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Proximity to agricultural fields as proxy for environmental exposure to pesticides among children: The PIAMA birth cohort

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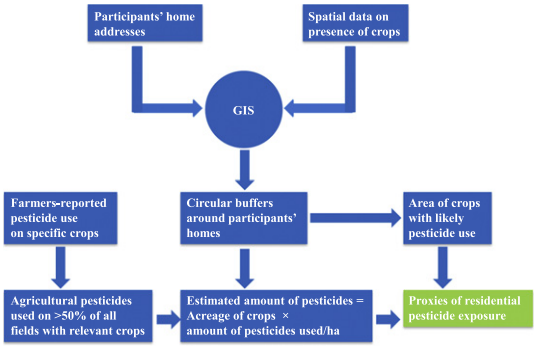
HIGHLIGHTS

- Proximity of home address to fields likely treated with pesticides was assessed.
- Proximity to likely treated fields was used as proxy for pesticides exposure.
- Acreage of fields was combined with farmer-reported pesticide use on those fields.
- Few participants lived within 100 m of fields likely treated with pesticides.
- About two-thirds lived within 1000 m of likely treated fields.

GRAPHICAL ABSTRACT



Assessment of residential proximity to crop fields likely treated with agricultural pesticides as proxies for environmental pesticide exposure - flow chart.

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ABSTRACT

Background: Agricultural pesticides are frequently used for crop protection. Residents living in close proximity to treated fields may be exposed to these pesticides. There is some indication that children living near agricultural fields have an increased risk of developing asthma and decreased lung function.
Objectives: The aim of this study was to assess the proximity of participants' homes to fields likely treated with pesticides as proxy for environmental exposure to agricultural pesticides among participants of a Dutch birth cohort study, and to combine acreage of fields with farmer-reported pesticide use.
Methods: Potential pesticide exposure at the home address at the time of the 14-year follow-up was estimated for 2291 participants of the Dutch PIAMA birth cohort study. We used spatial data on the presence of crops during the year 2012 to calculate the surface area of specific crops relevant for pesticide use in The Netherlands cultivated within 50, 100, 500 and 1000 m of the study homes. Farmer-reported pesticides use on specific crops from a national survey performed in 2012 was used to estimate the amount of all pesticides and pesticides with known irritant properties for the respiratory system applied within the aforementioned distances of the study homes.

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Results: For 3%, 7%, 40%, and 65% of the homes, any relevant crops were present within 50, 100, 500 and 1000 m, respectively. Among these, the most frequent crops were corn, cereals, and potatoes. For almost the same percentages of homes, it was estimated that pesticides with known irritant properties for the respiratory system were potentially applied within these distances.
Conclusions: We observed that a small proportion of the study participants lived in close proximity (<50 or <100 m) to agricultural fields with crops relevant for pesticide use in The Netherlands. The percentage of study homes within 500 or 1000 m of agricultural fields with these crops was much larger.

1. Introduction

The Netherlands is well known for the production of a variety of crops, such as corn, fruits, vegetables, potatoes, floriculture, and flower bulbs. Pesticides are widely used in agriculture in order to increase production and prevent damage (Van Dijk et al., 1999). Residents living in close proximity to agricultural fields may be exposed to pesticides through primary spray drift or after application, e.g. through volatilization of pesticide residues from crops and soil or wind erosion of soil particles (Deziel et al., 2015; FOCUS Working Group, 2008). This was examined in a study conducted in The Netherlands, which included 12 bulb growers' (farmers') homes and 15 nonfarmers' houses located approximately 10–400 m from flower bulb fields, and found increased concentrations of pesticides in house dust samples of farmers and non-farmers (Hogenkamp et al., 2003). Similar increases were reported by studies conducted in California and Iowa in homes within 500 m and up to 1250 m from vegetables, corn and strawberry fields (Gunier et al., 2011; Harnly et al., 2009; Ward et al., 2006). Findings of the US studies may not be directly transferable to The Netherlands because of differences in agricultural pesticide application practices.

