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A pilot study comparing observational and questionnaire measures as surrogates of residential pesticide exposures among residents impacted by the Ecuadorian Cut-Flower Farming industry

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Abstract

Self-reported measures of residential pesticide exposure are commonly used in epidemiological studies, especially when financial and logistical resources are limited. However, self-reporting is prone to misclassification bias.

This pilot study assesses the agreement between self-report of take-home pesticide exposure with direct observation measures, in an agricultural region of Ecuador, as a cross-validation method in 26 participants (16 rose workers and 10 controls), with percent agreement and kappa statistics calculated. Proximity of homes to nearby flower farms was found to have only fair agreement (kappa = 0.35). The use of discarded plastics (kappa = 0.06) and wood (kappa = 0.13) were found to have little agreement.

Results indicate that direct observation or measurement may provide more accurate appraisals of residential exposures, such as proximity to industrial farmland and the use of discarded materials obtained from the flower farms.

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Introduction

Worldwide, pesticides are commonly used in agricultural production. Exposure to these chemicals is linked with risk of adverse health outcomes including epigenetic modifications, endocrine disruption, cancer, neurological disease, poor mental health outcomes, reproductive disorders, and delayed or disrupted neurobehavioral development.[1,2,3,4,5,6,7,8,9,10] Agricultural workers face chronic exposure to pesticides, and thus at a greater risk of adverse health outcomes.[1,11,12,13] However, agricultural exposure to pesticides is not limited to occupational exposure; in communities engaged in agricultural production, pesticides move beyond the fields, orchards and greenhouses where workers are employed to expose populations who reside in the communities surrounding agricultural lands.[14,15–17]

Potential community exposure pathways including the proximity of homes to industrial agricultural land, pesticide drift, residential pesticide use, at-home use of discarded materials such as empty pesticide containers, and occupational take-home exposure are receiving growing attention.[18,19,20,21,22] Few studies to date have documented the health impact of community pesticide exposure levels related to industrial agricultural production in low-resource countries.[23–28] One barrier to such research is the lack of information on the ability of residents in these communities to identify and report their potential exposures.

Accurate exposure assessment is an important component of epidemiologic studies and evaluating chemical exposures in agricultural communities presents several challenges. In resource poor nations, obtaining corporate cooperation to monitor chemicals directly is difficult and using biomarkers to assess pesticide exposure is often not feasible given limited financial and logistical resources. Thus, asking workers and their families about their residential pesticide exposures is often the only available option. However, self-report is prone to bias and misclassification as it relies on individual perception of and ability to recall or recognize exposures.[29] Despite these concerns, self-report of exposure is a commonly used approach because it is feasible and inexpensive.[30] Alternative approaches include the use of direct measures, such as environmental observation and Global Positioning System/Geographical Information System (GPS/GIS).

Corporate industrial agriculture is an increasingly important component of the economies of developing countries and accounts for about half of the increase in pesticide use in these countries.[31] One such industry, the cut-flower industry, has become a major source of commerce in developing countries of the Southern Hemisphere. Pesticides are applied in great quantities on the flower farms because the growers are striving for a flawless product.[32,33,34] Most corporate cut-flower industrial farms employ the use of greenhouses, which are constructed from wood and plastics tarps.[35] Discarded materials may be available for use at home by workers and local residents. No research has assessed if the re-use of agricultural plastics and other discarded materials at home is a potential souce of exposure to pesticides although pesticides, including organophosphates, have been shown to be absorbed by low density polyethelene plastic without degradation.[36]

In Ecuador, cut-flowers have become the country's third most important export, yielding $590 million in 2010, with 42% being exported to the United States alone.[37] In 2011 this industry employed 50,000 people directly, with a workforce that is 60%–70% female.[33,38]

Two specific regions in the Pichincha Province of Ecuador, Cayambe and Pedro Moncayo, have seen a dramatic increase in greenhouses cut-flower production. In the northern Pichincha Province, there are approximately 3062 greenhouses devoted to flower production, of which 4092 acres are devoted to rose farms.[37] Research shows a single flower farm uses, on average, around 237,000 liters of water per hectare per month, and many of the farms lack proper filtration systems prior to disposal back into the surrounding environment.[28] In this region, local communities are located in close proximity to the flower farms.

We previously conducted a preliminary cross-sectional study of the relationship between potential pesticide exposure and neurobehavioral development in young children residing in several communities near Cayambe.[24,25,23] Building on this preliminary research, we conducted a pilot study to further characterize and quantify pesticide exposure levels of women working and living in these communities, specifically evaluating their awareness of and ability to report potential environmental exposures. This paper compares self-reported surrogate measures of take-home and environmental pesticide exposures associated with the flower industry with direct observational environmental assessment measures for several key potential exposure pathways.

