



# Breast milk intake and mother to infant pesticide transfer measured by deuterium oxide dilution in agricultural and urban areas of Mexico



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## HIGHLIGHTS

- This isotopic technique is accurate and non-invasive to assess breast milk intake and pesticide transfer to infants.

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## ABSTRACT

Vector-borne diseases have increased pesticide use in urban areas (UA) and agricultural areas (AA) in Mexico. Breast milk can be contaminated by pesticide exposure. The objective of the study was to measure breast milk intake by deuterium oxide dilution as well as organochlorine and pyrethroid transfer from mother to infant in AA and UA of Sonora, Mexico. Human milk intake was determined by the 'dose-to-mother' technique using deuterium oxide (D<sub>2</sub>O) dilution. Mothers' body composition was also assessed by this technique and the intercept method. Pyrethroids (deltamethrin, cypermethrin and cyhalothrin) and organochlorine pesticide residues (*p,p'*- DDT, *p,p'*- DDE, *p,p'*- DDD) in breast milk samples were measured by gas chromatography. Sixty-two lactating women and their infants participated in the study, 32 lived in the UA and 30 lived in the AA. Breast milk intake was approximately 100 mL higher in the AA than in the UA 799 ± 193 and 707 ± 201 mL/day, respectively ( $p < 0.05$ ). The concentrations of *p,p'*- DDT and cypermethrin levels in breast milk were higher in the UA than in the AA ( $p < 0.05$  and  $p = 0.001$ , respectively). None of the pyrethroids and organochlorine pesticides studied surpassed the Acceptable Daily Intake (ADI) in milk for humans according to EPA and FAO/WHO. In conclusion, breast milk intake was higher in the AA compared to the UA. The *p,p'*- DDT and cypermethrin levels in breast milk were higher in the UA compared to the AA. Since pesticide levels in human milk did not exceed the ADI, breastfeeding is still a safe practice and should be encouraged.

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## 1. Introduction

Breast milk is considered the best alternative to feed infants in order to achieve optimal growth, development and health. For this

reason, the World Health Organization (WHO) recommends exclusive breastfeeding (EBF) during the first 6 months of life (WHO, 2016; Kramer and Kakuma, 2012).

Despite being the optimal way of feeding infants and considered

**Abbreviations:** AA, agricultural area; ADI, acceptable daily intake; D<sub>2</sub>O, deuterium oxide; DDE, dichlorodiphenyldichloroethylene; DDT, Dichlorodiphenyltrichloroethane; EBF, exclusive breastfeeding; FFM, fat-free mass; FM, fat mass; L/A, length for age; MSPD, matrix solid phase dispersion; PBF, predominant breastfeeding; TBW, total body water; W/A, weight for age; W/L, weight for length; UA, urban area.

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essentially safe, exposure to substances in the environment, such as heavy metals and pesticides, can contaminate human milk (D'Apolito, 2013; Pérez-Maldonado et al., 2010; Torres-Sánchez and López-Carrillo, 2007; Sim and McNeil, 1992). More than 20% of pollutants can be transferred to the infant through breastfeeding practices and stored in the body depending on the pollutant's molecule affinity and the person's body composition (Gebremichael et al., 2013; Lackmann et al., 2005). Pyrethroids and organochlorine pesticides are bio-accumulated in organisms due to their high octanol/water partition coefficient ( $\log K_{ow} > 4$ ), which increases their lipophilicity and facilitates their build-up in fat-rich tissues. For that reason, pesticides are transferred passively from plasma to the mother's milk and its concentration is proportional to their lipid solubility (Waliszewski et al., 2012; Lackmann et al., 2005).

Dichlorodiphenyltrichloroethane (DDT) is a pesticide of moderate toxicity and high persistence in the environment (CICOPAFEST, 2004). It has been estimated that in the last 35 years 20,000 million pounds of insecticides have been applied on the planet, and of these, 3,000,000 correspond to DDT, which makes it the most applied organochlorine pesticide around the world during the second half of the 20th century (Torres-Sánchez and López-Carrillo, 2007; Matsumura et al., 1972; Pirsahab et al., 2015).

In Mexico the use of pesticides has played an important role. For more than 50 years, DDT was used in agriculture and antimalarial campaigns (López-Carrillo et al., 1996). Its persistency in the environment can be measured through dichlorodiphenyldichloroethylene levels (*p,p'*-DDE), since it is DDT's most common metabolite and can remain in the environment for more than 20 years (CICOPAFEST, 2004). Currently, DDT is permitted only in regions where malaria is endemic, mainly in coastal areas (Pirsahab et al., 2015). Mexico has controlled transmission of malaria in most of the country, although States such as Nayarit, Michoacan and Oaxaca still have cases (Uribarren, 2013; Health System of Mexico (2008)).

