the National Institute for Occupational Safety and Health (NIOSH) Sentinel Event Notification System for Occupational Risks (SENSOR) program. However, these existing passive reporting and surveillance systems mostly capture acute pesticide-related illness and injury (i.e., poisonings). Underreporting is a major problem, as there is no federal requirement to include pesticide illness and injury as a mandatory reportable condition, and pesticide illness symptoms can be similar to other illness symptoms, resulting in misdiagnosis by health care providers. Further, agricultural workers suffering from acute pesticide poisoning may not seek medical care for many reasons such as lack of financial capacity, fear of losing paid work, and language barriers. It is estimated that as many as 88% of acute pesticide-related illness and injury cases among farmworkers are not reported to public health authorities.[44] There are additional limitations in using these reports for surveillance purposes, such as non-standardized case definitions and missing data fields.[45; 46]

These data may be useful to identify high-risk pesticides or trends in acute pesticide poisonings, including among children. However, they are not able to measure pesticide exposure or capture adverse outcomes that may result from chronic, low-level pesticide exposure, such as changes in lung or neurobehavioral function or increased cancer incidence later in life.[47] The Agricultural Health Study, funded by the National

Cancer Institute and the National Institute of Environmental Health Sciences (NIEHS) in collaboration with the EPA and NIOSH, is an example of a successful prospective epidemiological study of pesticide applicators (mainly farmers) and their spouses that also included detailed exposure surveys.[48; 49] However, no similar prospective cohort studies have focused on field workers in general, nor child field workers specifically. Children's Environmental Health Research Centers, with their prospective longitudinal cohorts of children, have been able to enhance our understanding of different windows of vulnerability and impacts of low-level exposures to toxic chemicals. Some of these cohorts included children living or working in agricultural communities.[50] The Centers' findings have greatly enhanced our understanding of the limitations of past studies and what additional considerations are crucial for a more complete risk assessment process. However, gaps clearly remain.

Existing programs conducting and supporting exposure assessments could be leveraged or expanded to address the current gaps in the body of evidence. The National Institutes of Health's (NIH) Environmental Influences on Childhood Exposures (ECHO) Program examines environmental exposures impacting children, including pesticides, from the prenatal period through adolescence across multiple sites in the United States. Recently, ECHO reviewed the assessment of pesticide exposure conducted at sites participating in the ECHO program, though it is unclear if their sampling included children in agricultural employment.[51] A collaboration with the ECHO program could ensure that future sampling includes such populations. Additionally, programs such as NIEHS' Human Health Exposure Analysis Resource (HHEAR), which provides researchers access to high-quality exposure-assessment services, including state-of-the-art laboratory analysis of biological and environmental samples, could be useful to improve exposure assessments. In sum, pre-existing initiatives, such as ECHO and HHEAR, could be leveraged to seek additional data needed to develop assessments of pesticide exposures among children working in agriculture.

Recommendations:

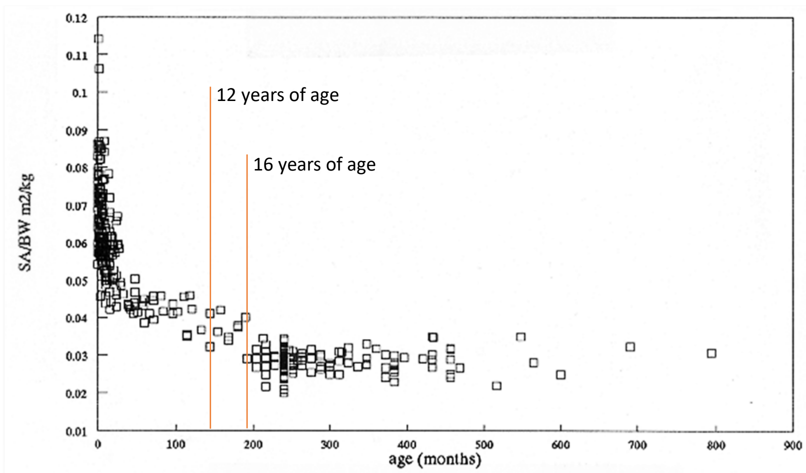
- The Committee recommends that EPA use an established, validated systematic review framework to evaluate current exposure-related evidence and the need for additional information.[52-54] Important factors to consider when evaluating the body of evidence include whether studies provide an adequate description of exposure-related parameters and sociodemographic characterization of the sample.
- To complement and expand upon the dosimetry studies described in the Assessment, the committee recommends the incorporation of studies using state-of-the-science monitoring tools and approaches to capture the full range of environmental exposures in diverse, well-characterized populations of child agricultural workers.
- The committee recommends that EPA augment pre-existing and ongoing multi-site programs, such as NIH's ECHO and NIEHS' HHEAR, to assess pesticide exposure more completely among children working in agricultural settings.