Methods

Study Population and Design

Pregnant women living in the Cayambe region of Ecuador were recruited for inclusion into a longitudinal birth cohort pilot study. Eligible women had resided in Cayambe (controls) or in one of the surrounding communities (exposed), for at least one year prior to enrollment. Eligible women were in their second trimester of pregnancy and were either currently employed in the rose industry or on leave from the industry during their pregnancy (exposed), or had not worked in agricultural industry in the past five years (controls). The target sample size was 30 women, 20 rose workers and 10 controls.

Recruitment occurred over approximately 10 months using a variety of recruitment approaches including working with a community advisory board (CAB) and community leaders, recruiting from local health clinics, hospitals and daycare centers, using radio advertisements in both Spanish and Quichua, and through word-of-mouth techniques. The study team initially identified potential participants during prenatal visits at the local clinics and then used snowball techniques for identifying more eligible women. Because of the difficulty in recruitment of pregnant rose workers given the potential intimidation of industry managers, using word-of-mouth techniques and working closely with our CAB was crucial. Approval for this project was obtained from the Institutional Review Boards at the University of New Mexico Health Sciences Center and the University San Francisco de Quito in Cumbaya, Ecuador. Informed consent was obtained.

Baseline Questionnaire

The self-reported residential pesticide exposure data were collected through a baseline questionnaire, which also asked about employment history and workplace and residential exposures. This questionnaire was adapted from the instrument we used in our previous study in the region. Specifically, the questionnaire included questions on the proximity of the home to the nearest flower farm (0–25, 26–50, 51–100, 101–200, 201–300, or >300 meters), presence of irrigation ditches near the home (yes/no), and domestic use of discarded flower farm materials (use of discarded greenhouse plastics: yes/no; use of discarded greenhouse wood material: yes/no).

Socio-demographic and economic information obtained by the baseline questionnaire included parental ethnicity (Indigenous, Mestizo/White), maternal age, parental education level, maternal marital status, length of residence in home, number of people in household, and mean hours of work per day in the past week. We also assessed socio-economic status through self-reported variables including income level, home ownership, housing characteristics, which included floor, wall, and roof materials, presence of electricity, type of hygienic services, and home water use. Finally, a scale was constructed of participants' material possessions (Yes/No: ownership of a television, computer, car, gas stove, and refrigerator). A total score of 5 indicated ownership of all 5 possessions.

Environmental Assessment Survey Instrument

The study team conducted the environmental assessment at the same time as the baseline interview. Observational data was collected through an environmental assessment survey instrument developed by our study team and piloted in this study. The instrument collected data on the proximity of the home to the nearest flower farm, presence of irrigation ditches near the home, domestic use of discarded flower farm materials (key variables that mirrored those asked in the baseline survey), and several additional variables including housing disrepair.

To obtain the distance of the home from the nearest rose farm the team used the Brunton MNS GPS unit, which is reported to have accuracy within 15 meters when used in an open area and 1–5 meters when DGPS is available.(Brunton Inc. 2000) Upon arriving at the home of each participant, the closest flower farm was located by the study team member through visual assessment of the area surrounding the home, and was confirmed by the resident. If nearest farm could not be visually identified, team members consulted with the participant to obtain the location of the nearest farm. To obtain the measurement, the team member stood at the exterior wall of the home that faced the identified farm, recorded the measurement start point, walked or drove to the identified farm, stood at the fence line facing towards the home, and set the measurement end point. The distance reported by the GPS unit was then recorded. Two measurements were taken to assess accuracy. GPS measured distances were recoded into the same distance categories as those obtained through self-report in the baseline questionnaire (meters).

The environmental assessment survey instrument was also used to record information on presence of irrigation ditches around the home (yes/no), where the irrigation ditch appeared to originate from, the distance of the ditch from the crops near the home, and the distance of the ditch from the home. Irrigation ditches are known sources of agricultural pesticide exposure making them relevant to include in our environmental assessment.[39] Little research exists on the contamination of the local water system in the study region.[28] However, the industrial flower farms grow their product in the ground (not in elevated beds). The result of this farming technique is that the water run-off from these farms goes directly into the irrigation ditches that are located in and around the farms and throughout the communities in which the farms are embedded.

