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Residential proximity to agricultural fumigant use and respiratory health in 7-year old children

Robert B. Gunier[a,*], Rachel Raanan[a,b], Rosemary Castorina[a], Nina T. Holland[a], Kim G. Harley[a], John R. Balmes[c,d], Laura Fouquette[a], Brenda Eskenazi[a], Asa Bradman[a]

[a] Center for Environmental Research and Children's Health (CERCH), School of Public Health, University of California, Berkeley, CA, USA
[b] Ministry of Health, Jerusalem, Israel
[c] Division of Environmental Health Sciences, School of Public Health, University of California, Berkeley, CA, USA
[d] Division of Occupational and Environmental Medicine, University of California, San Francisco, CA, USA

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ABSTRACT

Objectives: To examine the relationship between residential proximity to agricultural fumigant use and respiratory symptoms and lung function in 7-year old children.

Methods: Participants were 294 children living in the agricultural Salinas Valley, California and enrolled in the Center for the Health Assessment of Mothers and Children Of Salinas (CHAMACOS) study. We obtained information on respiratory symptoms and asthma medication use from maternal questionnaires and children performed spirometry to determine the forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and forced expiratory flow 25–75% ($FEF_{25–75}$) at 7-years of age. We estimated agricultural fumigant use within 3, 5 and 8 km of residences during pregnancy and from birth to age 7 using California's Pesticide Use Report data. We evaluated the association between prenatal and postnatal residential proximity to agricultural use of methyl bromide, chloropicrin, metam sodium and 1,3-dichloropropene with respiratory symptoms and use of asthma medication with logistic regression models and continuous lung function measurements with linear regression models adjusted for confounders.

Results: There were no significant associations between residential proximity to use of fumigants and respiratory symptoms or use of asthma medication. We did not observe any adverse relationships between residential proximity to fumigant use and lung function measurements. Unexpectedly, we observed suggestive evidence of improved FEV_1 and $FEF_{25–75}$ with higher use of methyl bromide and chloropicrin during the prenatal period. For example, for each 10-fold increase in methyl bromide use during the prenatal development period we observed higher FEV_1 ($\beta = 0.06$ L/s; 95% CI: 0.00, 0.12) and higher $FEF_{25–75}$ ($\beta = 0.15$ L/s; 95% CI: 0.03, 0.27). Maternal report of child allergies (runny nose without a cold during the previous year) modified the relationship between FEV_1 and prenatal proximity to methyl bromide use ($p = .07$) and we only observed higher FEV_1 among children without allergies ($\beta = 0.08$ L/s; 95% CI: 0.02, 0.14 for a 10-fold increase in methyl bromide use during the prenatal period).

Conclusions: Residential proximity to agricultural fumigant use during pregnancy and childhood did not adversely affect respiratory health in the children through 7 years of age. These findings should be explored in larger studies.

1. Introduction

Metam sodium, 1, 3-dichloropropene (1,3-DCP), methyl bromide, and chloropicrin are high-use agricultural fumigants that account for about 20% of the annual pesticide usage in California (CDPR, 2012). These fumigants are known respiratory toxicants and were the top four pesticides ranked by chronic health risk based on a risk assessment conducted in the early 2000s (Lee et al., 2002). Methyl bromide, 1, 3-DCP and chloropicrin have also been identified as the top three pesticides of public health concern used near schools (CDPH, 2014). An

Abbreviations: 1,3-DCP, 1,3 – dichloropropene (Telone); CHAMACOS, Center for the Health Assessment of Mothers and Children of Salinas; CI, confidence interval; FEV_1, Forced expiratory volume in one second; FVC, Forced vital capacity; $FEF_{25–75}$, forced expiratory flow 25–75%; OR, odds ratio; PUR, Pesticide Use Report

* Correspondence to: Center for Environmental Research and Children's Health (CERCH), UC Berkeley School of Public Health, 1995 University Avenue, Suite 265, Berkeley, CA 94704, USA.

E-mail address: gunier@berkeley.edu (R.B. Gunier).

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evaluation of pesticide drift-related illnesses in 11 states found that the largest percentage of cases were related to fumigant applications, indicating the particularly hazardous nature of these substances (Lee et al., 2011).

Methyl bromide was banned by the Montreal Protocol due to harmful effects on the ozone layer and is currently being phased out of use, resulting in increased usage of chloropicrin, metam sodium and 1,3-DCP in recent years (CDPR, 2016). Cases of acute methyl bromide exposure in adults and children have produced symptoms such as shortness of breath, pulmonary edema, cough, respiratory irritation and respiratory arrest (Goldman et al., 1987; Deschamps and Turpin, 1996; Squier et al., 1992; Breeman, 2009). In the Agricultural Health Study, which examines pesticides and health in a cohort of pesticide applicators and their families, methyl bromide application was associated with higher prevalence of chronic bronchitis in nonsmoking wives of farmers (Valcin et al., 2007).

Metam sodium degrades into methylisothiocyanate, which is known to irritate respiratory tissue (CDPR, 2004), and then further breaks down into methylisocyanate, the active ingredient responsible for the Bhopal tragedy that killed more than 3500 people (Dhara, 1992). In the Bhopal tragedy the most common and serious problems were related to respiratory symptoms (Mehta et al., 1990). Cases of metam sodium-related illnesses have involved minor respiratory symptoms including coughing and dyspnea (Bretaudeau Deguigne et al., 2011). A metam sodium spill in California resulted in persistent respiratory health problems (including irritant-induced asthma) for nearby residents (Cone et al., 1994). In a case study of drift from a metam sodium application in California, an association between cases of respiratory illness in nearby residents and proximity to the application area was observed (O'Malley et al., 2005).