Question 3: Section IV.A of *Consideration of Legally Working Children in Pesticide Exposure Assessment* describes how relevant exposure factors described in the EPA's Exposure Factors Handbook for skin surface and body weight along with an analysis of the ratios of skin surface area to body weight (Phillips et al, 1993) were used to evaluate the potential exposures of children compared to adults based on these attributes. Have appropriate exposure factors such as skin surface areas, body weights, and the ratios of skin surface area to body weight been utilized in this analysis? If not, please suggest alternatives and citations.

As described in section III.B. of the Assessment, EPA calculates adult dermal exposure in mg/kg/day by multiplying the pesticide-specific dislodgeable foliar residue (DFR) estimate (in µg/cm^2) by the task-specific transfer coefficient (in cm^2/hr) and hours worked (hr/day), divided by body weight (kg). To assess differences in surface area (SA) to body weight (BW) ratios between children and adults, EPA used "mechanistic approaches", presented in Section IV.A. First, adult and child SA to BW ratios were presented across age (Figure 7 of the Assessment) from an analysis by Phillips et al. (1993).[55] This analysis was based on 401 individuals from a study published in 1970.[56]

Using these data, EPA determined that "the relationship between dermal SA and BW remains relatively unchanged from about age 12 (144 months) through adulthood". However, when the committee marked this age in Figure 7 (with red line below), there is a clear downward trend in the data that does not flatten out until approximately age 16 (192 months). Therefore, assuming children less than 16 years old have SA to BW ratios equivalent to adults may not be sufficiently protective.

Figure 7: Surface Area to Body Weight Ratio versus Age



In the second mechanistic approach presented by EPA, adult and child SAs and SA/BW ratios (from the EPA Exposure Factors Handbook (EFH)) were compared (Table 2 in Section IV). EPA concluded that the SA/BW ratios were very similar for children 12-18 years old and adults. A limitation of this approach is the use of central tendency values for BW and some dermal SA values. Using a range of biometric parameters would better account for diversity in sizes and would be more protective. In addition, median was used for SA and mean was used for BW in this calculation, which was inconsistent. Since distributions of surface area and body weight are right-skewed, this would increase the body weight central tendency value relative to surface area central tendency. Another limitation is that the data used in the analysis are outdated, with exposure factor values taken from the 2011 EFH, which relied on body weight values from National Health and Nutrition Examination Survey (NHANES) survey years 1999-2002. During the period of these studies, the prevalence of childhood obesity was 5-10%.[57] By 2018, the prevalence had grown to 19%. Obesity affects dermal exposure and absorption of toxicants – and vulnerability to a variety of health conditions[58] – but its impact on vulnerability to pesticide harms is unknown.