Team members also visually assessed participants' homes using the environmental assessment survey instrument to obtain information on the presence of discarded flower farm materials (wood and plastic tarps). In the region, it is common practice for the industry greenhouses to replace materials several times per year, offering the used materials to workers and community members. Because of our prior work in the region and our understanding of this practice, we wanted to assess this question of the use of materials in home as a potential source of exposure in the home. The presence of discarded flower farm materials was obtained through inspection of the area directly surrounding the home. The study staff conducting the assessments followed a set protocol. The study staff conducting the assessments followed a set protocol. For the assessment of the plastic sheeting, the team assessed: 1) the specific use of the material (for example, window covering, room divider, etc.); 2) the size and shape of the sheeting (plastic sheeting discarded by the flower farms is typically found in small and irregular pieces); 3) the condition of the plastic sheeting including discoloration, yellowing, or transparency from use; and most importantly 4) the presence of a strong pesticide odor. The wood material was assessed in a similar manner. The team assessed: 1) the specific use of the wood beams; 2) the size and shape of the wood beams and any irregular cuts; 3) the condition of the wood including any discoloration, presence of nails, and any signs of burns (it is common practice in the region for residents to burn the wood from the flower farms to remove the nails in order to sell them); and 4) the presence of a strong pesticide odor. If the materials presented with these characteristics, the team recorded the discarded materials as being present (yes/no).

We assessed an additional variable: housing quality (housing disrepair), as residential use of pesticides is common in poor quality homes, where pest infestation is more common.[18] Housing disrepair, including cracked windows and doors, may also be an important exposure pathway for homes in close proximity to industrial farms. Four structural elements of the home (windows, roof, walls, and doors) were observed from the outside and assessed for damage (yes/no). Damage was defined as presence of holes, cracks, or gaps.

We also recorded observations of exposures not captured by the quantitative instruments, which for purposes of present analysis we will refer to as "qualitative observations." The qualitative observations provided additional information about what we saw that we will use to inform the further development of future study questionnaires and methodology. For example, when recording the quality of the home, notes were taken to describe the specific damage being observed. When recording the presence of discarded farm materials, notes were also taken to describe the specific use of these materials. Team members also sketched the relative location of the participant's home to the surrounding observed exposures in a space provided on the environmental assessment survey instrument.

Statistical Analysis

All analysis were run using Stata/IC v.11.2.(Stata Corp 2010). We first compared the demographic and work characteristics of the rose farm worker and non-agricultural worker comparison groups using Fisher's exact test for categorical variables and the Wilcoxon rank sum test for continuous variables. We calculated percent agreement between self-reported and observed at-home exposure variables and calculated the kappa statistics and standard errors. We assessed agreement between self-reported and observed data for the variables of interest among the entire study population and then stratified by various socio-demographic and economic characteristics of our study population when assessing proximity to the nearest flower farm.

Results

Study Characteristics

The pilot study population included 26 women, 16 rose farm workers and 10 non-agricultural worker controls, the majority of whom worked as retail workers or as street vendors. We assessed the distribution of socio-demographic and economic characteristics by exposure group (Table 1). Maternal education and the categorical material ownership scale differed significantly between rose workers and controls (p-value: 0.02 and 0.05, respectively). While income was not statistically different, rose farm workers reported significantly less education but higher monthly income when compared to the controls in our samples. A greater proportion of rose farm workers reported that they owned their own home (44%) as compared to controls (20%). Rose workers and controls displayed similar housing characteristics. Rose workers tended to live closer to the large industrial flower farms compared to controls. Controls tended to have more material possessions than rose workers, with controls more likely to own a refrigerator, an automobile or a computer.

Housing disrepair—The homes of two participants (8%) were observed through the assessment to have no visible damage to the structural elements assessed and the homes of 13 participants (50%) were observed to have visible damage to all four structural elements assessed. The other 11 participants (42%) had observed damage to at least one and up to three structural elements. Damage to the door was the most common structural element observed. The observed damage included gaps around the doorframe and holes/cracks in the doors.

Residential exposure analysis

Proximity to Nearest Flower Farm—The overall GPS observed mean distance of the residence to the nearest flower farm was 1262 (range: 24-5323) meters. Three mothers (12%) self-reported living between 101 and 200 meters from the nearest flower farm, six mothers (23%) self-reported living between 201 and 300 meters from the nearest flower farm, and 17 mothers (65%) self-reported living more than 300 meters from the nearest flower farm. No mothers self-reported living between 0 and 100 meters from the nearest flower farm. Using direct observational assessment (GPS), one mother (4%) was measured to live between 0 and 25 meters from the nearest flower farm, another (4%) between 51 and 100 meters, three mothers (12%) between 101 and 200 meters and 20 mothers (77%) were measured to live greater than 300 meters from the nearest flower farm (mean [range]: 1598 [420-5323]). This suggests that some women misclassified the distance from their home to the nearest flower farm. Of note, the two women who lived within 100 meters of a flower farm did not accurately report their proximity. When self-report distances were compared to the GPS-measured distances we found a kappa of 0.35 (95% CI: 0.11, 0.59), indicating just fair agreement between the self- reported and measured distances of participants' homes from the nearest flower farm (Table 2).