While it is true that most of the pesticides applied in modern agriculture are not persistent in the natural environment, they do tend to persist more in houses due to lack of degrading microorganisms, moisture and sunlight. This shows the importance of investigating exposure to agricultural pesticides among children, as pesticide exposure in homes has been associated with respiratory diseases among children (Lewis et al., 1994; Salameh et al., 2003; Schwartz et al., 2015; Xu et al., 2012).

There are several methods of assessing environmental exposure to agricultural pesticides: by collecting house dust samples or biological samples such as blood or urine. Such samples can be analysed for pesticide residues or their metabolites (Bouvier et al., 2005; Chevrier et al., 2014; Lewis et al., 1994). These direct methods of assessing environmental agricultural pesticides exposure, however, are time consuming and costly and therefore, not suitable for large-scale studies.

Environmental exposure to agricultural pesticides can also be assessed indirectly by combining spatial data on crop cultivation with information on the location of residential homes in a Geographic Information System (GIS). This method is suitable for efficiently assessing environmental exposure to pesticides in large population studies (Booth et al., 2015; Rappazzo et al., 2016). One of the limitations of this method is that is it does not provide information about the specific pesticides applied. In The Netherlands, spatial data on annual crop cultivation is available for recent years, but spatially resolved information on pesticide use is lacking. We addressed this problem in the present study by combining geographical information data on the presence of crops with likely pesticide use in The Netherlands with data on farmer-reported pesticide use on specific crops.

The aim of this study was to assess the proximity to fields likely treated with pesticides as proxy for environmental exposure to agricultural pesticides at the home addresses of the participants of the Dutch PIAMA cohort at the time of the 14-year follow-up. A second aim was to estimate average annual pesticide use on these fields using data on farmer-reported pesticide use.

2. Methodology

2.1. Study design and population

The PIAMA (Prevention and Incidence of Asthma and Mite Allergy) study is a prospective Dutch birth cohort study. The baseline study population consisted of 3963 participants from the northern, middle and western parts of The Netherlands. Participants were born in 1996 and 1997 (Wijga et al., 2014). The PIAMA study has been designed to study the influence of life style and environmental factors on the development of asthma and allergies in children. Questionnaires were administered to the parents during pregnancy, at the child's ages of 3 months and 1 year, and then annually until the age of 8 years. When the children were 11, 14, and 17 years old, both parents and children completed questionnaires (again).

Data on the presence of crops ('BRP gewaspercelen', Dutch Ministry of Interior and Kingdom Relations, 2013). and data on self-reported agricultural pesticide use, collected in a national survey among farmers (Statistics Netherlands (CBS), 2012), were available for the year 2012, when the participants were approximately 15 years old. Therefore, the residential address at the time of the 14-year questionnaire was used to assess participants' environmental agricultural pesticides exposure for the year 2012. A total of 2291 children, who participated in the 14-year follow-up and had geocoded residential addresses, were included in this study.

2.2. Environmental agricultural pesticide exposure assessment

Environmental exposure to agricultural pesticides was assessed using the participants' home addresses, geographic information system data on the presence of crops and survey data on specific pesticide use (Fig. 1). We assessed environmental exposure to agricultural pesticides in three different ways: 1) by the presence of any crops relevant for pesticide use in The Netherlands in circular buffers with radii of 50, 100, 500 and 1000 m around the children's homes; 2) by the presence of specific crops relevant for pesticide use in The Netherlands within these distances from the children's homes; 3) by estimating the amount of (specific) agricultural pesticides used within these buffers.

2.3. Presence of (specific) crops around the child's home address

We imported the x-y coordinates of the participants' home addresses at the time of the 14-year follow-up into a geographical information system using ArcGIS and combined them with the location of crop plots ('BRP gewaspercelen') of 2012 (National Georegistry, 2012). The BRP is a national vector data set of 69 different types of crops at an underlying scale of 1:10,000, with annually updated crop information. Next, for each home address, circular buffers with radii of 50, 100, 500 and 1000 m were created and intersected with the BRP dataset (Supplementary Fig. 1). These circular buffers were selected based on primary spray drift (likely relevant at 50 and 100 m primarily) and secondary transport processes (500 and 1000 m) from agricultural fields during and after application (Gunier et al., 2011; Hogenkamp et al., 2003; Simcox et al., 1995). For each of the selected crops (a list of all selected crops is presented in Supplementary Table 1), the total surface