Based on the mechanistic analyses, EPA concluded that the relationship between SA and BW remains relatively unchanged from about age 12 through adulthood, and therefore, "adult inputs of body size and weight as well as daily work time is protective of children who are legally working". This conclusion is not consistent with the data presented, which shows surface area to body weight ratios in children to be higher than in adults prior to ~16 years of age. Further, children less than 12 years old working in agriculture are not adequately considered in the Assessment. The committee recommends that EPA:

- Review findings in the scientific literature, with a focus on more recent studies, to further assess dermal surface area to body weight ratios across age. Consider body weight and surface area estimates from the most recent NHANES survey cycle to reflect the current population of children.
- Conduct subpopulation analysis of the mechanistic data based on race and ethnicity. Differences in biometric values by race and ethnicity have not been addressed in the analyses even though the majority of agricultural workers are foreign born and of Hispanic ethnicity.[7]
- Use distributional data on biometric values to fully characterize children working in agriculture. Sensitivity analyses using different assumptions to assess surface area to body weight ratios would help assess the reliability of the results.
- Assess potential increased exposure to children under 12 years of age, whose surface area relative to body weight is higher than both older children and adults.
- Use an age-adjusted dermal exposure factor in the dermal exposure equation to account for higher surface area to body weight ratios for children under age 16.
- Consider and evaluate a wider range of exposure factors beyond SA/BW ratios that may result in differential exposure between children and adults (e.g., differences in amount of skin exposure as a result of clothing choices, differences in the ergonomics of the post-application activity based on adult vs. child height, behavioral differences in the field, and dermal absorption factors that lead to differences in internal dose between adults and children.

Question 4: Section IV.B of *Consideration of Legally Working Children in Pesticide Exposure Assessment* describes the available monitoring data used to quantify the post-application dermal exposures of children and adults working concurrently. Please comment on the strengths and limitations of the methods used to complete the analysis of the exposure monitoring data.

Section IV.B, describes the analysis of monitoring data from seventeen individual studies. These studies were conducted as part of the "Pesticide Hazard Assessment Project: Harvester Exposure Monitoring Field Studies (1980-1986)" and cover a variety of field exposure scenarios during hand harvesting. As noted above, a major strength of these studies was the monitoring of children and adults simultaneously as they performed the same tasks, which is directly relevant to assessing differences in exposure between children and adults. The original Pesticide Hazard Assessment Project researchers concluded, overall, that there were no significant differences in pesticide exposure between child and adult farmworkers. EPA re-evaluated the results of these studies "in order to draw independent and holistic Agency conclusions using the data" and came to the same conclusion that children did not experience greater exposure when performing the same post-application tasks. However, there are some limitations in the monitoring studies and analysis methods that introduce uncertainty about this conclusion.

1) Exposure Scenarios

While the number of available studies was relatively large, the field exposure scenarios represented by the monitoring were deficient in certain ways. First, only one orchard crop was included (apples), even though over-the-head hand harvesting may result in greater and potentially differential exposure between children and adults. For the apple scenario, conclusions focused on the differences in exposure due to picking up apples from the ground/washing them/packing them in pallet boxes versus harvesting apples from the trees, rather than differences between the age groups. Second, pesticides in current use differ from those used 40 years ago. Many of the pesticides (e.g., the organochlorine insecticides toxaphene and endosulfan; benomyl, methyl parathion) are no longer used in the United States. At the same time, common classes of pesticides (e.g., neonicotinoids) and types of pesticides (i.e., herbicides) were not included despite widespread present-day use. Herbicide DFRs are anticipated due to their current use on herbicide-resistant crops, which allows for the plants themselves to be treated. It is also possible that “other ingredients”, such as carriers, emulsifiers, or adjuvants, commonly used in the 1980s are different from today’s formulations, which could impact DFRs – EPA may have information to assess this. Similarly, while the National Agricultural Workers Survey (NAWS) finds that the highest percentage of children 14-18 work in horticulture (Figure 3 in Section II of the Assessment), only outdoor, food crop scenarios were assessed. Further, EPA concluded from the NAWS that children most often engage in pre-harvest (weeding, pruning) and post-harvest activities (packaging), but the monitoring studies only assessed harvest activities. In sum, while multiple studies are available, there are still information gaps.