When stratified by employment we observed only a marginal difference in agreement among rose workers (kappa = 0.35) when compared to agreement among controls (kappa = 0.29). Differences in agreement were larger but not statistically significant for other socio-economic measures such as difficulty meeting the cost of household bills, with less agreement among those who answered yes compared to no (kappa = 0.27 versus kappa = 0.39, respectively). For all stratified analysis presented above, we collapsed the distance categories to ≤100 and >100 meters to increase cell size and re-calculated the kappa. The re-calculated kappas did not differ from those presented here.

Use of Discarded Flower Farm Materials - Wood—There was little agreement between self-reported and observed home use of wood suspected of having been discarded from the flower farms (kappa: 0.13 (se = 0.10)). We observed fourteen women (54%) using the suspected wood materials around their home (Table 2), but only two of these women reported using the wood. We found that 11 of the remaining 12 women were using the wood outside of the home and one woman was using the wood both inside and outside of her home. The use of wood outside the home varied from roofs and frames of animal enclosures to the framing of storage and laundry facilities adjacent to the home. One woman used the wood as a part of the ceiling support. No one reported wood use that was not confirmed by the study team. Without direct observation, we would have substantially underestimated the use of the discarded wood as potential source of pesticide exposure..

Use of Discarded Flower Farm Materials- Plastic—Agreement between self-reported and observed use of plastics discarded from flower farms was also poor (kappa: 0.06 (se = 0.06)). We observed fifteen women (58%) using plastics suspected to be discarded from flower farms in or around their home (Table 2). However, only one of these women reported using the discarded plastics around her home. As with the wood materials, we would have substantially underestimated this potential exposure if we relied on the questionnaire measure.

Among the 14 women who reported not using discarded plastics but were observed to use discarded plastics around their home, 12 women were using the discarded plastics outside of their home, one woman was using the discarded plastics both inside and outside the home, and one woman was using the plastics inside of her home only. The use of plastics outside of participant's homes varied from being used for the roofs and walls of animal enclosures and storage/laundry areas adjacent to the home to covers for storage containers found on the property. The discarded plastics found inside the participant's homes were used as covers on the ceilings and as makeshift walls to divide spaces in the home.

Presence of irrigation ditches—Three participants' homes (12%) were observed to have an irrigation ditch in the area directly surrounding their home, but five mothers (19%) reported having an irrigation ditch near their home (kappa: 0.42 (se = 0.01)), representing moderate level of agreement for this relatively uncommon exposure. Of the three observed ditches none appeared to originate from a nearby flower farm. One appeared to have stagnant water indicating that it may not have been used recently. Additionally, the other two were near homes that were in close proximity to a river, possibly indicating that the observed irrigation ditch originated from the river.

Discussion

To our knowledge, this is the first study to assess agreement between observational and questionnaire measures as surrogates of residential pesticide exposure associated with the flower industry in an agricultural region of Ecuador. It is also the first study, to our knowledge, to assess this relationship in a developing country setting impacted by large-scale corporate agricultural production. Through the use of the environmental assessment survey instrument, we found little agreement between the self-report data and observational measurement of the use of discarded greenhouse materials and proximity of the residence to the nearest flower farm, with slight differences when we stratified by socio-economic characteristics. Agreement for the less common presence of irrigation ditches was moderate.

This analysis of pilot study data contributes to existing literature on the measurement of community-based pesticide exposure by demonstrating the value of using direct environmental assessment to validate self-reported data. The use of direct observational data, including GPS data, allows for exploration of the agreement between exposure-related variables in situations when the use of biomarkers is not feasible due to financial or other logistical constraints. Studies that have used urinary biomarkers to evaluate agreement with questionnaire exposure data have reported considerable misclassification of exposure.[30,40] Our study suggests a similar potential for misclassification when using self-report. These findings support the use of an observational assessment of at-home exposures such as distance to corporate agricultural lands and use of discarded materials in the home, in combination with questionnaire measures, particularly in situations where using exposure biomarkers is not feasible.

Our pilot study also expands the exploration of the take-home exposure pathway to include residential use of discarded materials from the agricultural industry that in this study includes the use of discarded plastics and woods from the cut-flower farms. The use of these materials was common to both exposed and controls groups and may be an important exposure pathway to assess for families and children of both agricultural worker households and non-agricultural households living near large-scale agricultural industries.

The role of agricultural farming waste or discarded materials as an exposure source has not been explored extensively. One previous study, assessing the influences of personal protection, environmental hygiene and pesticide exposure on the health of immigrant farm workers in India, included assessment of the disposal of empty pesticide containers. The authors found that 59% of participants disposed of used pesticide containers on farmland.[41] Another similar study looked at the occupational hygiene behaviors of agricultural workers and asked specifically about the use of discarded empty pesticide containers from farms. Their data showed that only 1.4% of their participants reported taking home empty pesticide containers.[21] It is important to note that exposure patterns may differ between agricultural communities because useable discarded materials may differ between specific types of farms/industries. We found little agreement between the questionnaire data and observational measurement of the use of discarded materials and that the use of these materials was underreported. The lack of agreement and underreporting indicates that to accurately assess the hazard from the use of these containers, direct observation may be a more effective approach than self-report.

