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Home proximity to flower plantations and higher systolic blood pressure among children

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ABSTRACT

Background: Pesticide drift from agricultural plantations increases the chemical exposure potential of people living nearby. Some studies have described positive associations between pesticide exposures and blood pressure (BP) in adults, whereas limited evidence in children suggests negative associations. This study characterized the association between home proximity to plantations and BP among children living in a flower-growing county in Ecuador.

Methods: We included 310 4-9-year-old children living in Pedro Moncayo County, Ecuador as part of The ESPINA study. We calculated age, gender and height-specific BP z-scores. Geographic coordinates of homes and flower plantations were collected using GPS receivers and satellite imagery. Exposure-outcome associations were analyzed using linear regression.

Results: The mean home distance to the nearest flower plantation was 449 m (SD: 347) and the median plantation area within 150 m of participants' homes was 989 m^2 (25^{th}-75^{Th} percentile: 492–3164) among those with non-zero values. Children living closer to plantations had lower AChE activity. Systolic BP z-score increased with greater residential proximity to plantations (0.24 SD per 1000 m [95% CI: 0.01, 0.47]) and with greater areas of flower plantations within 150 m of homes (0.03 SD per 1000 m^2 [0.00, 0.06]), after adjusting for socio-economic, anthropometric and other factors. Further adjustment for acetylcholinesterase and hemoglobin strengthened these associations.

Conclusions: Proximity of homes to flower plantations and greater plantation areas within 150 m from homes were associated with higher systolic BP, independent of cholinesterase activity. This suggests that non-cholinesterase inhibitor pesticide drift from agricultural plantations may be sufficient to induce physiologic changes on children living nearby.

1. Introduction

People living near agricultural fields are known to have an increased risk of chronic exposure to pesticides, which in turn may alter physiological processes. Pesticide exposures appear to affect the cardiovascular system, and could increase the risk for cardiovascular conditions including arrhythmia, coronary artery disease, and congestive heart failure (Hung et al., 2015). High blood pressure is an important risk factor for cardiovascular disease (Kannel, 2000; Rapsomaniki et al., 2014) and a limited number of studies have described associations between history of pesticide exposures and blood pressure in children and adults (Gordon and Padnos, 2000; Grandjean et al., 2006; Samsuddin et al., 2016; Smith and Gordon, 2005; Suarez-Lopez et al., 2013).

Among mosquito control workers in Malaysia, duration and magnitude of pesticide exposure were associated with elevated diastolic blood pressure (DBP) and systolic blood pressure (SBP) (Samsuddin et al., 2016). Among Sicilian women, twice the incidence rate of gestational hypertension was noted among those occupationally exposed to pesticides compared to those who had indirect exposures or were not

Abbreviations: AChE, acetylcholinesterase activity; SBP, Systolic blood pressure; DBP, Diastolic blood pressure

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exposed to pesticides (Ledda et al., 2015). In a study of Ecuadorian school children, maternal work in agriculture during pregnancy, but not concurrent pesticide exposure of children, was associated with elevated systolic blood pressure in children (Grandjean et al., 2006). These positive associations from epidemiological studies were also observed in experimental studies in which rats treated with the organophosphate chlorpyrifos, a cholinesterase inhibitor, developed increases in SBP and DBP (Gordon and Padnos, 2000; Smith and Gordon, 2005). In contrast to these findings, we previously observed lower systolic blood pressure among children who lived with a flower plantation worker, and observed a positive association between acetylcholinesterase (AChE) activity and SBP and DBP, among children growing up in agricultural communities in Ecuador (Suarez-Lopez et al., 2013). AChE is a physiological marker of exposure to cholinesterase inhibitor pesticides; lower values reflect greater exposure (Taylor, 2011). The differing associations observed across the studies mentioned above may be due to differences in the age-groups of participants and in the construct of exposure used (e.g. urinary metabolites vs AChE activity vs history of work in agriculture). One construct of exposure which has not been studied in this context is home proximity to agricultural pesticide spray sites.

Several studies suggest that pesticide drift may play an important role in pesticide exposures and health of families living within the vicinity of the application sites. For instance, a 20% increase in an urinary organophosphate metabolite per mile of greater residential proximity to farmland was observed among families living in agricultural areas in Washington State, USA (Coronado et al., 2011). Similarly, dose-response relationships have been described between acreage of farmland within 750 m of homes and herbicide levels in house dust among families in rural Iowa, USA (Ward et al., 2006). These effects have been observed at smaller distances in two pediatric studies, in which children living within 60 m from fruit orchards and agricultural fields had higher pesticides levels in house dust and urinary metabolite levels than those living farther away (Bradman et al., 2011; Lu et al., 2000). Residential distance to plantations is an indicator of pesticide drift for many classes of pesticides, as fungicides, insecticides and herbicides are usually used concomitantly in agriculture.