2) Study Quality

Some of the studies had methodological problems that limit their utility in the Assessment. In some studies, monitoring was performed too many days after application, resulting in few quantifiable results. Other studies only provide hand/glove residue results rather than data on patch locations representative of the major body areas. According to Table 7-2 of the EPA EFH, hands only account for 4.5% of total body surface area for a 12 year old child.[59] For some scenarios, children did have higher exposure than adults (for “total” exposure and/or certain body regions), but there was no examination of the potential reasons for these differences. Additionally, many studies did not have sufficient power to be able to extrapolate the statistical results to the overall population due to small sample sizes (discussed further below).

An overall key limitation is that it does not appear EPA applied a validated systematic review framework to evaluate the monitoring studies and the overall body of evidence. As described in the recommendations related to Charge Question 2, the quality of each study should be evaluated against this framework.

3) Biomonitoring and Air Monitoring Data

Some of the monitoring studies collected urine and personal air monitoring measurements, but the results were not considered. These data could be valuable in the comparison of adult versus child exposures. No information was provided on why EPA did not evaluate these data. Biomonitoring studies are useful because they assess exposure from all exposure pathways and provide a more complete understanding of differences in exposure by life stage. Comparing biomonitoring results of children and adults may provide information that is not adequately captured by the passive dosimetry measurements and can account for potential pharmacokinetic differences between children and adults. One pathway of exposure that may impact children more than adults is incidental ingestion of residues on treated crops in the field. Child workers may be more likely to eat while working or have more hand-to-mouth behaviors such as nail biting and be less likely to wear protective clothing or use handwashing stations.

Currently, researchers have a better understanding of how to conduct biomonitoring studies, and there is a wider range of analytical methods with more sensitive limits of detection compared to the 1980s. Many analytical methods for agricultural pesticides are validated and published (e.g., the CDC National Biomonitoring methods). Both pre- and post-work period samples can be collected to help account for “background” or non-occupational exposures. While EPA emphasizes that inhalation is not as significant a route of exposure as dermal for post-application fieldwork activities, and it was not considered in the Assessment, variability in respiratory rate of individuals based on age may lead to differences in inhalation of airborne pesticide residues between children and adults that should be considered. Personal air monitoring data from these studies can be reviewed and combined with child- and activity-specific inhalation rates for assessment.

4) Statistical Analyses

The statistical analyses of the monitoring data were completed on each individual study separately, and the sample size for each study was small (between 7 to 30 subjects, often with only 3-5 children). The very small sample sizes, particularly for children, means that the statistical tests are likely not valid due to greatly reduced power to detect differences between children and adults (i.e., increased risk of type II error of failing to detect an effect when there is one to be detected). Analyses combining data from different studies could be considered to increase sample sizes. The studies to be combined should focus on the same type of crops and same pesticides and have similar proportions of child workers.

To compare pesticide exposure rates between adults and children, two-tailed statistical tests were performed. In some studies, a conclusion was made that adults had statistically significant higher exposure than children since a one-tailed p-value was <0.05. These one-tailed p-values were derived from the two-tailed p-values. However, choosing a one-tailed p-value after running a two-tailed test is not appropriate. As EPA's goal is to protect children, running a one-tailed test to see if children had higher exposure than adults would make more sense. This would also give more power to detect a significant difference between the two age groups in situations where children had higher exposure than adults.

Statistical analyses for studies with a high frequency of left-censored values (non-detects) should not test for differences in central tendency concentrations but rather differences in detection frequency using zero-inflated models. Boxplots were used to visually present the data; however, they displayed log transformed exposure outcomes. Boxplots should also show the exposure data in the original scale. This would improve understanding of the actual exposure levels, the true variabilities, and the differences in the distributions of exposure between age groups. A total of 40 children under 12 years of age are included in the exposure monitoring studies and statistical analyses. As described in the response to Charge Question 1, the Assessment is inconsistent in how it addresses children under twelve years of age. Models should be re-run separately for children <12 years old and ≥12 years old as a sensitivity analysis if sample size allows.

In several studies, the same subjects were monitored over multiple days. A mixed model was used in the analyses to account for the correlated observations within subject. Age groups and days of measurement were included as fixed effects in the models. Using mixed models is appropriate, but besides including the main effects of these two factors, the interaction between the age groups and days could be considered and added into the models. If the interaction term cannot not be added into the model (i.e., due to convergence problems), assessing how exposure differences between the two age groups change over multiple days would be helpful. For example, it may be possible that there are higher DFRs on the first day, or participant behavior in one age group may change between the first study day and the second study day of monitoring.