Our study assessed residential proximity to cut-flower farms as an important exposure due to pesticide drift. Agreement between self-reported exposure data and the observed or GPS measured exposure data was only fair, however our interpretation was limited by the small sample size of our pilot study. Notably, approximately a quarter of the sample incorrectly indicated the distance between their homes and the farms, showing substantial misclassification in the self-reported data. None of the women measured to be living within 100 meters of the nearest flower farm were able to accurately estimate the actual distance from their home to the nearest flower farm. They often overestimated the distance, suggesting that in these communities GPS assisted documentation of residential proximity to flower fields may be necessary in order to properly classify the most at-risk population. The accurate measurement of distance from the nearest farm is important for assessing the potential exposure of participants. At distances less than 100 meters from agricultural land, residents are known to have increased pesticide exposures, although there is some variability in the literature with increased pesticide exposure found at distances up to 750 meters.[12,14,17,4243] Exposure can also differ based on whether the farms are using aereal spraying or other airborne application methods, as is the case with the cut-flower industry.

In our sample, agreement between self-report and GPS measured distances varied when stratified by various demographics. A trend of increasing agreement between self-reported distances and GPS measures was seen when stratified by income, housing construction, and cost of living measures. A similar study examining the distance of homes from nearby agricultural land compared self-report distances and distances obtained from land use maps.[44] The authors reported that participants were largely unable to accurately estimate the distance of their home, often reporting closer distances, and had displayed differential reporting by various demographic characteristics.

A study conducted in Imperial County, California used GPS/GIS to validate proximity to agricultural land estimates collected through self-report from participants.[15] Results from this study showed decreased levels of agreement when comparing the self-reported proximity and GPS/GIS measured distance of the home to the nearest agricultural land. The authors reported that self-reported proximity of participant's home to the nearest agricultural field had 75% agreement with GPS/GIS measurement during initial interviews, decreasing to 66% in the second interview, indicating a more stable measure of proximity of the home to agricultural fields may be through the direct measurement using GPS/GIS.[15] Another study used GPS measurements for validation of self-report data obtained through diaries found that parents reported their children's location at specific times incorrectly about half the time.[45]

Our study has several important limitations. The small sample size of our pilot study limited our ability to conduct in-depth statistical analysis of agreement and limited the external validity and application of the findings. The findings here may not be representative of the broader population of rose-farm workers in this region. Furthermore, the manner in which the discarded materials were observed may have resulted in some misclassification, as there is some challenge in determining if the materials were brought home from a flower farm. However, there are several key characteristics of the study region as well as certain steps that the study team took which reduce the possibility of misclassification. The farm industry materials we assessed have distinct appearances and a distinct odor, which helped the team, mostly comprised of local residents familiar with the flower industry and the pesticides used in the industry, to more accurately conduct the assessment. For instance, in the assessment of the plastic tarps, study team members looked for signs of yellowing and for plastic tarps present in small, irregular pieces, as typically plastic tarps bought new at a store are sold in large sizes. In addition, the plastic sheeting from the farms are often attached to the discarded wood beams. The pesticide odor found on these discarded materials is quite distinctive and can be easily distinguished from fertilizers or other household products. There are also key characteristics of the study region that help reduce the possibility of this type of misclassification. It is common for the flower farms to sell used greenhouse materials at a low price to flower workers and local community members, who will typically use the materials at home or sort through them to resell. It is common for residents in this region to use discarded materials to build their home or as roofing or window and door coverings. It is also important to note that the economic situation of the residents in this region does not allow for purchasing of new sheeting and wood beams, which can be cost-prohibitive. The participants in our study were of modest economic backgrounds and these materials are expensive relative to their overall monthly household income. Finally, though we were not able to measure the actual levels of pesticide residues on the materials as a source of take-home exposure in the present pilot study, this would be an important addition to future studies.

Despite these limitations, the findings from this analysis have important relevance. Our findings highlight the need to incorporate various methods of exposure assessment into study methodology, particularly in communities living in close proximity to agricultural industries.

Conclusion

While self-report is a common approach for assessing exposure in environmental epidemiological studies, our analysis suggests that using direct observation or measurement in conjunction wit questionnaire measures may provide more accurate exposure estimates.

This approach may be particularly valuable in community-based epidemiological studies, particularly those conducted in agricultural communities in developing countries.