Malaria is not considered endemic in Sonora, Mexico. Nevertheless, intensive campaigns against the mosquito *Aedes aegypti*, responsible for diseases such as dengue and, more recently, chikungunya and zika, have been applied in urban cities like Hermosillo and agricultural areas of the state (Althouse et al., 2015; Díaz-Quinonez et al., 2016; Gatherer and Kohl, 2016). The most commonly used pesticides in these campaigns are cypermethrin, cyhalothrin and deltamethrin (Health System of Mexico (2014)). These campaigns have also targeted home gardens, particularly in low-income settlements where mosquitoes are bound to proliferate (Martínez-Sánchez et al., 2015). For instance, from January through September 2013, more than 14,000 L of fumigant were used in the state of Sonora, Mexico, to cover 51,000 ha to control the mosquito *Aedes aegypti* (Health System of Mexico (2013)).

Since 2007, Mexico's Regional Action Plan for Risk Reduction Program was implemented in order to use new strategies for pest control, substituting DDT for deltamethrin (Health System of Mexico (2008)). Despite its low persistency in the environment, the use of deltamethrin can be toxic and harmful to humans, animals and ecosystems (ATSDR, 2003; Torres-Sánchez and López-Carrillo, 2007). We hypothesized that some pyrethroids and organochlorine pesticides could be transferred through breast milk to infants in some agricultural and urban areas of Sonora. For this reason, we measured total breast milk intake by deuterium oxide dilution as well as organochlorine and pyrethroid transfer from mother to infant in agricultural and urban areas of Sonora, Mexico.

## 2. Materials and methods

### 2.1. Ethics and study design

The study was conducted between October 2012 and March 2013. The Bioethics and Research Committee of the Department of Medicine and Health Sciences, University of Sonora, approved the study's protocol and procedures. A cross-sectional design was used and study areas included the urban area (UA) of Hermosillo, which is the capital city of Sonora and Poblado Miguel Aleman as the agricultural area (AA), located on the Sonoran Coast (INEGI, 2011). All participating mothers signed an informed consent form.

### 2.2. Selection and recruitment of participants

Breastfeeding mothers and their infants were selected from either UA or AA. Local health clinics were the main source to recruit mothers and their infants, potentially with EBF or predominant breastfeeding (PBF) practice. Participants who reported having EBF or PBF practices were enrolled in the study. Infants had to be born at term (38–42 weeks of gestation period) and be between 3 and 6 months of age. We included mother-infant pairs who resided for more than 1-year in one of the two study areas. Participants who had consumed alcohol, drugs and/or tobacco were excluded as well as infant twins or infants in the weaning process (Caire et al., 2002). In order to include participants with a plentiful breast milk intake process, we eliminated participants with low breast milk intake (less than 250 mL per day) when the sample collection and analysis ended (Haisma et al., 2003). The use of this criteria resulted in the further exclusion of four participants who had declared EBF and completed the sampling days.

The data collection period for each mother-infant pair lasted 15 days. Participants were able to undertake their regular activities and those who lived in the AA were scheduled and measured in a public health clinic, while subjects that lived in the UA were visited in the clinics or at home (IAEA, 2010).

### 2.3. Anthropometric data

#### 2.3.1. Mothers

Anthropometric measurements were made using standard international protocols at the onset and at the end of the dosing period (Cameron, 1986; WHO, 2008). Mothers were weighed on a digital electronic scale (SECA<sup>®</sup> model: 872 1321959, 0 to 200 Kg  $\pm$  0.05 Kg). The scale was placed on a level surface and mothers wore minimal clothing and no shoes. Waist circumference was measured with a fiberglass tape (Gulik, 180 cm), and their height using a portable stadiometer (SECA<sup>®</sup> model: 217 1721009, 30–205 cm  $\pm$  1 mm reach). From these measurements, body mass index (BMI) was calculated and classified according to WHO cut-offs (WHO, 2000a).

#### 2.3.2. Infants

Infants were weighed on a paediatric scale (0–20 Kg  $\pm$  0.05 Kg; SECA<sup>®</sup> model: 728 1321834) and recumbent length was measured using an infantometer (SECA<sup>®</sup> model: 416 1821009, 33–100 cm  $\pm$  1 mm) at the beginning and at the end of the dosing period. Z scores for weight for age (W/A), length for age (L/A) and weight for length (W/L) in infants were based on the WHO reference, using the Anthro software Version 3.2.2 (WHO, 2000b).

### 2.4. Breast milk intake and mother's body composition assessment

The conventional technique to measure breast milk intake is to weigh infants before and after each feed, known as "test weighing".

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