Appendix 2 provided more details about the individual analyses. The data for Study 5 showed that a mean weight of 68.9 kg was used for both female and male adults. This weight is an underestimate for adult males, which means the exposure rate for male adults could be overestimated, as the exposure rate was calculated by dividing the exposure quantity by body weight and duration of work. This overestimation of the adult rate of exposure could falsely lead to the conclusion that children had lower or similar exposure rates as adults when the true exposure rate for children was higher. Using a more accurate weight for male adults could be done as a sensitivity analysis.

In several studies, for example Study 3, productivity was measured, and positive correlations were seen between productivity and age. Without knowledge of how children were recruited into these studies, it is unknown whether the levels of productivity reported are representative of experienced child workers. Further, the amount of time children actively engaged in work while in the field was not described, making it difficult to determine whether the child and adult exposures are similar. Therefore, the lower productivity noted in several of these studies should not be used as a justification to discount the higher potential dose for child compared to adult workers due to greater skin surface area to body weight ratio. EPA's analyses were based on exposure rate in mg/kg/hr derived from the monitoring studies, without consideration of productivity. Analyses should be done adjusting for productivity (e.g., volume picked). If the exposure level for children is higher after this adjustment, this indicates that children have higher pesticide exposure compared to adults when controlling for productivity.

The committee recommends the following:

- EPA should use a validated systematic review framework such as the Navigation Guide[52] or NTP's OHAT[53] to conduct a comprehensive and unbiased review of the monitoring studies and literature. This includes developing protocols with study inclusion and exclusion criteria prior to commencing the review, using empirically based risk of bias domains to evaluate individual studies, and evaluating the overall body of evidence considering relevance, quality, strengths, and limitations.
- Using the systematic review framework, EPA should assess the existing biomonitoring and air monitoring data available in the Pesticide Hazard Assessment Project and incorporate the data into the analysis and conclusions as appropriate.
- Given the limited sample size in each individual monitoring study, the committee recommends conducting analyses combining data from different sites to increase the overall sample size, where feasible. Using a systematic review framework can help inform which studies are appropriate to combine in such an analysis.
- The data analyses should utilize one-tailed statistical tests to assess whether children had higher exposure than adults. Overall, this approach would be more protective of children, since it has more power to detect a significant difference in situations where children had higher exposure than adults.
- The analytical approach should consider other influential factors in the statistical modeling, including, but not limited to, productivity, interaction terms, and post-application days.
- EPA should fund new studies that are designed to both generate data to fill gaps on pesticide exposures currently experienced by children working in agriculture as well as provide actionable information on reducing pesticide risks to children. Information gaps are particularly large around over-the-head (e.g., orchard) crops, horticultural tasks, and pre- and post-harvest tasks. Exposure should be quantified using multiple methods (e.g., biomonitoring, air monitoring, passive dosimetry). EPA should consider creating a workgroup comprised of partners from farmworker organizations, community groups, human subjects' protection experts, non-governmental and governmental agencies, and academics to provide input on methods to ethically and appropriately conduct the studies and capture important covariates that introduce variability.

Conclusions

The Committee appreciates the opportunity to provide guidance to EPA on the analyses in *Consideration of Legally Working Children in Pesticide Exposure Assessment*. In this letter, we have highlighted concerns with both the methods and conclusions reached by EPA and offer recommendations on ways to address them. Briefly,