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References

1. Alavanja MCR, Hoppin JA, Kamel F. Health effects of chronic pesticide exposure: Cancer and neurotoxicity. Annual Review of Public Health. 2004; 25:42.
2. Collotta M, Bertazzi PA, Bollati V. Epigenetics and pesticides. Toxicology. 2010
3. Freire C, Koifman S. Pesticides, depression and suicide: A systematic review of the epidemiological evidence. International Journal of Hygiene and Environmental Health. 2013; 216(4):15.
4. Hanke W, Jurewicz J. The risk of adverse reproductive and developmental disorders due to occupational pesticide exposure: an overview of current epidemiological evidence. International Journal of Occupational and Environmental Health. 2004; 17(2):20.
5. Qiao D, Seidler FJ, Tate CA, Cousins MM, Slotkin TA. Fetal chlorpyrifos exposure: adverse effects on brain cell development and cholinergic biomarkers emerge postnatally and continue into adolescence and adulthood. Environ Health Perspect. 2003 Apr; 111(4):536–544. [PubMed: 12676612]
6. Schettler T, Stein J, Reich F, Valenti M. In harm’s way: Toxic threats to child development. 2000
7. Eskenazi B, Marks AR, Bradman A, et al. Organophosphate pesticide exposure and neurodevelopment in young Mexican-American children. Environmental Health Perspectives. 2007; 115:6.
8. Young JG, Eskenazi B, Gladstone EA, et al. Association between in utero organophosphate pesticide exposure and abnormal reflexes in neonates. Neurotoxicology. 2005; 26(2):10.
9. Engel SM, Berkowitz GS, Barr DB, et al. Prenatal organophosphate metabolite and organochlorine levels and performance on the Brazelton Neonatal Behavioral Assessment Scale in a multiethnic pregnancy cohort. American Journal of Epidemiology. 2007; 165(12):7.
10. Faustman EM, Silbernagel SM, Fenske RA, Burbacher TM, Ponce RA. Mechanisms underlying Children's susceptibility to environmental toxicants. Environ Health Perspect. 2000 Mar; 108(Suppl 1):13–21. [PubMed: 10698720]
11. Baldi I, Filleul L, Mohammed-Brahim B, et al. Neuropsychologic effects of long-term exposure to pesticides: Results from the French Phytoner Study. Environmental Health Perspectives. 2001; 109:839. [PubMed: 11564621]
12. Coronado GD, Vigoren EM, Thompson B, Griffith WC, Faustman EM. Organophosphate pesticide exposure and work in pome fruit: evidence for the take-home pesticide pathway. Environ Health Perspect. 2006 Jul; 114(7):999–1006. [PubMed: 16835050]
13. Rohlman DS, Anger WK, Lein PJ. Correlating neurobehavioral performance with biomarkers of organophosphorous pesticide exposure. Neurotoxicology. 2011; 32(2):8.
14. Lu C, Fenske RA, Simcox NJ, Kalman D. Pesticide exposure of children in an agricultural community: evidence of household proximity to farmland and take home exposure pathways. Environ Res. 2000 Nov; 84(3):290–302. [PubMed: 11097803]
15. Royster MO, Hilborn ED, Barr D, Carty CL, Rhoney S, Walsh D. A pilot study of global positioning system/geographical information system measurement of residential proximity to agricultural fields and urinary organophosphate metabolite concentrations in toddlers. J Expo Anal Environ Epidemiol. 2002 Nov; 12(6):433–440. [PubMed: 12415492]