There is some evidence that proximity to pesticide spray sites may affect the health of children. Pregnant mothers in California who lived near fields where organophosphate or pyrethroid pesticides were used were found to have offspring with lower cognitive function in childhood, or with greater risk of having autism spectrum disorders (Gunier et al., 2016; Roberts et al., 2007; Rowe et al., 2016; Shelton et al., 2014). Additionally, there is some evidence that proximity of pregnant women's homes to pesticide spray sites is associated with certain heart defects in their offspring (Carmichael et al., 2014). More studies assessing various health components of children living near agricultural sites are needed, as it is important to understand how far residential zones and schools should be from pesticide spray sites to minimize the potential for exposure and related adverse health problems.

The aim of this study was to determine whether proximity of homes to flower plantations was associated with blood pressure alterations among a cohort of Ecuadorian children who did not work in agriculture but lived in agricultural communities in Pedro Moncayo County, Ecuador. The floricultural industry in Pedro Moncayo has a prevalent use of insecticides (organophosphates, neonicotinoids and pyrethroids) and fungicides (quinone outside inhibitors, azoles, dithiocarbamates) (Grandjean et al., 2006; Handal et al., 2016; Harari, 2004; Suarez-Lopez et al., 2017).

2. Materials and methods

2.1. Study description

The study of Secondary Exposures to Pesticides among Children and Adolescents (ESPINA, Exposición Secundaria a Plaguicidas en Niños y Adolescentes)(Suarez-Lopez et al., 2012) is aimed at understanding the effects of asymptomatic pesticide exposures on child development in a population of children living in Pedro Moncayo County, Pichincha, Ecuador. With approximately 1800 hectares of flower plantations (5.3% of the County's surface area) (Gobierno Municipal del Canton Pedro Moncayo, 2011), a sizeable portion of the residents of this Andean county live in the vicinity of a flower plantation.

We examined 313 boys and girls of ages 4–9 years in 2008, 73% of whom were recruited using contact information from their participation in the 2004 Survey of Access and Demand of Health Services in Pedro Moncayo County, a large representative survey of Pedro Moncayo County conducted by Fundación Cimas del Ecuador in collaboration with the communities of Pedro Moncayo county. The remaining 27% of participants were recruited by word of mouth or community announcements. We also conducted home interviews of 451 parents and agricultural workers who lived with the examined children. The ESPINA study was carried out in response to the needs defined locally by the people and leaders of Pedro Moncayo County. Additional recruitment information has been described elsewhere (Suarez-Lopez et al., 2012). For the present analyses, we included 310 (98%) children who had all covariates of interest.

The ESPINA study was approved by the Institutional Review Boards of Fundación Cimas del Ecuador, the University of Minnesota, the University of California San Diego, Universidad San Francisco de Quito and the Ministry of Public Health of Ecuador. Informed consent, parental authorization of child participation and child assent of participants 7 years of age and older were obtained.

2.2. Survey

Information on socio-economic status, demographics, health, and pesticide exposure histories of participant children, children's parents and other adults in the household were obtained through home interviews by trained interviewers.

2.3. Examination

Children's heights were measured using a height board, following recommendations by the World Health Organization (World Health Organization, 2008). Resting heart rates were measured during a 30-s auscultation. Blood pressure was measured with a pediatric Omron aneroid sphygmomanometer, appropriate for the arm sizes of the children. Blood pressure measurements followed the recommendations of the American Heart Association (Pickering et al., 2005). Children were seated with uncrossed legs and both feet on the floor with the antecubital fossa supported at heart level. Two measurements were taken after at least 5 min of rest. The average of both blood pressure measurements were used in these analyses. Interpretation of blood pressure levels in pediatric populations is conducted using age, gender and height specific blood pressure z-scores (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004). Such blood pressure z-scores were calculated using formulas from the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004).

2.4. Biological measures

Erythrocytic AChE activity and hemoglobin concentrations were measured from a single finger stick sample using the EQM Test-mate ChE Cholinesterase Test System 400 (EQM AChE Erythrocyte Cholinesterase Assay Kit 470).