- While geographic diversity is represented in the monitoring studies, there is no information on participant sociodemographic factors and other factors that have been shown to influence exposure to pesticides, which limits study generalizability. Potential for increased exposure among children younger than 12 years old was not adequately addressed.
- The Committee describes a selection of relevant research studies that have been conducted in the last three decades and the advances that have been made in the field of exposure science, including improved analytical techniques and methods, as well as a better understanding of unique susceptibilities among children. This information should be considered when evaluating the exposures of working children. A list of references is provided.
- The mechanistic analysis of the ratios of skin surface area to body weight across ages from Phillips et al. (1993) showed that children less than sixteen years old have higher skin surface area to body weight compared to adults and thus greater potential pesticide exposure. Therefore, one cannot assume that dermal doses for anyone greater than 12 years old will be the same with all other exposure factors being equal. We have highlighted additional exposure-related factors throughout this letter that should be considered in conjunction with the physical attributes of children. Children's higher potential dose values based on their inherent physical attributes should not be disregarded based on an assumption that children will be less efficient workers, given in some industries children are valued as relatively more efficient and effective than adults for their dexterity with smaller fingers, etc.[60]
- The general design of the monitoring studies (monitoring both children and adults at the same time, performing the same tasks) is valuable to understanding child versus adult pesticide exposures during harvesting tasks. However, many of the individual studies suffer from methodological problems that limit our understanding of children's exposure to pesticides, and there were notable information gaps. Further, the available biomonitoring and inhalation data were not considered but may have provided important supportive information. Small sample sizes and frequent non-detectible results pose major challenges for meaningful statistical analysis. We have provided some suggestions for improving the statistical analyses, including adjusting for productivity rate between adults and children.

In sum, there are limitations in the supportive information underlying EPA's conclusion that its current methodologies to calculate dermal exposure for adults working in treated agricultural fields are protective of children performing the same kinds of work. Where data gaps and uncertainties remain regarding children's exposures, EPA should apply adjustment factors to ensure its risk assessments are protective of children. New studies employing up-to-date exposure methods and adequate sample sizes could also help to address key gaps. Studies can be designed to both fill current data gaps and provide information to develop actionable guidance on how to reduce pesticide risks within this population to better protect children's health. Ideally, studies should be done in collaboration with the farmworker community and reflect the lived experiences and priorities of the families whose children are in the fields.

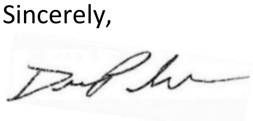
While outside the scope of the charge questions, we advise EPA to fully consider children's unique vulnerabilities in its risk assessments. These include potential pharmacokinetic differences between children and adults that impact internal exposure and dose and toxicokinetic and toxicodynamic differences due to developmental stage and exposure timing. The Committee also encourages EPA to integrate post-application dermal exposure within the context of the real-world experience of children working in agriculture, who are not only exposed to multiple pesticides through work but also through drift, diet, drinking water, and take-home exposures from parents. Ideally, these aggregate pesticide exposures would be considered with cumulative exposures, the combined exposures to multiple chemical and non-chemical stressors.

CHPAC encourages EPA to collaborate with existing programs to increase pesticide safety education and health promotion interventions among children and families working in agriculture. NIOSH has links through the National Agricultural Safety Database to the National Children's Center for Rural and Agricultural Health and Safety as well as the National Farm Medicine Center. These groups operate a website, Cultivate Safety, which has materials targeted toward youth working in agriculture as well as other family-focused information. Many of these materials are also available in Spanish. EPA's ongoing partnership with the Association of Farmworker Opportunity Programs can be further leveraged by enhancing existing programs specifically focused on the health and safety of farmworker children. Other examples include United Farm Workers and the National Center for Farmworker Health, Inc., which have connections with regional organizations that directly serve farmworker communities and may be helpful in reaching people that are less trusting of government agencies. Another channel to reach families is through Migrant and Seasonal Head Start. Providing farmworker children with culturally appropriate comprehensive education and improved healthcare access not only reduces the risk of pesticide-related health effects but increases children's future opportunities overall.

EPA plays a key role in protecting children from pesticide exposures in agricultural settings. For as long as children are employed in agriculture, EPA has a continued responsibility to monitor pesticide-related exposures and risks among this vulnerable working population; and translate findings into practices that ensure safe working conditions for child workers through training, education, and other exposure reduction strategies.