16. Thompson B, Coronado GD, Grossman JE, et al. Pesticide take-home pathway among children of agricultural workers: study design, methods, and baseline findings. J Occup Environ Med. 2003 Jan; 45(1):42–53. [PubMed: 12553178]
17. Bradman A, Castorina R, Boyd Barr D, et al. Determinants of organophosphorus pesticide urinary metabolite levels in young children living in an agricultural community. International Journal of Environmental Research and Public Health. 2011; 8:22.
18. Quiros-Alcala L, Bradman A, Nishioka M, et al. Pesticides in house dust from urban and farmworker households in California: an observational measurement study. Environ Health. 2011; 10:19. [PubMed: 21410986]
19. Rothlein J, Rohlman D, Lasarev M, Phillips J, Muniz J, McCauley L. Organophosphate pesticide exposure and neurobehavioral performance in agricultural and nonagricultural Hispanic workers. Environmental Health Perspectives. 2006; 114(5):5.
20. Woods N, Craig IP, Dorr G, Young B. Spray drift of pesticides arising from aerial application in cotton. J Environ Qual. 2001 May-Jun;30(3):697–701. [PubMed: 11401259]
21. Rao P, Gentry AL, Quandt SA, Davis SW, Snively BM, Arcury TA. Pesticide safety behaviors in Latino farmworker family households. Am J Ind Med. 2006 Apr; 49(4):271–280. [PubMed: 16550565]
22. Rodriguez T, Younglove L, Lu C, et al. Biological monitoring of pesticide exposures among applicators and their children in Nicaragua. Int J Occup Environ Health. 2006 Oct-Dec;12(4):312–320. [PubMed: 17168218]
23. Handal AJ, Harlow SD, Breilh J, Lozoff B. Occupational exposure to pesticides during pregnancy and neurobehavioral development of infants and toddlers. Epidemiology. 2008; 19(6):8.
24. Handal AJ, Lozoff B, Breilh J, Harlow SD. Sociodemographic and nutritional correlates of neurobehavioral development: a study of young children in a rural region of Ecuador. Rev Panam Salud Publica. 2007 May; 21(5):292–300. [PubMed: 17697482]
25. Handal AJ, Lozoff B, Breilh J, Harlow SD. Effect of community of residence on neurobehavioral development in infants and young children in a flower-growing region of Ecuador. Environmental Health Perspectives. 2007; 115(1):5. [PubMed: 17366812]
26. van Wendel de Joode B, Barraza D, Ruepert C, et al. Indigenous children living nearby plantations with chlorpyrifos-treated bags have elevated 3,5,6-trichloro-2-pyridinol (TCPy) urinary concentrations. Environ Res. 2012 Aug.117:17–26. [PubMed: 22749112]
27. Breilh J. New model of accumulation and agro-business: the ecological and epidemiological implications of the Ecuadorian cut flower production. Ciencia & saude coletiva. 2007 Jan-Mar; 12(1):91–104. [PubMed: 17680061]
28. Breilh J, Campana A, Hidalgo F, et al. Floriculture and the Health Divide: A struggle for fair and ecological flowers. Latin American Health Watch: Alternative Latin American Research Review. 2005; 40
29. Daniels JL, Olshan AF, Teschke K, Hertz-Picciotto I, Savitz DA, Blatt J. Comparison of assessment methods for pesticide exposure in a case-control interview study. Am J Epidemiol. 2001 Jun 15; 153(12):1227–1232. [PubMed: 11415959]
30. Perry MJ, Marbella A, Layde PM. Nonpersistent pesticide exposure self-report versus biomonitoring in farm pesticide applicators. Ann Epidemiol. 2006 Sep; 16(9):701–707. [PubMed: 16616517]
31. Ecobichon DJ. Pesticide use in developing countries. Toxicology. 2001; 160(1–3):6.
32. Dinham B. Flowers- A tale of beauty and the beast. Pesticide News. 2008; 82:19–23.
33. Sawers L. Non-traditional or new traditional exports: Ecuador's flower boom. Latin American Research Review. 2005; 40(3):40–67.
34. Van Liemt, G. The World Cut Flower Industry: Trends and Prospects. Sectoral Activities Programme; 1996.
35. Kyrikou I, Briassoulis D. Biodegradation of agricultural plastic films: A critical review. Journal of Polymers and the Environment. 2007; 15:25.
36. Nerin C, Tornes AR, Domeno C, Cacho J. Absorption of pesticides on plastic films used as agricultural soil covers. Journal of Agricultural and Food Chemistry. 1996; 44:5.

37. Direccion de Inteligencia Comercial e Inversiones. Analisis Sectorial de Flores. ProEcuador. Instituto de Promocion de Exportaciones e Inversiones. Ministerio de Relaciones Exteriores Comercio e Integracion. 2011
38. Korovkin T. Cut-Flower Exports, Female Labor, and Community Participation in Highland Ecuador. Latin American Perspectives. 2003; 30(4):24.
39. Luo Y, Zhang X, Liu X, Ficklin D, Zhang M. Dynamic modeling of organophosphate pesticide load in surface water in the northern San Joaquin Valley watershed of California. Environ Pollut. 2008 Dec; 156(3):1171–1181. [PubMed: 18457909]
40. Acquavella JF, Alexander BH, Mandel JS, Burns CJ, Gustin C. Exposure misclassification in studies of agricultural pesticides: insights from biomonitoring. Epidemiology. 2006 Jan; 17(1):69–74. [PubMed: 16357597]
41. Gomes J, Lloyd OL, Revitt DM. The influence of personal protection, environmental hygiene and exposure to pesticides on the health of immigrant farm workers in a desert country. Int Arch Occup Environ Health. 1999 Jan; 72(1):40–45. [PubMed: 10029229]
42. McCauley LA, Lasarev MR, Higgins G, et al. Work characteristics and pesticide exposures among migrant agricultural families: a community-based research approach. Environ Health Perspect. 2001 May; 109(5):533–538. [PubMed: 11401767]
43. Ward MH, Lubin J, Giglierano J, et al. Proximity to crops and residential exposure to agricultural herbicides in iowa. Environ Health Perspect. 2006 Jun; 114(6):893–897. [PubMed: 16759991]
44. Rull RP, Ritz B, Shaw GM. Validation of self-reported proximity to agricultural crops in a case-control study of neural tube defects. Journal of Exposure Science and Environmental Epidemiology. 2006; 16:8.
45. Elgethun K, Yost MG, Fitzpatrick CT, Nyerges TL, Fenske RA. Comparison of global positioning system (GPS) tracking and parent-report diaries to characterize children's time-location patterns. J Expo Sci Environ Epidemiol. 2007 Mar; 17(2):196–206. [PubMed: 16773123]