Increased respiratory symptoms have been reported as a result of community exposure to chloropicrin following application (Barry et al., 2010; CDC, 2004). A larger analysis of chloropicrin-related illness in California from 1992 to 2003 found that 54% of cases involved respiratory irritation (Oriel et al., 2009). Toxicology studies conducted on rodents have shown that 1, 3-DCP exposure is related to benign lung tumor incidence as well as enlargement of the respiratory epithelium (Lomax et al., 1989; Stott et al., 2001; Breslin et al., 1989).

Several epidemiological studies have found an association between occupational exposure to pesticides and an increased risk of respiratory symptoms and asthma (Mamane et al., 2015a, b). No research to date has been conducted on fumigant exposure and respiratory health in children, who are particularly vulnerable to inhalation risk due to relatively higher inhalation-rate-to-body-weight ratios (Lee et al., 2002). There are no biomarkers available to assess human exposure to fumigants in epidemiologic studies (Magnavita, 2009). Residential proximity to fumigant use is currently the best method to characterize potential exposure to fumigants. California has maintained a Pesticide Use Reporting (PUR) system which requires commercial growers to report all agricultural pesticide use since 1990 (CDPR, 2016). A study using PUR data showed that methyl bromide use within ~ 8 km radius around monitoring sites explained 95% of the variance in methyl bromide air concentrations, indicating a direct relationship between nearby agricultural use and potential community exposure (Li et al., 2005). In the present study, we investigate associations of residential proximity to agricultural fumigant usage during pregnancy and childhood with respiratory symptoms and pulmonary function in 7-year-old children participating in the Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS), a longitudinal birth cohort study of primarily low-income Latino farmworker families living in the agricultural community of the Salinas Valley, California.

2. Methods

2.1. Study population

We enrolled 601 pregnant women in the CHAMACOS study between October 1999 and October 2000. Women were eligible for the study if they were ≥ 18 years of age, < 20 weeks gestation, planning to deliver at the county hospital, English or Spanish speaking, and eligible for low-income health insurance (Medi-Cal). We followed the women through delivery of 537 live-born children. Research protocols were approved by The University of California, Berkeley, Committee for the Protection of Human Subjects. We obtained written informed consent from the mothers and children's oral assent at age 7.

Information on respiratory symptoms and use of asthma medication was available for 347 children at age 7. Spirometry was performed by 279 of these 7-year-olds. We excluded participants from the prenatal analyses for whom we had residential history information for less than 80% of their pregnancy. We excluded participants from the postnatal analyses for whom we had residential history information for less than 80% of the child's lifetime from birth to the date of the 7 year assessment. Prenatal estimates of proximity to fumigant applications and relevant covariate data were available for 257 children and postnatal estimates of proximity to fumigant applications and relevant covariate data were available for 276 children for whom we obtained details of prescribed asthma medications and respiratory symptoms. Prenatal estimates of proximity to fumigant applications and relevant covariate data were available for 229, 208, and 208 children for whom we had FEV_1, FVC and $FEF_{25–75}$ measurements, respectively. Postnatal estimates of proximity to fumigant applications and relevant covariate data were available for 212, 193, and 193 children with FEV_1, FVC and $FEF_{25–75}$ measurements, respectively.

A total of 294 participants were included in either the prenatal or postnatal analyses. Participants included in this analysis did not differ significantly from the original full cohort on most attributes, including maternal asthma, maternal education, marital status, poverty category, and child's birth weight. However, mothers of children included in the present study were slightly older (mean age 26.7 versus 24.9, $p < .01$) and more likely to be Latino (99.3% versus 93.4%, $p < .01$) than those from the initial cohort.

2.2. Maternal interviews and respiratory symptoms

Women were interviewed twice during pregnancy ($M \pm SD$ = 13.4 ± 4.7, 26.5 ± 2.6 weeks gestation), following delivery, and when their children were 0.5, 1, 2, 3.5, 5, and 7 years old. Information from prenatal and delivery medical records was abstracted by a registered nurse. Home visits were conducted by trained personnel during pregnancy (~ 13 weeks gestation) and when the children were 0.5, 1, 2, 3.5 and 5-years old. At the 7-year-old visit, mothers were interviewed about their children's respiratory symptoms, using questions adapted from the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire (Asher et al., 1995; Raanan et al., 2015). Additionally, mothers were asked whether the child had been prescribed any medication for asthma or wheezing/whistling, or tightness in the chest.

We defined respiratory symptoms as a binary outcome based on a positive response at the 7-year-old visit to any of the following during the previous 12 months: (1) wheezing or whistling in the chest; (2) wheezing, whistling, or shortness of breath so severe that the child could not finish saying a sentence; (3) trouble going to sleep or being awakened from sleep because of wheezing, whistling, shortness of breath, or coughing when the child did not have a cold; or (4) having to stop running or playing active games because of wheezing, whistling, shortness of breath, or coughing when the child did not have a cold. In addition, a child was included as having respiratory symptoms if the mother reported use of asthma medications, even in the absence of the above symptoms.

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