Thank you for the opportunity to provide recommendations on exposure assessment methods for children working in agriculture and how future efforts to protect this population can be enhanced.

Sincerely,



Deanna Scher, Ph.D.
Chair

cc: Jeanne Briskin, Director, Office of Children's Health Protection
Edward Messina, Director, Office of Pesticide Programs
Nica Louie, CHPAC Designated Federal Official, Office of Children's Health Protection

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Attachment 1

CHPAC Charge – May 10, 2021

EPA Office of Pesticide Programs: *Consideration of Legally Working Children in Pesticide Exposure Assessment*

EPA is committed to protecting children's health. Executive Order (E.O.) 13045, *Protection of Children from Environmental Health Risks and Safety Risks* applies to economically significant rules under E.O. 12866 that concern an environmental health or safety risk that EPA has reason to believe may disproportionately affect children. EPA also has a longstanding commitment to environmental justice, which is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Concern for farmworkers and their families has been a major focus of the Agency's protection of children's environmental health and environmental justice efforts in its pesticide program. The Federal statute applicable to farmworker exposure to pesticides is the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

EPA conducted an analysis which is presented in the document entitled *Consideration of Legally Working Children in Pesticide Exposure Assessment* that assesses post-application dermal exposure to children working in fields previously treated with pesticides.[1] The paper along with the companion appendices have been provided. The analysis was completed specifically to evaluate how the methods used in exposure assessment for adults working in such circumstances may potentially account for exposures of working children in the same types of conditions.[2] The findings indicate that children's exposures are accounted for in approaches used by EPA based on monitoring data and a mechanistic approach that was employed.

There are many possible issues which could impact the health and safety of farmworkers, especially children. These include their susceptibility to chemicals compared to adults and different exposure pathways such as spray drift, volatilization, infield inadvertent exposures during treatment, aggregate exposures, and take-home exposures. These issues are considered in other contexts by EPA and, as such, they are not a focus of this current effort. Information related to these and other possible exposure pathways is publicly available. [3] Take home exposures, as noted during the May 3rd CHPAC meeting, will be addressed at a later meeting in the fall of 2021 (date is to be determined). The focus of this meeting will be on the dermal exposures of working children compared to adults for those involved in post-application activities such as crop harvest and it will not address activities involving direct handling or use of pesticide products. Dermal exposure is the predominant pathway in such circumstances as noted above and occurs because of work activities in previously treated fields result in exposure due to physical contact with treated plants.

Pesticide exposures in agriculture may occur from post-application activities, such as harvesting crops from fields previously treated with pesticides. EPA has analyzed how pesticide exposures of children performing agricultural post-application hand labor tasks are considered in its risk assessment process to ensure that EPA's regulatory decisions are health protective of such children. The minimum age for farmworkers conducting non-hazardous[4] farm labor is 12 years of age under the Fair Labor Standards Act (FLSA) but children less than 12 years old can be involved in labor activities in farms employing less than 7 people per calendar year (i.e., "family farms"), so they were also considered.[5] Also note EPA limits children younger than 18 from being pesticide handlers or early entry workers[6] under the final revisions to the Worker Protection Standard (WPS; 40 CFR Part 170).

The analysis focused on post-application dermal exposures to adults and children working in fields previously treated with pesticides because it is the predominant exposure pathway for these working conditions. Two independent approaches were used including: (1) a mechanistic approach based on exposure factors associated with physical characteristics of children by age and (2) analysis of an extensive set of monitoring data collected under a variety of conditions involving both children as young as age 6 and adults working concurrently in the same fields.

The mechanistic analysis examined how the ratio of surface area to body weight changes in children as they mature since these attributes affect dermal exposure to pesticides. The findings of the mechanistic analysis demonstrate that, assuming other factors (such as level of pesticide residue, amount of time worked, and productivity) are equal, exposure assessments for adults are protective of children who are 12 and older because the established empirical relationship between dermal surface area (SA) and body weight (BW) remains relatively unchanged from about age 12 through adulthood. Children younger than 12 years are inherently accounted for in the exposure assessment methodology from a mechanistic perspective because they are known to be less efficient workers compared to adults and older children based on the observations from the available monitoring data which are detailed in the EPA document.