Table 1

Socio-demographic and Economic Characteristics of Study Participants (n=26), Cayambe-Pedro Moncayo region of Ecuador, 2010–2012

Characteristic	Rose Workers (n=16)	Non-agricultural Workers (n=10)
	N (%)	N (%)
Maternal Age		
Mean (range)	28 (18, 39)	25 (19, 36)
Maternal Ethnicity		
Mestizo/White	10 (62)	8 (80)
Paternal Ethnicity		
Mestizo/White	7 (44)	7 (70)
N/A (No Partner)	3 (19)	1 (10)
Maternal Education		
None- Primary Complete	8 (50)	1 (10)
Secondary Incomplete/Complete	7 (44)	4 (40)
University Incomplete/Complete	1 (6)	5 (50)
Paternal Education		
None- Primary Complete	5 (31)	1 (10)
Secondary Incomplete/Complete	7 (44)	5 (50)
University Incomplete/Complete	1 (6)	3 (30)
N/A (No Partner)	3 (19)	1 (10)
Maternal Marital Status		
Married/ Civil Union	13 (81)	7 (70)
Length of Residence in Home		
> 5 years	7 (44)	4 (40)
Number of People in Household		
≤ 5	9 (56)	5 (50)
Number of Adults in Household		
≤ 2	12 (75)	5 (50)
Number of Children in Household		
≤ 2	8 (50)	7 (70)
Monthly Family Income Level		
> $400	10 (62)	5 (50)
Homeownership		
Owned	7 (44)	2 (20)
Housing Construction Characteristics		
Floor		
Wood	2 (12)	1 (10)
Tile, Paving Stone	4 (25)	4 (40)

Characteristic	**Rose Workers (n=16)**	**Non-agricultural Workers (n=10)**
	N (%)	**N (%)**
Cement/Brick	10 (63)	5 (50)
Wall		
Adobe/Mud	3 (19)	1 (10)
Cement/Brick/Concrete	13 (81)	9 (90)
Roof		
Tile/Wood	3 (19)	4 (40)
Zinc	2 (12)	0
Cement/Brick/Concrete	11 (69)	6 (60)
In Home Electricity		
Yes	16	10
In Home Hygienic Service		
None	1 (6)	0
Latrine	3 (19)	0
Toilet, W/Septic Tank	1 (6)	0
Toilet, W/Sewer System	11 (69)	10 (100)
At Home Water Use		
Potable Water	15 (94)	10 (100)
Distance of Home From Nearest Farm, Meters (Observed)		
Mean (range)	1011 (24-3688)	1662 (157-5323)
Own Television[a]		
Yes	16	10
Own Computer[a]		
Yes	4 (25)	4 (40)
Own Car[a]		
Yes	2 (12)	5 (50)
Own Gas Stove[a]		
Yes	16 (100)	10 (100)
Own Refridgerator[a]		
Yes	14 (88)	7 (70)
Ownership Scale (Continuous)		
Mean (range)	3 (3,5)	4 (2,5)
Ownership Scale (Categorical)		
> 3	3 (19)	6 (60)
Hours of Work		
Mean (range)	47 (40, 99)	51 (36, 84)
Difficulty Meeting Cost of Food		
Yes	4 (25)	6 (60)

Characteristic	Rose Workers (n=16)	Non-agricultural Workers (n=10)
	N (%)	N (%)
Difficulty Meeting Cost of Household Bills		
Yes	4 (25)	6 (60)
Home Disrepair		
Windows		
Yes	11 (69)	7 (70)
Roof		
Yes	10 (63)	6 (60)
Exterior Walls		
Yes	13 (81)	6 (60)
Door		
Yes	14 (87)	9 (90)
Total Home Disrepair Mean (range)	3 (0–4)	2.8 (0–4)

[a]Variable used to create Ownership Scale

Table 2

Self-reported and Observed Exposures for Select Surrogate Pesticide Exposures, Cayambe-Pedro Moncayo region of Ecuador, 2010–2012

	Self-Reported Exposure		Observed Exposure		Kappa (s.e.)
Distance of Home From Nearest Farm (meters)					.35 (.12)
0–25	0		1		
26–50	0		0		
51–100	0		1		
101–200	3		3		
201–300	6		1		
>300	17		20		
	Yes	No	Yes	No	
Use of Discarded Wood (n=26)	2	24	14	12	.13 (.10)
Use of Discarded Plastics (n=26)	1	25	15	11	.06 (.06)
Irrigation Ditch Present Near Home (n=26)	5	21	3	23	.42 (.18)