A comprehensive statistical analysis was also conducted using observational worker exposure monitoring data collected over several years in the 1980s. The activities which were monitored remain relatively unchanged in current practice which supports the continued applicability of these data for this analysis. These data were generated via a joint funding effort between the EPA and the U.S. Department of Labor. The research was conducted by 7 different universities in 17 distinct studies in various agricultural production areas of the country. Specifically, worker monitoring was completed in 8 states in 11 crops for 16 different pesticides (including multiple classes of pesticides). The individuals who participated ranged in age from 6 to 85 years old and a large percentage (54%) of the overall participants were children 6 to 18 years old. All totaled, 87 unique exposure conditions and 1472 workdays were monitored.[7] This research was also reviewed for compliance with federal ethical standards involving human subjects in research and found to be acceptable. The findings of this analysis indicate, when comparing dermal exposures (mg/kg/day) between the two age groups, either adult exposure exceeded or no statistical differences were observed between exposures to adults and working children in the vast majority of exposure conditions (all but 4).

The available lines of evidence support the Agency's overall conclusion that the current pesticide exposure assessment methodologies that calculate exposures for adults working in treated agricultural fields, which are described in the accompanying paper, are also protective of children performing the same kinds of work. The researchers that originally conducted the exposure monitoring studies reached a similar conclusion. It should also be noted these studies were conducted by multiple researchers and institutions, which reduces the potential for bias. Also, the breadth of the exposure conditions that were encountered (87) in the exposure monitoring studies and the total number of exposure days monitored that were considered (1472) demonstrates the rigor of the analysis and its findings.

Charge to the Committee:

The paper entitled *Consideration of Legally Working Children in Pesticide Exposure Assessment* analyzed whether OPP's current occupational exposure assessment methodologies adequately protect for potential exposures of working children in agriculture. The analysis was based on 2 approaches. The first approach used exposure factor information based on the different stages of child development. The second was based on an extensive set of monitoring data that involved measurement of exposure for children working in agricultural fields alongside adults. This allowed for direct comparison of exposures between adults and children. These data were conducted by 7 different universities and were funded by EPA and DOL. Monitoring was completed in 8 states, during cultivation of 11 different crops and during use of 16 different pesticides. All totaled, close to 1500 workdays were monitored, which is an extensive exposure dataset.

1. Have appropriate demographic factors been considered in the identification and characterization of the population of working children in agriculture who are the focus of this analysis? Did this analysis appropriately characterize populations of working children in agriculture? If not, please identify any which were omitted.

2. The *Consideration of Legally Working Children in Pesticide Exposure Assessment* is based on research conducted by multiple universities in several crop production situations where adult and child exposures were concurrently measured in the same fields at the same time (i.e., under identical exposure conditions). Is the Committee aware of high-quality scientific studies or other types of data that could provide additional information on exposures of children in agricultural settings not identified in the current analysis which could be added to further evaluate the exposures of working children (e.g., exposure monitoring, poison center data, medical case studies, etc.)? If so, please identify and provide citations to EPA.

3. Section IV.A of *Consideration of Legally Working Children in Pesticide Exposure Assessment* describes how relevant exposure factors described in the EPA's Exposure Factors Handbook for skin surface and body weight along with an analysis of the ratios of skin surface area to body weight (Phillips et al, 1993)[8] were used to evaluate the potential exposures of children compared to adults based on these attributes. Have appropriate exposure factors such as skin surface areas, body weights, and the ratios of skin surface area to body weight been utilized in this analysis? If not, please suggest alternatives and citations.

4. Section IV.B of *Consideration of Legally Working Children in Pesticide Exposure Assessment* describes the available monitoring data used to quantify the post-application dermal exposures of children and adults working concurrently. Please comment on the strengths and limitations of the methods used to complete the analysis of the exposure monitoring data.

Attachment 2

New Study References Pertaining to Charge Question 2
Studies listed alphabetically by first author

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